FACIES	25	253-278	Taf. 63-68	7 Abb.	6 Tab.	ERLANGEN 1991

Carbonate Platform Facies Reflected in Carbonate Basin Facies (Triassic, Northern Calcareous Alps, Austria)

Kalkturbidite als Zeugen von Faziesveränderungen auf der Karbonatplattform (Trias der Nördlichen Kalkalpen, Österreich)

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KEYWORDS: CARBONATE SEDIMENTOLOGY – CALCITURBIDITES – SEA LEVEL – FACIES – NORTHERN CALCAREOUS ALPS – TRIASSIC (NORIAN)

CONTENT

SUMMARY

A 95 m long section (Lacke section) located in the Northern Calcareous Alps of Austria was analyzed in detail. Detailed field measurements and point-counting of thin-sections revealed a distinct compositional variation of calciturbidites deposited in the Triassic Hallstatt Basin (Pedata-Pötschen Schichten). After a pilot study seven point-count groups were developed distinguishing input from different paleoenvironments. Statistical analysis of the point-count data using summary statistics, cluster- and correspondence analysis assisted in describing the compositional variation within the calciturbidites. Alternated flooding and exposure of the platform as a result of sea-level fluctuations, creating and destroying shallow-water habitats on the flat platform top, produced the variations in turbidite composition.

1 INTRODUCTION

The Dachstein Limestone Formation (Norian and Rhaetian) of the Northern Calcareous Alps consists of thick series of shallow-water limestones with extensive reef complexes. Facies analysis studies of Upper Triassic reefs started with the study of the Sonnwend Mountains in Tirol by WÄHNER (1903), followed by the Steinplatte Reef (VORTISCH 1926) and the sediment-petrological study by SANDER (1936). Later these reef-slope-transition sediments were studied by OHLEN (1959), PILLER (1981) and STANTON & FLÜGEL (1989). The results, combined with other studies of sediments of the Dachstein Limestone Reefs, led to the development of widely used reef facies models (e.g. PILLER 1981; SENOWBARI-DARYAN et al. 1982) and the reconstruction of the history and evolution of Alpine Triassic reefs (FLÜGEL 1982b). The cyclicity and the megacyclic grouping of the cyclothems is another striking feature of the sediments of the Dachstein Limestone Formation (SANDER 1936; SCHWARZACHER 1948, 1949, 1954). FISCHER (1964) established the link between the Lofer cyclothems in the Triassic platform sediments and fluctuations in eustatic sea level. The ideal transgressive cyclothems are not often found in the Dachstein Formation and the classical cycle is usually capped with a regressive intertidal member B' (HAAS 1982). Subsequent research on cyclicities in the Dachstein Formation yielded two different options. In their analysis of Hungarian and Austrian Dachstein Limestone successions SCHWARZACHER &

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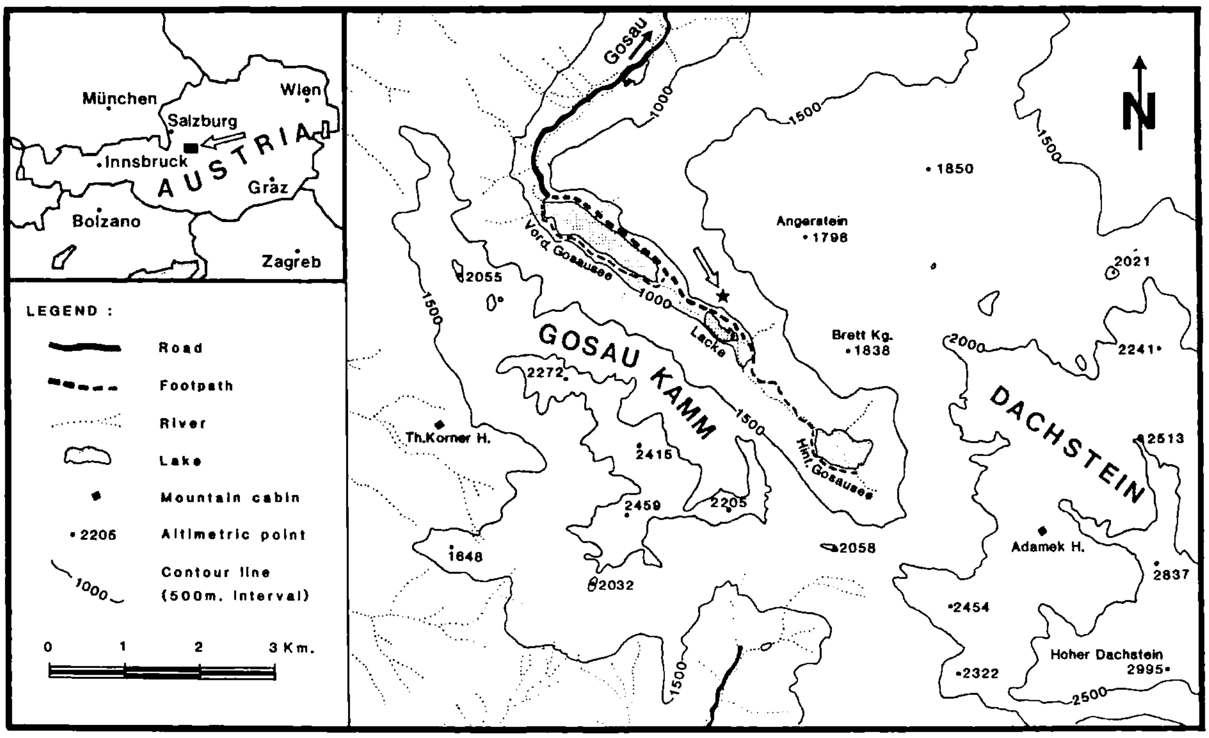

Fig. 1. Location map, the studied section is indicated with an asterisk.

HAAS (1986) frequently encountered the regressive cyclothems. They demonstrated to a large extent the tie between the cyclicity observed on the platform and the quasi-periodicities of the Milankovitch model. GOLDHAMMER et al. (1990), though, suggested that Lofer facies deposition of the Dachstein Formation of the Leoganger-Steinberge Mountain Range was mainly controlled by short-term variations in subsidence rate leading to a chaotic stratigraphy distribution of cycle thicknesses and diagenetic features. Whether or not the cyclicity observed on the platform is orbitally driven does not affect the scope of this study, because both studies affirm that the facies changes on the platform are the result of fluctuations in sea level.

The shallow-water platform areas containing Lofer cyclothems are found in association with deeper marine basins like the Hallstatt basin in which an alternation of pelagic limestones, carbonate gravity flows and turbidites was deposited in a Bahamian-type environment (ZANKL 1971; BERNOULLI 1981). The calciturbidites deposited in this basin are called the Pedata/Pötschen Schichten. These basin sediments were analyzed with the following objectives: (1) to study the compositional variation of the basinal sediments, (2) to relate this compositional variation to biofacies and environments on the platform, and finally (3) to investigate whether facies changes on the carbonate platform induced by sea-level fluctuations or tectonics can be correlated with the compositional variation of the calciturbidites analogous to the studies in Bahamian sediments by CARTWRIGHT (1985) and HAAK & SCHLAGER (1989).

1.1 Setting

The Lacke section, which is the basin section under investigation, is located in the Northern Calcareous Alps (Nördliche Kalkalpen) about 60 km southeast of Salzburg in the Oberösterreich near the Lacke in the Gosau Valley (Fig. 1; Pl. 63/1). The lithology consists of an alternation of blue-grey mudstones, packstones and grainstones (in the sense of DUNHAM (1962) and green-yellow calcisilts to marls (Pl. 63/2-5). The thickness of the mudstone to grainstone beds varies between 0.5 and 132 cm, the calcisiltites between 0.1 and 7 cm (Fig. 2 and Pl. 63/5). The mud to grainstone beds show grading and sharp contacts and are interpreted as calciturbidites. The thickness ratio between calcisiltites and calciturbidites is approximately 1 to 20. Chert nodules and chert layers occur in the entire section. Based on conodont biozones a Late Norian age of the sediments is inferred. Five meters above the base of the section the boundary between

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Fig. 2, part 1 to part 4. Vertical distribution of the calciturbidite point-count analysis along the Lacke section. Vertical scale in meters. The subset column indicates the subsets distinguished in outcrop. All calciturbidites are attributed a chalk notation in the second column. In the next column the lithology of the calciturbidites is shown, using the classification scheme of DUNHAM (1962). The other columns display the results, the counts, of the individual point-count groups within each sample. A horizontal bar denotes a layer that was point-counted. The counts of every single point-count group are plotted around its mean for the whole sample population and which is indicated with a vertical line and its value at the top of the figure. The counts of every single point-count group are plotted around its mean for the whole sample population and which is indicated with a vertical line and its value at the top of the figure. For every individual analysis the counts sum up to 200 points.

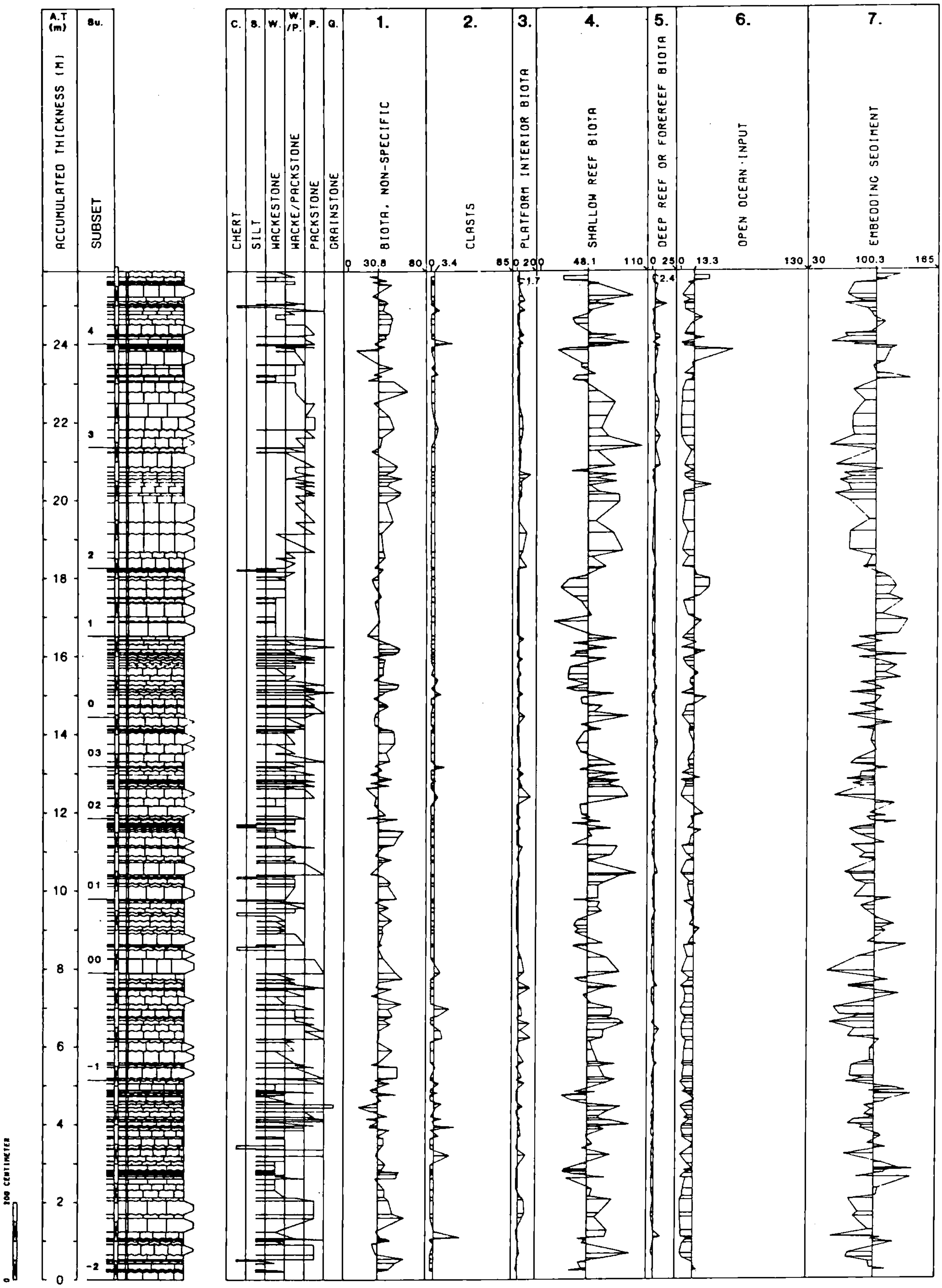


Fig. 2, part 1. Vertical distribution of the calciturbidite point-count analysis along the Lacke section.

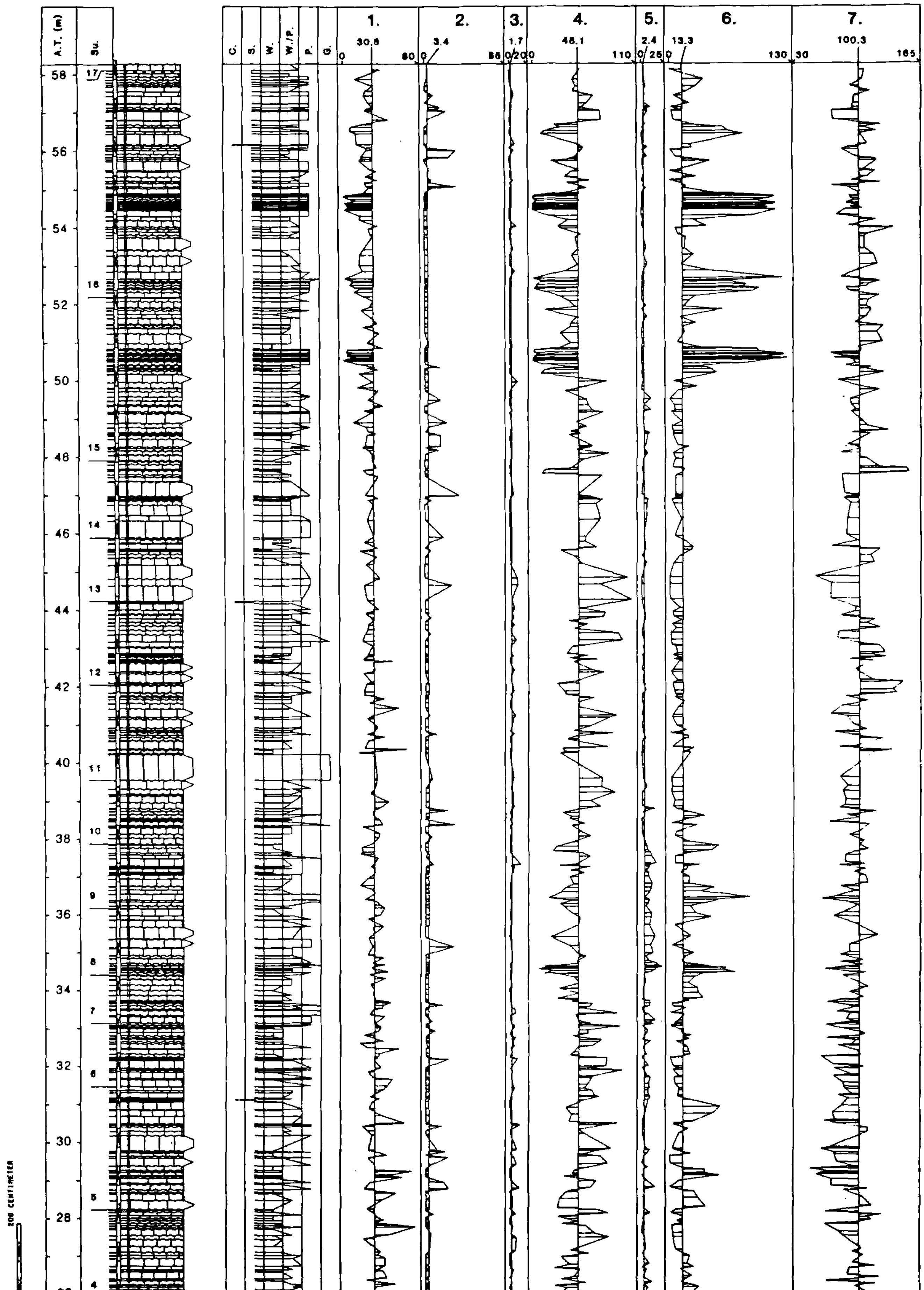


Fig. 2, part 2. Vertical distribution of the calciturbidite point-count analysis along the Lacke section.

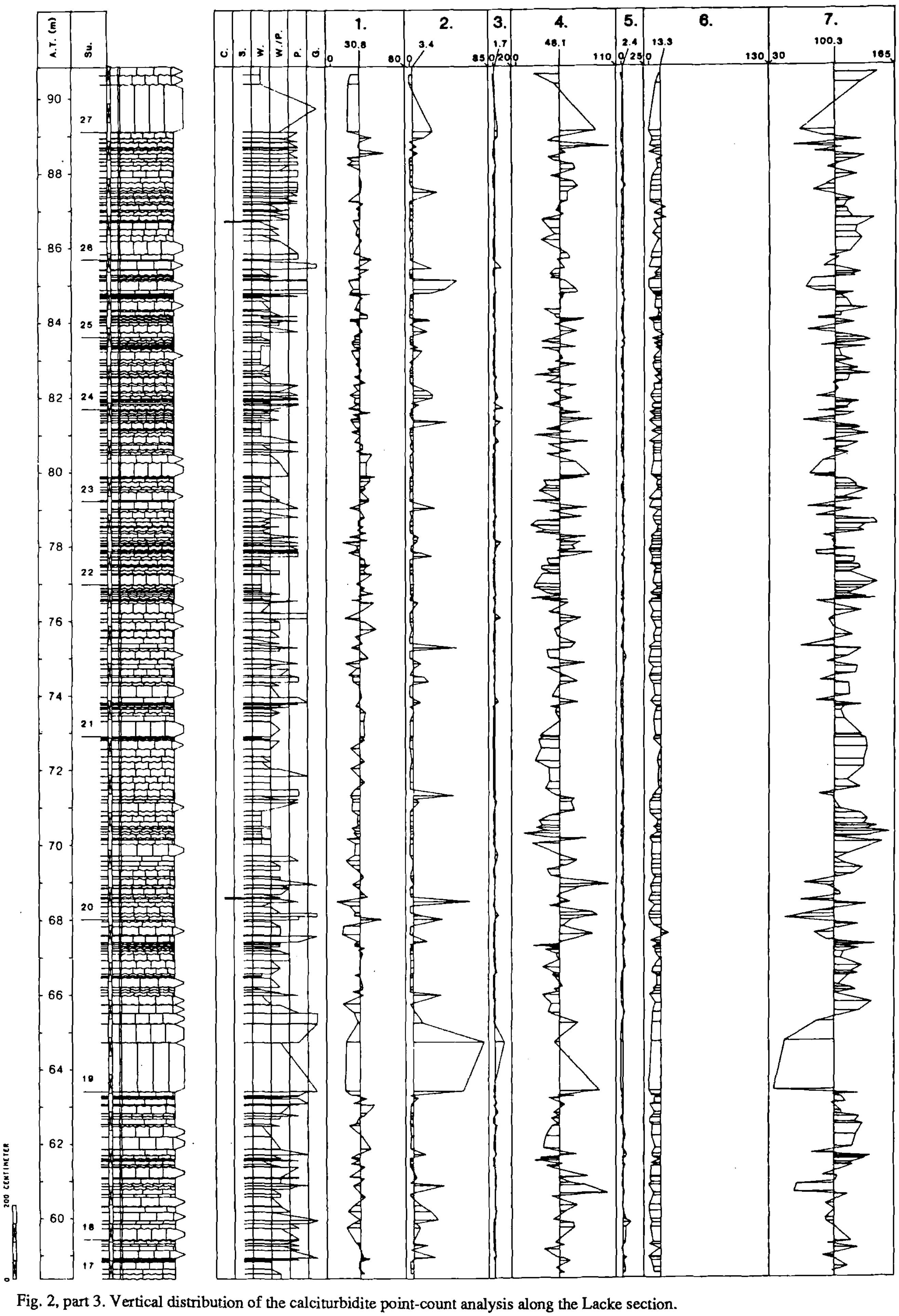


Fig. 2, part 3. Vertical distribution of the calciturbidite point-count analysis along the Lacke section.

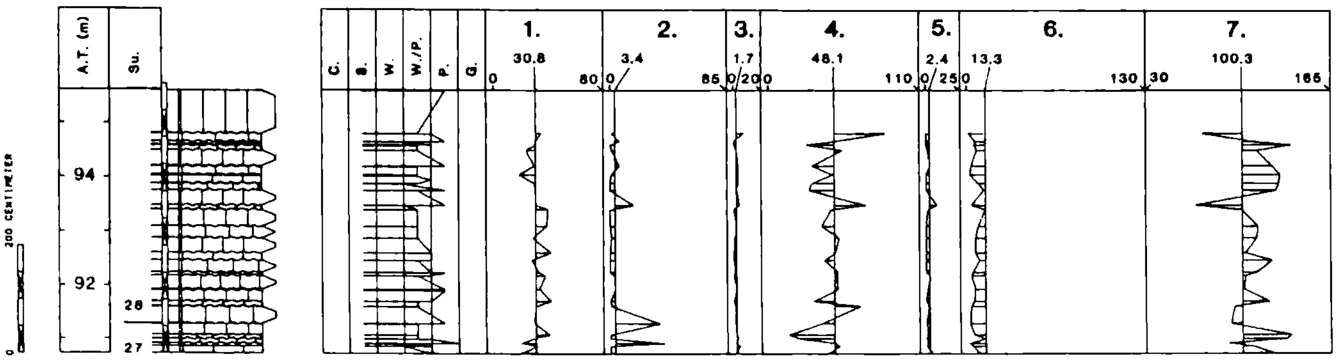


Fig. 2, part 4. Vertical distribution of the calciturbidite point-count analysis along the Lacke section.

Alaunian and Sevatian 1 is present and at the top of the outcrop (80 - 90 m above the top of the analyzed section) the Sevatian 1 to 2 transition was found (L. KRYSTYN pers. comm.).

1.2 Paleogeography

The sediments in the Lacke section represent the basinal equivalent of the platform limestones of the Dachstein Formation and are lithostratigraphically attributed to the Pötschen Schichten (SCHLAGER 1966) or Pedata Schichten (TOLLMANN 1976). The transition from the basinal Hallstatt facies, the Pedata/Pötschen Schichten, to the facies of the platform, the Dachstein facies, was demonstrated in the Gosaukamm area by GANSS et al. (1954), SCHLAGER (1967) and MATZNER (1986) and in the Totes Gebirge area by SCHÖLLNBERGER (1973). TOLLMANN & KRISTAN-TOLLMANN (1970) and TOLLMANN (1976) though, interpret the contact between the basinal and the slope sediments in the Gosaukamm area as purely tectonic. The contact between slope and basinal sediments in the Lacke section is visible at the top of the section (Pl. 63/3) and is in our opinion stratigraphically undisturbed.

2 METHODS

2.1 Field measurements

The field procedure in the Lacke section started with visually dividing the sequence into subsets based on the weathering profile and thinning and/or thickening upward trends. Then, bedding thicknesses were measured and lithologies described using the classification scheme of DUNHAM (1962). Next, grain size and bedding characteristics were determined and the presence and size of chert layers or nodules noted. The field procedure ended with sampling the top and bottom of each calciturbidite bed. In calciturbidite beds thicker than 30 cm an additional sample was taken from the middle part. The green-yellow calcisiltites, the thin intercalations between the calciturbidites, were also sampled if possible.

2.2 Thin-section analysis

In the 95 m of the section 810 individual calciturbidite beds were present (Fig. 2; Pl. 63/1 - 5). In total 810 thin-sections were made of the coarsest part of the calciturbidite layers, usually from the base but occasionally at a higher level, and 747 were subsequently point-counted. Sixty-three beds (7.8 %) were eliminated from the analysis because of strong chertification or dolomitization.

First a pilot study was executed on the first 35 m with mainly biota based point-count groups, and counting 400 points per thin-section. On the basis of the statistical calculations performed on these data, new point-count groups were developed. In each thin-section 200 points were counted. Counting was performed volumetrically, i.e. grains were counted once or more often according to their size. REIJMER et al. (subm.) reported on the first results in the lower 35 m section using 200 points, volumetrical, method.

2.3 Numerical methods

To analyse the results of the point-counting of the 747 samples on the seven point-count groups several numerical procedures were used. Although most of the numerical methods were also used in the pilot study (400 points) to determine the relevance of the point-count groups, only the result of the correspondence analysis on these data will be shown here (see Fig. 3).

2.3.1 Summary statistics

A general impression of the statistical behaviour of individual point-count groups within the population was obtained by calculating summary statistics. Calculations were performed with the program BASTAT (SPRENGER & TEN KATE 1990), which can process a multidimensional data array in which missing values are allowed. BASTAT calculates for each variable among others: the range (minimum and maximum values), measures of location (mean, median and mode), measures of dispersion (variance, standard deviation and coefficient of variation), measures of shape (skewness and kurtosis), a test of normality and 95 % confidence limits about the population mean and variance. The variation of each variable along the section is available through the coefficients of variation (see Table 3). Furthermore histograms were computed and plotted (see Fig. 5).

The point-counts were not discretely distributed resulting in a functional relationship between the mean and variance parameters. Spearman's rank correlation coefficient was calculated as an alternative coefficient to express the rela-

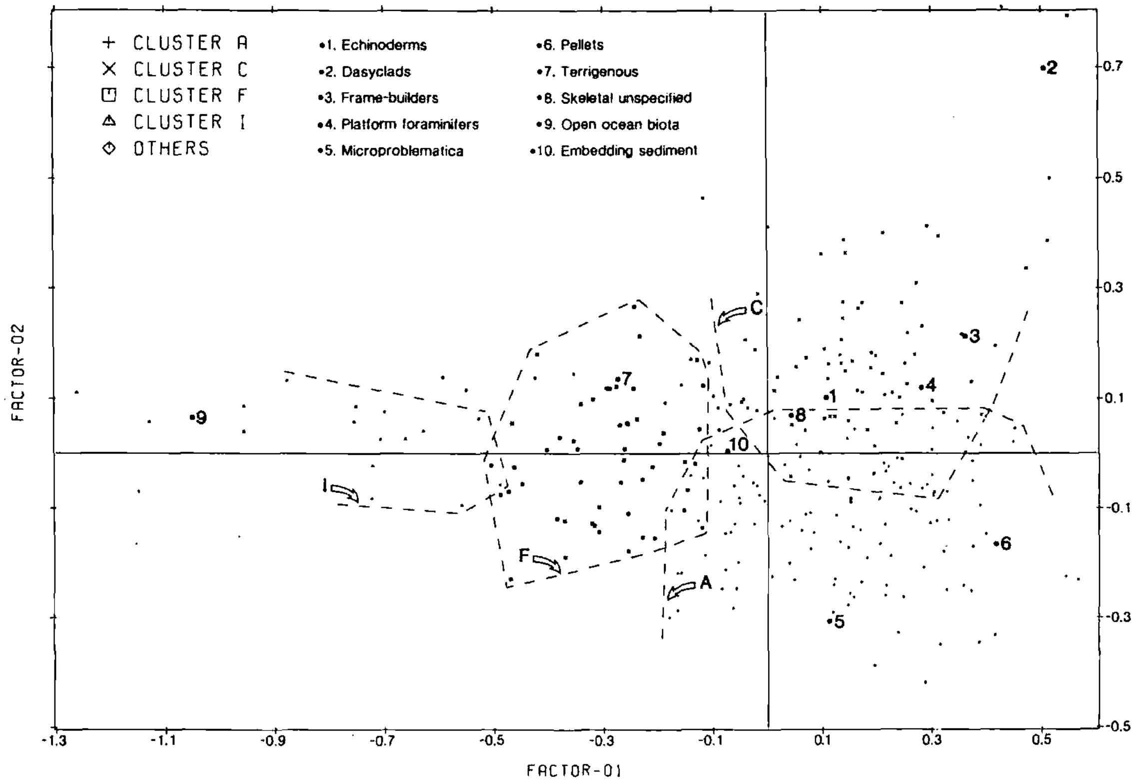


Fig. 3. The projection of sample points and variables used in the first point-count analysis, on the plane through the first and second factor axis of correspondence analysis. The two axes explain 56.5 % of the total variation in the dataset. Samples belonging to the same cluster were denoted by an identical symbol (which is not very visible at this format).

tionship between the point-count groups (Stata 1986) (see Table 3), displaying the similarity between two sets of measurements (Davis 1986).

2.3.2 Numerical classification

To see whether the set of samples is classifiable in clusters determined by a characteristic combination of variables, two methods of numerical classification are applied: 1) Dynamic Cluster Analysis (DYCLAN) designed by Diday (1973) and programmed by Bochi (1973) and 2) Correspondence analysis (CORRES), as proposed by Benzecri (1973). These methods are complementary for they both use the Chi-square distance as a measure of similarity.

DYCLAN looks at the grouping of the samples into subsets and clusters. The connection at various hierarchical levels among these subsets is expressed in a dendrogram. The horizontal scale measures the similarity. When subsets follow the same path in the dendrogram, the similarity increases from left to right (see Fig. 6).

CORRES is a form of principal component analysis combining Q and R mode. It illustrates graphically the connection between samples and variables. DYCLAN produces discrete clusters whereas CORRES is an ordination technique in which samples and variables are expressed in a continuous space of minimum dimensions, spanned by the factor axes (eigenvectors). Factor axes are orthogonal and arranged in decreasing order of importance. In general, a small number of independent eigenvectors can explain a large part of the total variation of the dataset (see Table 6). The degree in which a variable or sample is represented by a factor axis is measured by its relative contribution to a particular axis. The absolute contributions measure the degree in which the various variables/samples contribute to a particular factor axis. The clusters produced by DYCLAN can be displayed in the factor plots by attributing the same symbol to samples within the same cluster (see Fig. 7). In this way the results of both classifying methods are visible.

2.4 Point-count group definition

2.4.1 The pilot study

The division into point-count groups as described in the main part of this report resulted from a pilot study on the lower 35 m of the Lacke section. In this pilot study we used biota groups as a basis for the point-count groups. The division was derived from an extensive literature study and is described in the following section. Apart from biota, specific grains with a genetically related origin or non-diagnostic grains were lumped in separate point-count groups (groups 6, 7, 8, and 10). Numerical analysis showed their applicability in developing new point-count groups (Fig. 3).

1. Echinoderms (Pl. 66/8).

This group includes all grains of echinoderm spar, dominated by the remains of crinoids, echinoderms and holothurians. These organisms are assumed to have lived mainly in normal marine environments on the platform and, in minor numbers, on the slope (Pantic & Rampnoux 1972; Lobitzer 1975; Piller 1976; Dullo 1980; Sadati 1981; Senowbari-Daryan et al. 1982; Wurm 1982).

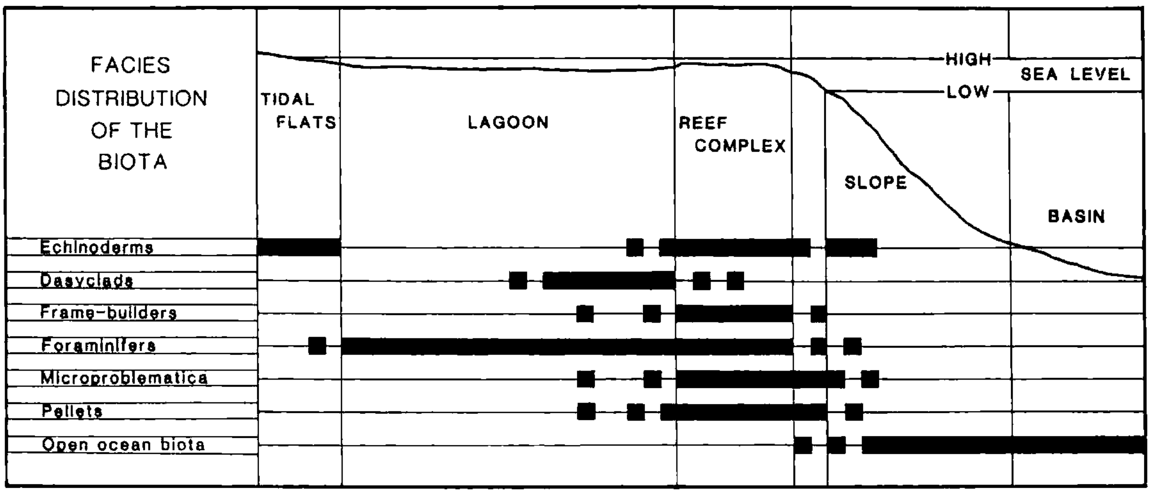


Fig. 4. Biofacies model indicating the paleofacies distribution of the main biota groups. The point-count groups used in the 95 m analysis are derived from these biota groups, based on their most likely occurrence on the platform-to-basin transition. High and low sea level in this figure indicate the highstands and lowstands which flood and expose the platform over a long period. the conversion from biota groups towards facies-oriented groups is shown in Table 1.

2. Dasyclads (Pl. 64/1).

All dasyclads as described by Flügel (1977) are included in this group. Their main habitat was the platform interior behind the reef belt, including restricted environments (Zankl 1969; Flügel 1975; Wilson 1975; Piller 1976; Abate et al. 1977; Piller & Lobitzer 1979; Dullo 1980; Senowbari-Daryan 1980; Gaetani et al. 1981; Goldhammer 1987; Harris 1988). Dasyclads are also encountered in the reef complex, but are of minor importance in this environment (Flügel 1979).

3. Frame-builders (Pl. 64/2-5).

This group comprises Solenoporaceans, calcisponges (sphinctozoans, inozoans), Porostromata, corals, hydrozoa and bryozoa. The environment inhabited by this diverse group is restricted to the lagoonal patch reefs, the reef belt along the platform margin, and, possibly, mounds in the photic environments of the upper slope (Fabricius 1966; Pantic & Rampnoux 1972; Wilson 1975; Abate et al. 1977; Piller & Lobitzer 1979; Dullo 1980; Senowbari-Daryan 1980; Sadati 1981; Flügel 1981, 1982a; Schäfer & Senowbari-Daryan 1982; Senowbari-Daryan et al. 1982; Fois & Gaetani 1984; Böhm 1986; Hagemeister 1988; Riedel 1988; Stanton & Flügel 1989).

4. Foraminifers (Pl. 65/1-15).

This group contains foraminifers of all sorts occurring in a variety of environments ranging from inner lagoon to upper slope, but mainly on the platform proper. These foraminifers can be used as facies indicators for lagoon, backreef, reef complex and forereef environments when determined to the level of genus or species (Hohenegger & Lobitzer 1971; Hohenegger 1974; Hohenegger & Piller 1975a, b; Piller 1978; Salaj et al. 1983). The genera distinguished in this analysis and presumed to be facies indicators are : 1) Inner lagoon with *Aulotortus* sp.; 2) Reef belt at the platform margin with *Alpinophragmium* sp., *Glomospirella* sp., *Glomospira* sp. (Senowbari-Daryan 1980), *Kaeveria* sp., *Sigmoilina* sp., *Galeanella* sp. and other, often sessile foraminifers; 3) Open ocean environment with thin shelled Nodosariids, thin shelled agglutinants and *Lenticulina* sp.

5. Microproblematica (Pl. 66/1-9).

This point-count group covers sessile and hemisessile biota such as: *Baccanella, Bacinella, Cheilosporites, Microtubus, Radiomura, Thaumatoporella, Tubiphytes*, among others (for an extended summary see Senowbari-Daryan 1980). The habitat of the microproblematica was discussed by Wurm (1982) and Senowbari-Daryan (1980). One group, including *Radiomura, Microtubus*, and *Baccanella* lives in open marine, but slightly protected (muddy) environments, such as the muddy parts of the reef core and the deep forereef. Another group, with *Tubiphytes, Lithocodium, Bacinella* and *Thaumatoporella*, prefers the very shallow environment of the platform top. The maximum occurrence of *Tubiphytes, Lithocodium* and *Bacinella* seems to lie in open marine, agitated environments, such as the sands around the reef patches and the oncolitic backreef apron, whereas *Thaumatoporella* occurs most abundantly in the (slightly) protected platform interior, i.e. in birdseye muds and grapestone sands (Pantic & Rampnoux 1972; Piller 1976; Abate et al. 1977; Sadati 1981; Flügel 1982a; Senowbari-Daryan et al. 1982; Wurm 1982).

6. Pellets and ooids (Pl. 67/1-2).

Also present in the Pedata/Pötschen turbidites are small micrite clasts and pellets s. l. (Pl. 68/2-4), that, although not biologic, were lumped on the basis of their distribution on the platform. They are representatives of the intraclasts, micritized bioclasts and reworked cemented micrite from the platform (Flügel 1982b; Stanton & Flügel 1989). Reid (1987) described micrite clasts as peloidal sediments and crusts that occur in spaces between framebuilders in the reef. These peloids are interpreted to be precipitates, possibly resulting from bacterial activity (Macintyre 1985; Chafetz 1986). Another, but very minor, constituent within this category are ooids. Also included in this group are peeled and curled mud chips, originally dried and curled thin films of lime mud and raised layers of algae. They were buried rapidly by sediment or redeposited in nearby channels and rills as intraclasts (SHINN et al. 1969).

7. Terrigenous detritus.

This category is formed by very fine to fine silt-sized quartz grains together with dolomite and calcite clasts. Platform-derived carbonate lithoclasts are included here as a minor constituent, but became more abundant higher in the section. During the pilot study their origin could not be determined so they were lumped together in this group. In the main study the clasts were to be counted in a separate group from the quartz grains which were then included in the open biota group.

8. Skeletal grains, unspecified.

This group covers the poorly preserved grains that could not be assigned to one of the above mentioned biota groups, but were clearly of biogenic origin.

9. Open ocean biota (Pl. 66/10 and 67/3-5).

The group of the open ocean biota contains genetically unrelated biota, that share a similar paleogeographic distribution. The thin shelled bivalves ('filaments') of the *Halobia-Posidonia* group are the main constituent of this point-count group. The living environment of these biota is subtidal to bathyal (ZANKL 1971; GRUBER 1977; FLÜGEL 1982a). Radiolaria as well as *Globochaete* are also included in this group because of their predominant occurrence in deep-water limestones (FLÜGEL 1982a).

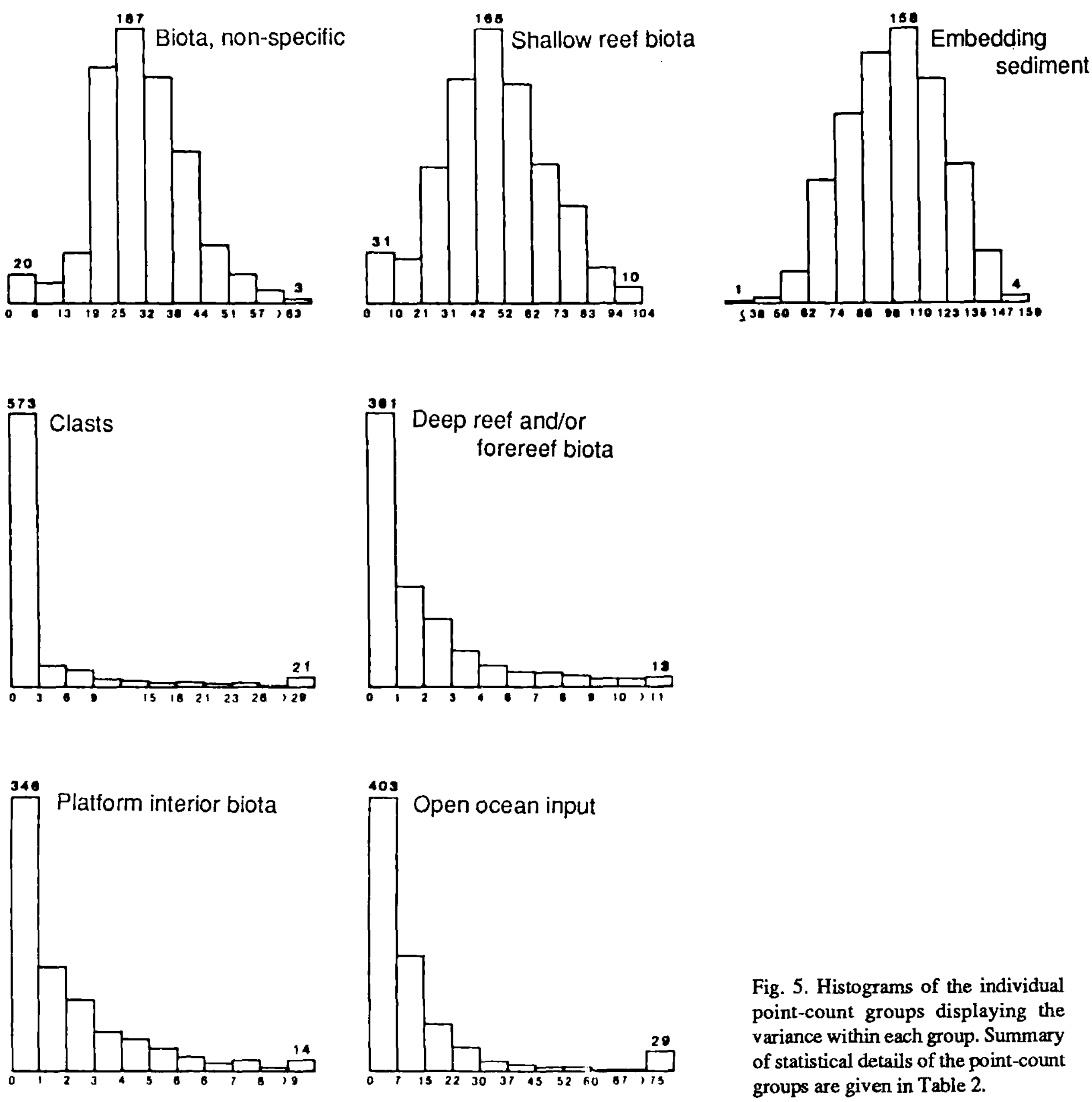


Fig. 5. Histograms of the individual point-count groups displaying the variance within each group. Summary of statistical details of the point-count groups are given in Table 2.

10. Embedding sediment and cement (matrix).

Micrite and, in minor quantities, sparite are counted in this volumetrically important category. This group is also separated from the others to decrease the strong negative correlations between the groups occurring as a result of the counting method and because their relation to the depositional processes is hard to determine.

The range of the biota groups, 1 to 6 and 9, on platform and basin is schematically shown in Fig. 4. High and low sea level in this figure point to the large-scale high- and lowstands that flood or expose the platform. In the pilot study 400 points per thin section were counted.

During the pilot study cluster- and correspondence analysis was performed on the counting results as well as on the point-count groups, to show their relevance for the later division into paleoenvironment-based point-count groups (Fig. 3). The biota groups enabled a clustering of the samples into clearly separate clusters, each characterized by environmentally significant species or grains. The correspondence plot shows that the factor axes have an environmental, instead of just a biological, meaning and the cluster plot on these axes in a significant way grading from open ocean input on the left to the platform input on the other side of the plot.

2.4.2 Point-count groups of the 95-m section

Based on the numerical analysis of the pilot study it was decided to analyse the thin-sections of the total profile using new point-count groups based on paleoenvironment. The new point-count groups characterize particular paleoenvironments, i.e. lagoon, reef complex, and basin or represent a common origin. Biota and other grains were allotted to these groups or to their common origin. The conversion from the old groups to the new is summarized in Table 1, and when relevant described in the next section. The validity and relevance of the new point-count groups is shown in Reijmer et al. (subm.) in their analysis of the point-count from the first 35 m.

THIS PAPER \ PILOT STUDY	Echinoderms	Dasyclads	Frame-builders	Foraminifers	Microproblematica	Pellets and ooids	Terrigeneous detritus	Skeletal grains, unspecified	Open ocean biota	Embedding sediment and cement (matrix)
Biota, non-specific	●			●				●		
Clasts							●			
Platform interior biota		●		●	●	●				
Shallow reef biota			●	●	●	●				
Deep reef and/ or fore reef biota					●					
Open ocean input				●			●		●	
Embedding sediment										●

Table 1. Conversion from the biota oriented point-count groups of the pilot study towards the facies oriented point-count groups used in this analysis.

1. Biota, non-specific.

Biota that are not characteristic for a certain paleoenvironment are incorporated in this point-count group. It includes unspecified skeletal material, echinoderms and crinoids as well as non-facies diagnostic foraminifers and microproblematica.

2. Clasts.

The grains incorporated in this group consist of so-called intra-reef clasts (Reid 1987), cemented clasts and lithoclasts with among others, mud and echinoderm fragments (Pl. 68/3-4). This group was included in the terrigenous input group in the first 35 m, but increased occurrence and importance higher in the section warranted the formation of a separate group.

3. Platform interior biota.

This group comprises the platform foraminifers like *Aulotortus* sp. (Pl. 65/9), *Triasina* sp. (Pl. 65/3, 4), the microproblematicum *Thaumatoporella* (Pl. 66/4). Dasyclads and the rare ooids (Pl. 67/2) have been allotted to this group as well.

4. Shallow reef biota.

This group contains frame building biota, the microproblematica *Tubiphytes*, *Lithocodium* and *Bacinella*, the

Variables	1. Biota, non-specific	2. Clasts	3. Platform interior biota	4. Shallow reef biota	5. Deep reef or forereef biota	6. Open ocean input	7. Embedding sediment
Minimum value	0	0	0	0	0	0	35
Maximum value	74	80	15	104	21	124	159
Mean value	30.77	3.43	1.69	48.14	2.38	13.32	100.25
Median value	30.18	1.91	1.11	47.81	1.21	6.93	100.43
Modal value	28.11	1.53	0.57	46.55	0.68	4.74	102.27
Variance	117.59	74.62	6.22	407.87	8.35	419.28	435.63
Standard deviation	10.84	8.64	2.49	20.20	2.75	19.49	19.86
Coeff. of variation	35.23	251.96	147.32	41.95	121.20	153.71	20.82
Skewness	0.14	3.84	2.17	0.03	2.13	3.22	-0.04
Kurtosis	0.87	18.95	5.58	0.00	6.0	11.10	-0.45

Table 2. Summary of the basic statistics of the 7 point-count groups analyzed in 743 thin sections. In each thin section 200 points were counted. Numbers in combination with the names at the top of the table denote the different point-count groups.

	1.	2.	3.	4.	5.	6.	7.
1. Biota, non-specific	1.00						
2. Clasts	-0.18	1.00					
3. Platform interior biota	0.02	0.25	1.00				
4. Shallow reef biota	0.08	0.35	<u>0.54</u>	1.00			
5. Deep reef or forereef biota	0.03	0.05	0.08	0.18	1.00		
6. Open ocean input	-0.06	<u>-0.46</u>	<u>-0.50</u>	<u>-0.63</u>	-0.06	1.00	
7. Embedding sediment	-0.22	-0.31	<u>-0.41</u>	<u>-0.66</u>	-0.16	0.22	1.00

Table 3. Matrix of Spearman's rank correlation coefficients from the untransformed point-count values of 747 samples. The coefficients that exceed plus or minus 0.40 are underlined.

platform foraminifers *Alpinophragmium* sp. (Pl. 66/1), *Glomospirella* sp., *Glomospira* sp. (SENOWBARI-DARYAN 1980), *Kaeveria* sp., *Sigmoilina* sp. (Pl. 65/1), *Galeanella* sp. (Pl. 65/10-11) and other, often sessile foraminifers (Pl. 65). Pellets s.l. have been counted in this group as well, based on the corresponding environment (Pl. 67/1).

5. Deep reef and/or forereef biota.

The constituents of this group are the microproblematica *Radiomura* (Pl. 66/6-7), *Microtubus, Baccanella, Cheilosporites, Muranella*, and *Lamellitubus*.

6. Open ocean input.

This group includes filaments, Radiolaria, *Globochaete* (Pl. 66/10, 67/3-4) as well as the thin shelled Nodosariids, thin-shelled agglutinants and *Lenticulina* sp., and contains the quartz grains formerly included in the terrigenous input group.

7. Embedding sediment.

The volumetrically important point-count group includes cement and embedding sediment (matrix). An additional reason for lumping them in a separate group is to decrease the strong negative correlations occurring as a result of the counting method.

3 RESULTS

Although looking very similar and monotonous in outcrop (Plate 63/3-6) considerable compositional variation exists in calciturbidites. Measuring and sampling the section very accurately already showed three rough trends in the field (Fig. 2). First, an upward slight increase in micritic beds with thin-shelled pelecypods (open ocean input) was encountered, culminating in three coquinas of Halobiids, 50 - 55 m above the base of the section, subsets 15 and 16. This increase is followed by a sharp decrease, showing a variation of perennial background sedimentation. Second, the occurrence of pronounced or less pronounced bundling in the turbidites. Clear bundling coincides with an increase in calcisiltitic sedimentation between the turbidites, a decrease in thickness and with intervals with many micritic beds, subsets 7 - 14. Third, an increase in the bedding thickness of the calciturbidites combined with a change in grainsize and composition, an increased number of grainstones, is found above the coquina levels. Two thick coarse-grained layers at 64 and 90 m represent the upper limit of the increase in bedding thickness and grainstone occurrence. These two layers probably represent debris-flow sedimentation.

3.1 Summary statistics of composition

The statistical analysis shows considerable variation among the seven point-count groups due to variations in sediment composition of the calciturbidites. We quantified this variation by various statistical measures and plots have been made to show the variation of the point-count groups along the section (Fig. 2 and 5; Table 2-4). For example Figure 2 illustrates the trends along the length of the section. Comparison of the coefficients of variation (relative standard deviations) reveals that platform interior (group 3) in spite of its low standard deviation and modest numbers varies considerably along the section and that embedding sediment, with a high standard deviation, varies the least (Table 2). The highest coefficient of variation is shown by clasts (group 2). Inequality of mean, median and modal values as well as the values of skewness and kurtosis indicate non-symmetrical frequency distributions as shown in the histograms of the point-count groups (Fig. 5).

Some groups seem to co-vary along the section and

<u>Variables</u>	1. Biota, non-specific	2. Clasts	3. Platform interior biota	4. Shallow reef biota	5. Deep reef or forereef biota	6. Open ocean input	7. Embedding sediment
Grand Mean	30.8	3.4	1.7	48.1	2.4	13.3	100.3
1) Lower interval (0-50 m)	34.3	2.3	2.2	53.0	3.1	11.5	93.7
2) Coquina interval (50-55 m)	15.3	0.4	0.3	17.5	0.8	64.9	100.8
3) Upper interval (55-95 m)	28.9	5.5	1.3	47.2	1.8	6.7	108.7

Table 4. Means of the point-count groups per interval : 1) below the coquina level (0 - 50 m). This interval contains 427 calciturbidites of which 394 were pointcounted; 2) the coquina interval itself (50 - 55 m; 57 calciturbidites in total, 4 not analyzed); and 3) the section above the coquinas (55 - 95 m; 326 calciturbidites in total; 26 not analyzed). On the horizontal axis the individual point-count groups are listed and on the vertical axis the different parts of the section. The means of each point-count group over the entire dataset are stated on top of the table.

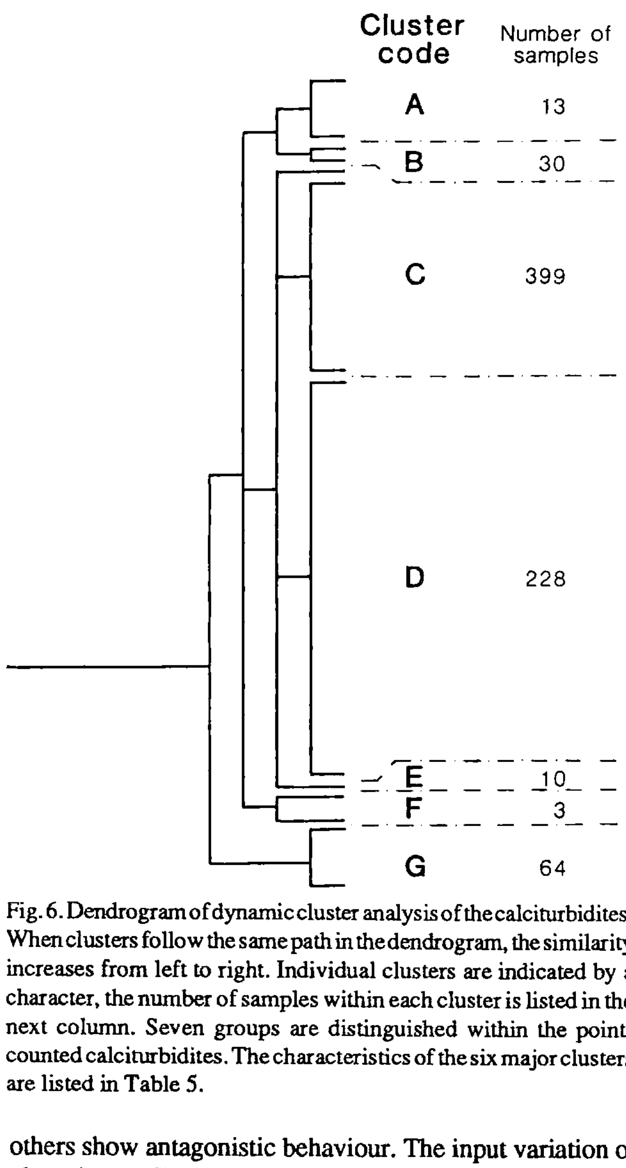


Fig. 6. Dendrogram of dynamic cluster analysis of the calciturbidites. When clusters follow the same path in the dendrogram, the similarity increases from left to right. Individual clusters are indicated by a character, the number of samples within each cluster is listed in the next column. Seven groups are distinguished within the point-counted calciturbidites. The characteristics of the six major clusters are listed in Table 5.

others show antagonistic behaviour. The input variation of clasts (group 2) and frame builders (group 4) for example, is very similar, especially in the top half of the section, while the latter group shows inverse behaviour patterns with open ocean input (group 6; Figs. 2 and 4). As expected, tests on normality were rejected for almost all point-count groups, so an alternative similarity measure was used to calculate a correlation matrix (Table 3). Moderate to high positive correlation (for geological data) are shown by platform interior and shallow reef (0.54), and shallow reef and clasts (0.35). The highest negative correlations are found between the platform input (groups 3 and 4) on the one hand and the open ocean input and the embedding sediment group on the other hand. The neutral behaviour of the deep reef or forereef and that of the non-specific biota is remarkable. The highest correlation is found between embedding sediment and shallow reef input at 43.6 % (= $[-0.66]^2 \times 100$). The discrepancy between the so-called open ocean input and the input of platform-derived grains of biotic origin, clearly shown in the stratigraphic section (Fig. 2), are confirmed in the correlation calculations.

In the middle of the section (at 50 - 55 m) a very characteristic interval is visible containing a high open ocean input. Summary statistics on the input of the point-count groups before and after these coquinas reveals differences in overall input (Table 4). The input of biota non-specific, platform interior, shallow reef, deep reef and open ocean input decreases after this lumachelle together with an increased input of clasts and embedding sediment.

3.2 Numerical analysis of composition

Cluster analysis (by DYCLAN) on the total section yielded seven clusters (Fig. 6). Six clusters (A, B, C, D, E, and G) represent 744 of the 747 samples (99.5 %). The individual clusters can be described by the relative values of one or more point-count groups compared to the overall means (Table 5). The main characteristics of each cluster are best visible in Figure 7 by looking at the plotted distances of the point-count groups and in Table 6. Cluster C, the largest group with 399 samples, shows normal values throughout all variables showing only a slightly higher percentage of embedding sediment (Pl. 68/1). The other groups show tendencies either to the open ocean input or to the platform derived input groups. Cluster A is characterized by high input of open ocean input and deep reef biota and low input of shallow reef and platform interior biota (Pl. 67/6). The highest mean input of open ocean input combined with a minimum of shallow reef and non-specific biota typify cluster B (Pl. 67/7). Cluster D, containing 228 samples, is characterized by high shallow reef and platform interior input and a low input of embedding sediment (Pl. 68/2). Clusters E and G are dominated by high input of platform originated grains like clasts, platform interior and shallow reef biota. Cluster E is more pronounced in that respect than cluster G (Pl. 68/3, 4).

	N	1. Biota, non-specific	2. Clasts	3. Platform interior biota	4. Shallow reef biota	5. Deep reef or forereef biota	6. Open ocean input	7. Embedding sediment
Total	747	30.8	3.4	1.7	48.1	2.4	13.3	100.3
A	13	24.0 -	0.0	0.4 -	20.2 --	5.0 +	55.8 ++	94.5
B	30	7.1 --	0.0	0.0 -	3.8 --	0.1 -	97.5 ++	91.6
C	399	32.1	0.5	0.7	38.4	2.1	12.7	113.5 +
D	228	33.6	1.9	3.2 +	68.4 ++	3.0	4.4	85.5 -
E	10	24.1	12.4 ++	4.8 ++	74.6 ++	1.6	1.6 -	80.9 -
G	64	26.2	27.5 ++	3.1 +	59.3 +	2.8	2.7 -	78.5 -

Table 5. Mean values of the groups/clusters resulting from the dynamic cluster analysis. On the horizontal axis the individual point-count groups are listed and on the vertical axis the different cluster groups. The means of each individual point-count group over the entire dataset are enumerated on top of the table. The symbol after the value of a point-count group within a cluster indicates its relative position towards the overall mean of that specific group (S denotes the standard deviation):
++ : maximum increase : > [mean + 1.0 S (Standard deviation)]
\+ : modest increase : [mean + 0.5 S] to [mean + 1.0 S]
: neutral : [mean - 0.5 S] to [mean + 0.5 S]
\- : modest decrease : [mean - 1.0 S] to [mean - 0.5 S]
-- : maximum decrease : > [mean - 1.0 S]

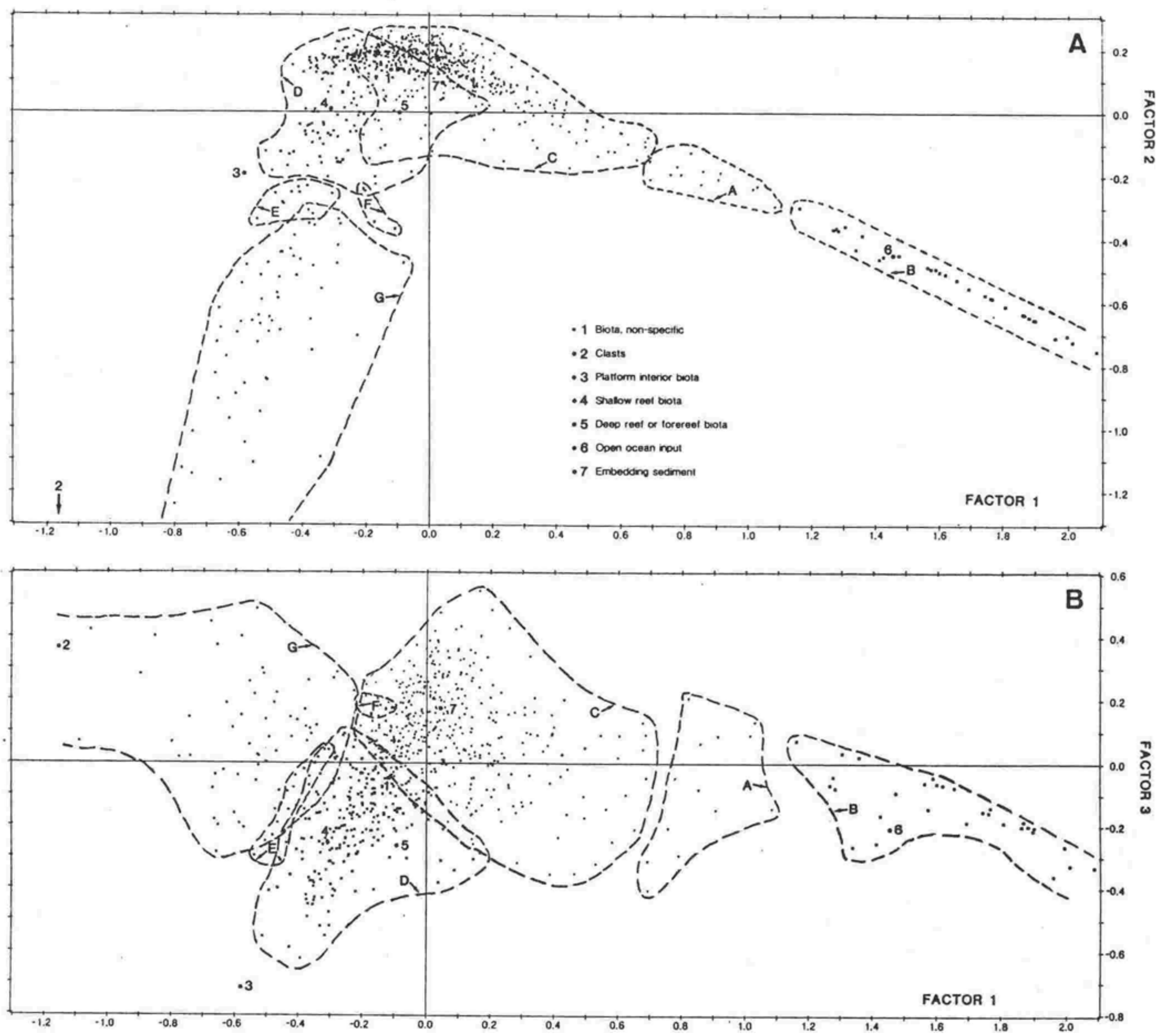


Fig. 7. The projection of sample points and original variables on the plane through the first and second factor axis of correspondence analysis in 7-A and through the first and third factor axis in 7-B. The first two axes explain 74.0 % of the total variation in the dataset. The characteristics of the factor axes and of the variables are shown in Table 6. Samples belonging to the same cluster (Figure 6 and Table 5) have been given an identical symbol (which is not very visible at this format). The contours of the clusters A to G are shown. The factor 2 axis in Fig. 7-A has been cut off at the value of -1.3 and as a result 5 plotted samples are not visible. The projection of variable 2, clasts, has been indicated by an arrow (its true value is -1.156/-2.2048).

According to the classification scheme of WILSON (1975) the sediments of clusters A and B (Pl. 67/6, 7) can be attributed to SMF-3 pelagic lime mudstones (micritic matrix with pelagic microfossils e.g. radiolarians or megafauna e.g. thin shelled bivalves like *Halobia*). These type of sediments are characteristic for the basin and lower slope environments (Facies belts 1 and 3 of WILSON 1975). Clusters D, E and G contain material characteristic for slope environments (Facies belts 3 and 4 of WILSON 1975; Pl. 68/2-4). These slope sediments are described as type SMF-4, microbreccia or bioclastic-lithoclastic packstone (locally derived bioclasts and previously cemented lithoclasts; commonly graded) and type SMF-5, bioclastic grainstone-packstone. The sediments mainly contain organic debris from organisms inhabiting reef top and flank and are deposited on the reef flank. Cluster C shows a dualistic character in its composition. On the one hand cluster C exhibits a suppressed platform interior and shallow reef input and on the other hand a normal open ocean input and no higher deep reef or forereef input (Pl. 68/1). The sediments of cluster C represent turbidites deposited during the transition from one system to another (A-B versus D-G) or turbidites deposited in a system producing so much mud that it dilutes the input of the platform and basin. The distribution of the samples suggests the likelihood of the first explanation, but the second cannot be discarded.

The results of correspondence analysis of the 95 m-section are summarized in Table 6. The first three factors explain about 88 % of the total variation. Factor 1, accounting for 50 % of the total variation, is controlled by the variable groups of open ocean input versus shallow reef biota and clasts. Factor 2, explaining 27 % of the variation, is also loaded with the clast and open ocean input variables (Table

Table 6. Results of correspondence analysis.
A. Listed are the individual factor axes with their eigenvalue followed by the percentage of total variation explained by this axis and the cumulative percentage.
B. The absolute contributions of the individual point-count groups to the first six factors are enumerated in this part of the table. The vertical rows sum up to 100 %.
C. The relative contributions of the point-count groups to the first six factors are shown in this section. The individual rows of each point-count group sum up horizontally to 100 % when all factors are included.
A plot of Factor 1 versus Factor 2 is shown in Figure 7-A and Factor 1 versus 3 in Figure 7-B.

A. Factors

Factor axis	Eigen-value	Percentage of total variation	Cumulative percentage
1.	0.1927	50.08	50.08
2.	0.1041	27.05	77.13
3.	0.0416	10.80	87.93
4.	0.0186	4.84	92.77
5.	0.0164	4.26	97.03
6.	0.0114	2.97	100.00

B. Absolute contributions

Point-count groups	Factor axis 1	Factor axis 2	Factor axis 3	Factor axis 4	Factor axis 5	Factor axis 6
1. Biota, non-specific	1.12	2.65	0.87	36.56	40.90	2.50
2. Clasts	11.90	80.07	5.45	0.60	0.27	0.00
3. Platform interior biota	1.48	0.31	10.46	12.25	0.01	74.65
4. Shallow reef biota	11.89	0.03	38.34	5.90	1.36	18.41
5. Deep reef or forereef b.	0.05	0.00	2.02	39.40	53.64	3.70
6. Open ocean input	73.07	12.86	7.05	0.00	0.25	0.10
7. Embedding sediment	0.48	4.08	35.80	5.29	3.58	0.64

C. Relative contributions

Point-count groups	Factor axis 1	Factor axis 2	Factor axis 3	Factor axis 4	Factor axis 5	Factor axis 6
1. Biota, non-specific	11.33	14.48	1.90	35.66	35.14	1.50
2. Clasts	21.09	76.68	2.08	0.10	0.04	0.00
3. Platform interior biota	15.58	1.74	23.70	12.42	0.00	46.56
4. Shallow reef biota	54.16	0.06	37.67	2.60	0.53	4.98
5. Deep reef or forereef b.	0.59	0.00	4.80	41.92	50.27	2.42
6. Open ocean input	89.59	8.52	1.86	0.00	0.03	0.01
7. Embedding sediment	4.25	19.58	68.59	4.54	2.70	0.34

6-A and -B). Platform interior biota combined with shallow reef biota and embedding sediment contribute mainly to the variation of Factor 3. Factor 4, 5 and 6 are minor contributors to the overall variation. Figure 7 shows plots of the samples on the three main factors that control this dataset. Factor axes intersect each other at the centre of gravity and divide the projections of sample points and variables with an antagonistic relationship. The coordinates of the individual point-count groups indicate their contribution to the variation of the axes (the absolute contribution) (columns in Table 6-B). The relative contributions to the axes by a variable or sample are shown in the rows of Table 6-C. The horseshoe shape of the plotted samples in the plot of Factor 1 versus Factor 2 needs an explanation first (Fig. 7-A). According to literature the reason for this type of plot is the presence of a dependency relation between the main variables that are determining Factors 1 and 2, but does not affect the interpretations of the dataset (Guillaume 1977; Jöreskog et al. 1976). The variation along Factor 1 is mainly controlled by the variation in open ocean input with an antagonistic relationship with the other point-count groups. The variation along Factor 2 is determined by platform interior and clasts combined with basin derived biota versus non-specific biota and embedding sediment (groups 2, 3, and 6 versus 1 and 7). Factor 3 is controlled by embedding sediment and clasts versus biota dominated groups (Fig. 7-B).

Plate 63 The outcrop features of the Lacke section (Norian, Northern Calcareous Alps)

Fig. 1. An overview of the outcrop in which the section analyzed is situated. The length of the person, indicated with an arrow, at the bottom of the picture is 1.82 m. The section researched is indicated with two arrows on the side of the picture. Figs. 3 - 6 show details of the section.

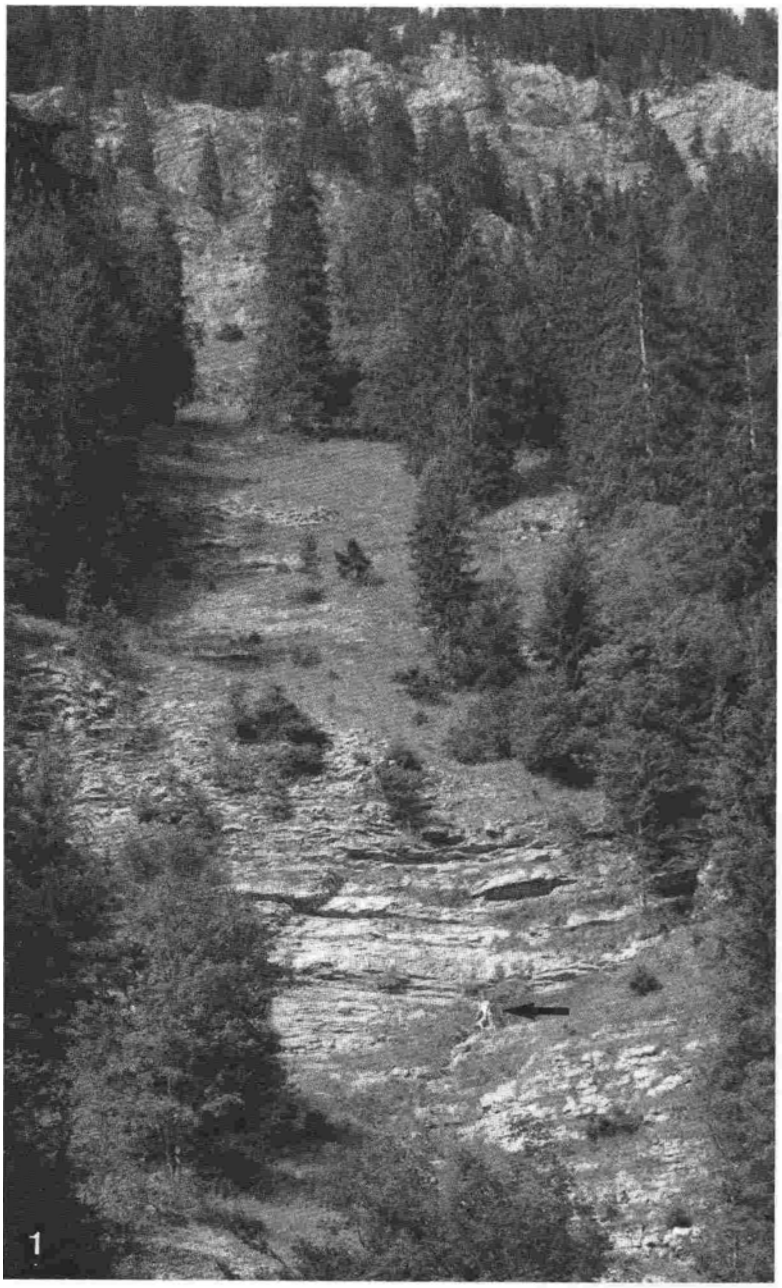
Fig. 2. Schematic drawing of Figure 1, showing the location of the detail photographs Figs. 3 - 6, combined with a scale of the entire outcrop.

Fig. 3. The uppermost part of the outcrop showing the transition between the basinal Pedata/Pötschen Schichten and the prograding slope deposits of the Dachstein Formation. Vertical scale approximately 20 m.

Fig. 4. An overview of the middle part of the succession analyzed (approx. 82 m from base level). Notice the persistence of the individual calciturbidite beds. Hammer for scale.

Fig. 5. Detail of the lithology in the outcrop, showing calciturbidites alternating with marls or calcisiltites. Note the chert layer at the bottom of the picture. Hammer for scale.

Fig. 6. Overview of the middle part of the section (40 - 45 m above base; Subsets 9-11). Vertical scale approx. 5 m.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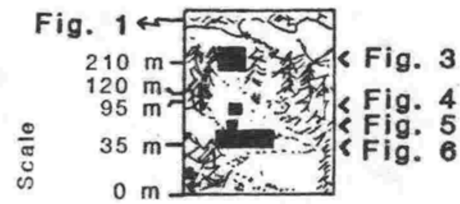
Fig. 1
210 m
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Scale
Fig. 3
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Fig. 5
Fig. 6


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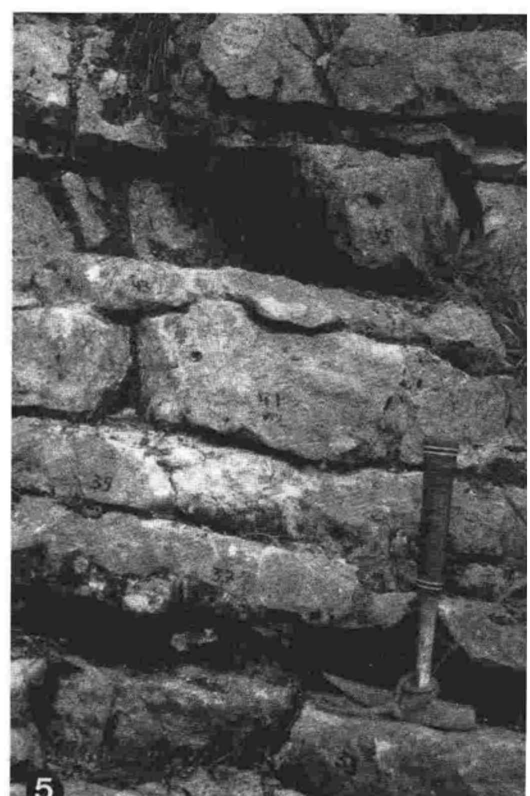
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4 DISCUSSION

The point-counting of the samples and the results of the numerical analyses confirm and amplify the changes observed in the field and add new trends. The subsets recognized in the field do not clearly show up in the numerical analysis, showing the minor relevance of outcrop trends in these sediments.

An explanation for co-variation trends can be found in the fact that different groups of biota are confined to specific environments on the platform (see point-count group definition). For example the lagoon and backreef environment are mainly inhabited by specific platform foraminifers and in a minor sense by dasyclads (point-count group 3; see also Fig. 4), while frame-builders are mainly found along the platform margin (point-count group 4). These two point-count groups, volumetrically dominated by the shallow reef input, co-varied very strongly so in the analysis they were often taken together into one platform group. A totally different environment, the basin, is represented by Radiolaria and 'filaments' (the open ocean biota). In the point-count analysis, the increase of micritic limestones in the field corresponds to a decrease in platform material and an increase in the open ocean input (Fig. 2), which is supported by their negative correlation coefficient (Table 3).

The correlation matrix in Table 3 generally supports the facies model presented in Fig. 4. The only discrepancy is the lack of correlation between the material from the deep reef or forereef and the shallow reef material. Contrary to statements in the literature (e.g. FLÜGEL 1982a, 1982b), we propose a facies model in which the shallow reef biota form patches at the platform top while the microproblematica of deep reef or forereef environment are deep-photic, stabilizing the upper slope, thus reacting to different environmental stimuli. Facies models of the Gosaukamm (WURM 1982) and the Steinplatte (PILLER 1981, STANTON & FLÜGEL 1989) support this interpretation.

In the pilot study terrigenous material (quartz grains) in the samples correlated with the open ocean input and not with the platform input. We conclude that terrigenous material was not transported over the platform but represents input from a basinal circulation containing material from a distant source.

A relative increase of the clasts and input of embedding sediment simultaneous with a decrease in the input of the other grains is found after the coquinas. We propose an explanation of the increase in mud input by a higher production of this material on the platform as a result of more constant flooding of the platform or an environmental change. The increase in clasts can be explained by erosion from an exposed platform or by a superdevelopment of the rim on a flooded platform. We consider the latter as the most likely in view of the simultaneous increase in mud. For the depositional mechanism and timing of the two coarse-grained, clast-rich grainstones at 64 and 90 m, two scenarios can be envisaged. On the one hand the layers may represent an autochthonous carbonate deposit developed during a lowstand in sea level, the autochthonous lowstand wedge of SARG (1988). Or oversteepening caused by superdevelopment of the rim followed by large-scale failure of the upper slope during the transition from a highstand towards a lowstand in sea level (CREVELLO & SCHLAGER 1980, SHANMUGAM & MOIOLA 1984) resulted in the two layers. In view of the composition of the deposits in combination with the trends visible in the section we prefer the second option.

When looking at the plot of the variables on the axes of the correspondence analysis (Fig. 7-A), the relation of the variables to each other becomes clear. It shows the contrast between the open ocean input versus platform biota along Factor axis 1 and the change within the clast input versus embedding sediment and non-specific biota along Factor axis 2. Factor 3 shows the more subtle change between platform interior and shallow reef biota versus embedding sediment. The most likely explanation of the contrast between clusters A-B and D-E-G, is that it signifies the fluctuation between deep water sedimentation and platform derived input. It is the contrast in sediment shed during highstands versus lowstands in sea level. During a highstand the sediment shed by the platform is dominated by shallow reef input from shallow patch reef along the rim together with platform interior input from the lagoon. During lowstands shallow reef and platform interior stopped producing and mainly open ocean biota are found together with some material from deep reefs with microproblematica that continued producing. Factor axes 2 and 3 can be explained as the dilution by mud probably related to changes in productivity or supply of grains. High production of sediments during highstands and low productivity during lowstands of sea level is in analogue to the Quaternary of the Bahamas (DROXLER & SCHLAGER 1985; REIJMER et al. 1988). The difference between the biofacies of the rim and the interior of the platform is less distinct in the Triassic than in

Plate 64 Framebuilding organisms (calcareous algae, hydrozoans, and calcisponges) of the Lacke section (Norian, Northern Calcareous Alps)

Fig. 1. *Clypeina* ? sp. indet. Fragment. (Sample 0.1). x 54

Fig. 2. Segmented calcisponge (Sphinctozoa). Recrystallized specimen. Overgrown by algae. (Sample 19.1). x 16

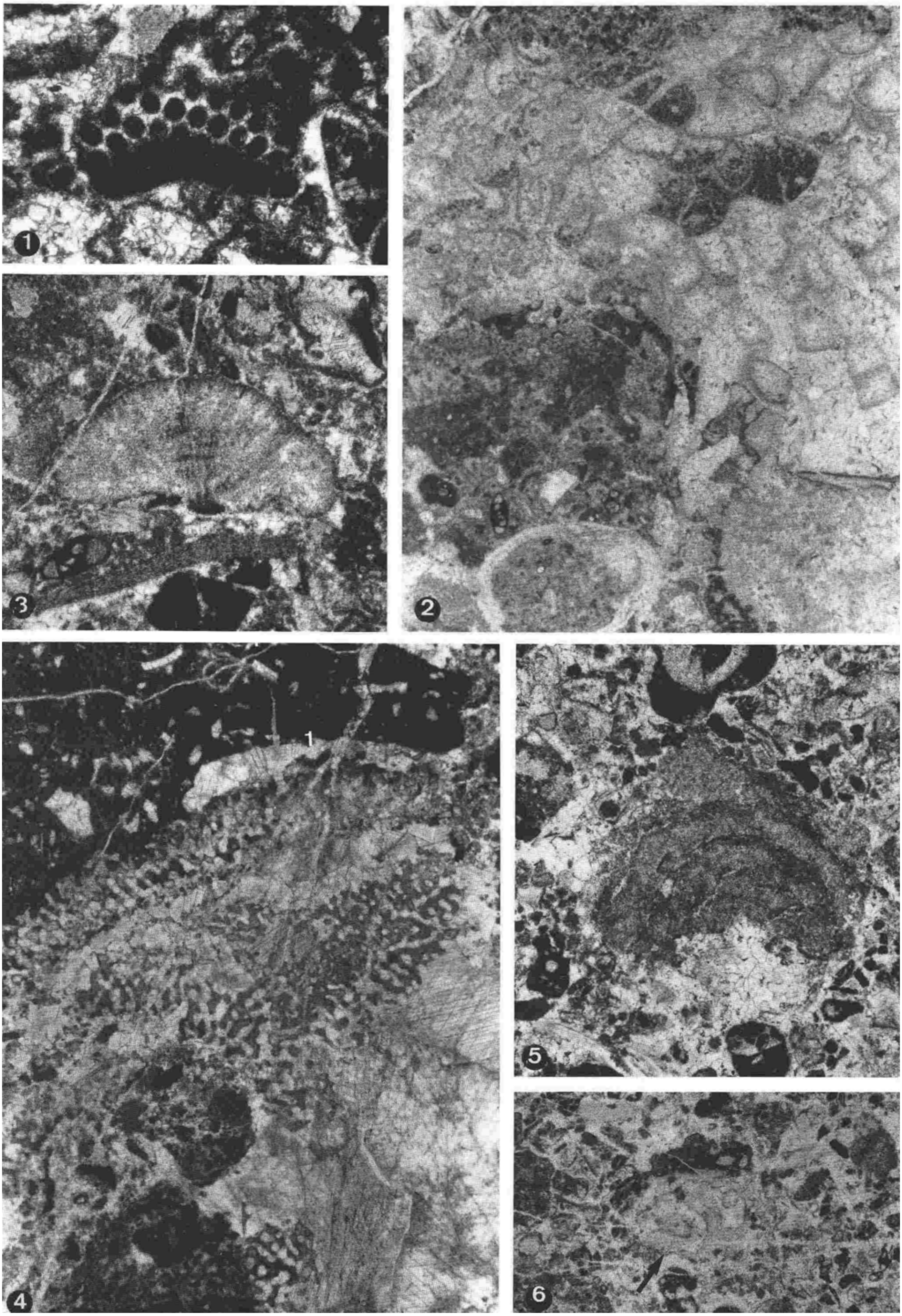
Fig. 3. Porostromate blue-green algae of the type *Cayeuxia/Garwoodia*. (Sample 21.15). x 32

Fig. 4. Hydrozoa. (Sample 19.1). x 16

Fig. 5. *Solenopora* sp. Dome-shaped thallus with growth zones. (Sample 5.3.25). x 20

Fig. 6. Coral. Strongly recrystallized specimen (arrow) encrusted by *Alpinophragmium perforatum*. (Sample 2.63.5). x 12.5

Plate 64



modern day Bahamas, resulting in a more radical discontinuance in the Triassic carbonate production during a lowstand in sea level. The compositional variation present in the calciturbidites gives evidence of this intermittent interruption and can be explained within the proposed scenario.

The large-scale changes in the top of the section after the coquinas need an extra explanation. We propose either (1) a shift in the depositional centre of the turbidite material or (2) sea-level cycles that alternatingly expose and flood the platform top, thus modulating the production and dumping of platform sediment or (3) progradation of the system, the section is situated in a position nearer to the point of production.

The origin of the waxing and waning trends in platform derived or open ocean input probably can be solved by analysis of the periodicity present in the section (REIJMER et al. 1990) and compare this with the periodicity present on the platform, the Lofer cyclothems (FISCHER 1964 and SCHWARZACHER & HAAS 1986).

5 CONCLUDING REMARKS

The analysis of the compositional variation of Upper Triassic calciturbidites revealed an alternation of (1) turbidites with predominantly platform top derived grains (shallow reef and platform interior) and (2) turbidites containing mainly bathyal derived material, planktonic and pseudoplanktonic grains in combination with fine-grained carbonate mud. The observed oscillations within the compositional variation can best be interpreted as the result of exposure and flooding of the platform. With a flooded platform the calciturbidites receive input from the platform top, while input from the slope and basin needs a situation where the platform is exposed and bathyal material is redeposited.

The Lofer cycles, present in the carbonate platform sediments of the Dachstein Formation, display changing facies patterns in response to fluctuations in sea level (FISCHER 1964; SCHWARZACHER & HAAS 1986). The variations in the platform-derived fraction of the calciturbidites may reflect the same sea-level cycles.

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Plate 65 Foraminifera of the Lacke section (Norian, Northern Calcareous Alps)

Fig. 1. '*Sigmiolina*' sp. Geopetal fabric present in the specimen, mud drape. Several stages of cement are present: 1. rim cement on the inside of the chambers and the outer wall of the specimen, 2. blocky calcite filled the chambers in a later stage (Sample 0.1). x 205
Fig. 2. *Pseudocucurbita* BORZA & SAMUEL 1978 (Sample 15.18). x 160
Fig. 3. *Triasina hantkeni*. Micritized (Sample 5.3.25) x 25
Fig. 4. *Triasina hantkeni*. Well preserved specimen (Sample 21.15). x 32
Fig. 5. *Spiriamphorella* sp. (Sample 8.12). x 40
Fig. 6. *Spiriamphorella* sp. (Sample -1.6). x 40
Fig. 7. *Glomospirella* sp. (Sample 2.2). x 40
Fig. 8. *Tetrataxis inflata* KRISTAN (Sample 0.1). x 85
Fig. 9. *Aulotortus* sp. (Sample 0.2). x 110
Fig. 10. *Galeanella* sp. (Sample -2.13). x 40
Fig. 11. *Galeanella* sp. (Sample -1.8). x 40
Fig. 12. *Tetrataxis* sp. (Sample 5.3.31). x 85
Fig. 13. *Nodosaria* sp. (Sample 0.2.). x 110
Fig. 14. Sessile foraminifer. Occurs frequently in central reef areas (SENOWBARI-DARYAN 1980). Sample 16.10. x 40
Fig. 15. *Endothyra* sp. (Sample -2.13). x 40

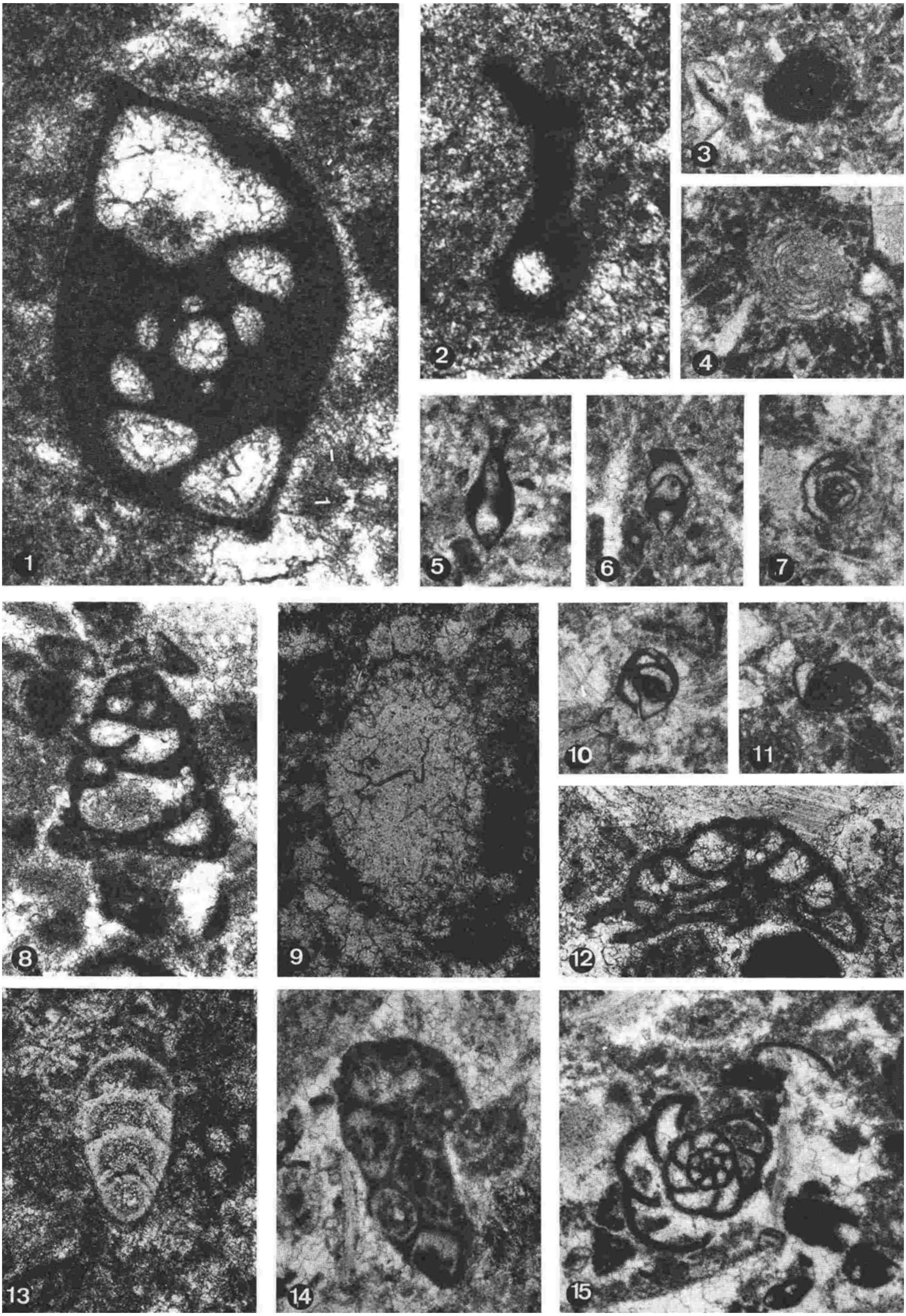
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Plate 66 — Facies-diagnostic foraminifera and microproblematica of the Lacke section (Norian, Northern Calcareous Alps)

Fig. 1. *Alpinophragmium perforatum* FLÜGEL, a very abundant encrusting foraminifera of the reef patches (Sample 3.1). x 40

Fig. 2. Microproblematicum 4 FLÜGEL. Similar structures have been referred to as problematical algae *Thaumatoporella* (STANTON & FLÜGEL 1989), (Sample 6.15). x 160

Fig. 3. Problematicum sp. 2 SCHÄFER 1979 and SENOWBARI-DARYAN 1980, chain-like structure, consisting of double filament. Isolated within the sediment. Might be attributed to bryozoa (Sample 16.105). x 40

Fig. 4. *Thaumatoporella parvovesiculifera* (RAINERI), (Sample 0.2). x 25

Fig. 5. *Lithocodium* ELLIOTT (Sample 22.45). x 40

Fig. 6. *Radiomura cautica*. Foraminifera have been enclosed within the chamber (Sample 0.28). x 110

Fig. 7. Encrusting algae (Sample 22.45). x 40

Fig. 8. *Muranella sphaerica* BORZA. A characteristic microfossil within the sediments of small reef cavities. Note the pressure solution effect visible between the microfossil and the echinoderm fragment (arrow), (Sample 27.1). x 40

Fig. 9. Sphinctozoan ?. An algal crust and *Alpinophragmium perforatum* are surrounding the fragment (Sample 0.12). x 40

Fig. 10. *Globochaete alpina* LOMBARD (Sample -1.8). x 40

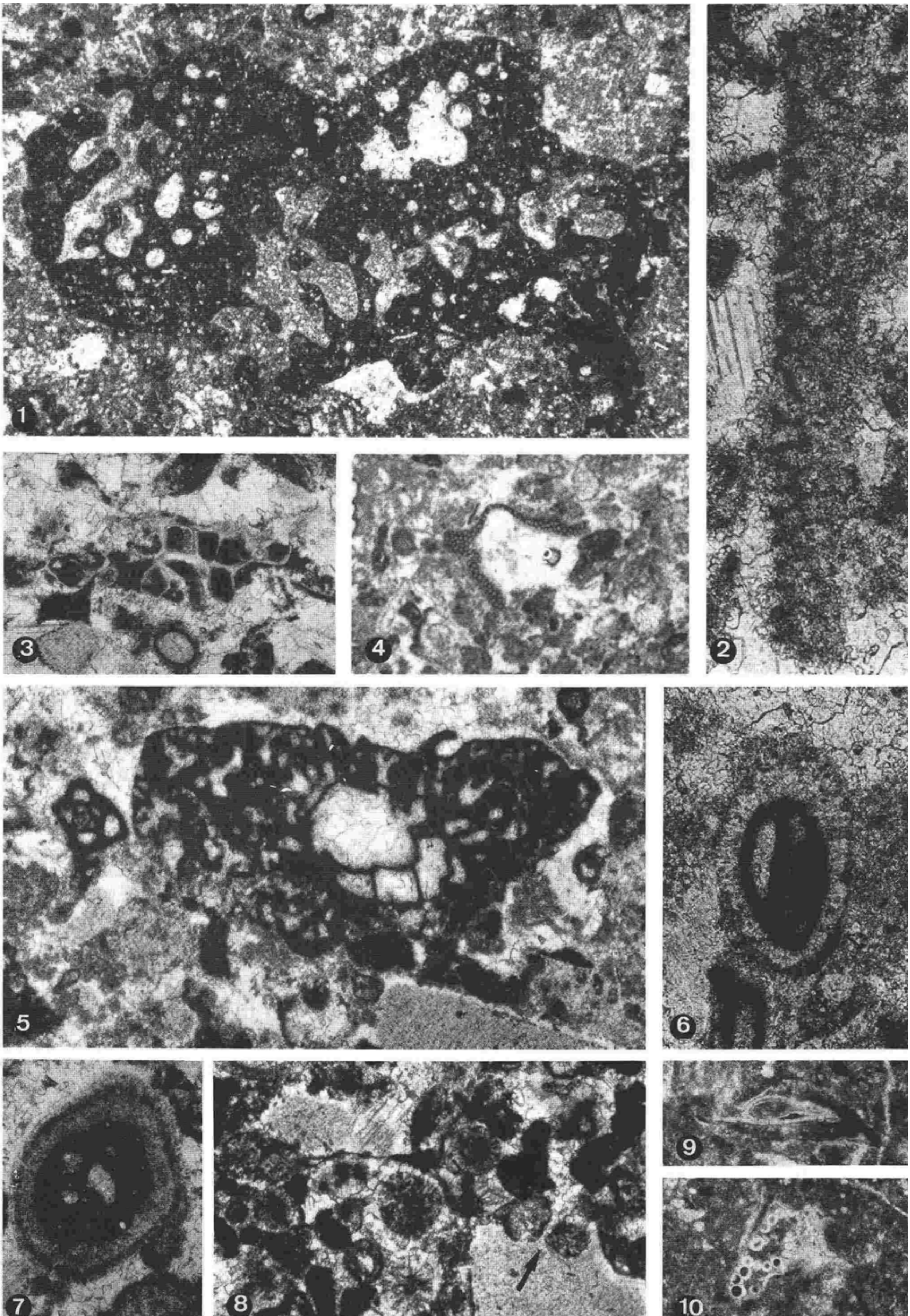
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Plate 67 — Pellets, ooids, pelagic biota and microfacies types A and B of the Lacke section (Norian, Northern Calcareous Alps)

Fig. 1. *Palaxius* sp. (Sample 8.16). x 40
Fig. 2. Tangential structured ooid (Sample 17.15). x 40
Fig. 3. *Globochaete* sp. (Sample 25.17). x 40
Fig. 4. *Globochaete* sp. Crossed nicols (Sample 25.17). x 40
Fig. 5. Pelagic pelecypods. Radiolarians are present (Sample 13.13). x 12.5
Fig. 6. Representative thin-section photomicrograph of cluster A. These calciturbidites show an abundance of filaments combined with increased embedding sediment (Sample 8.3). x 12.5
Fig. 7. Representative thin-section photomicrograph cluster B. Note the occurrence of *Variostoma crassum* KRISTAN (arrow), characteristic foraminifer for the Norian Hallstatt facies. This cluster is characterized by the low proportion of embedding sediment and dominance of open ocean biota (Sample 16.37). x 10

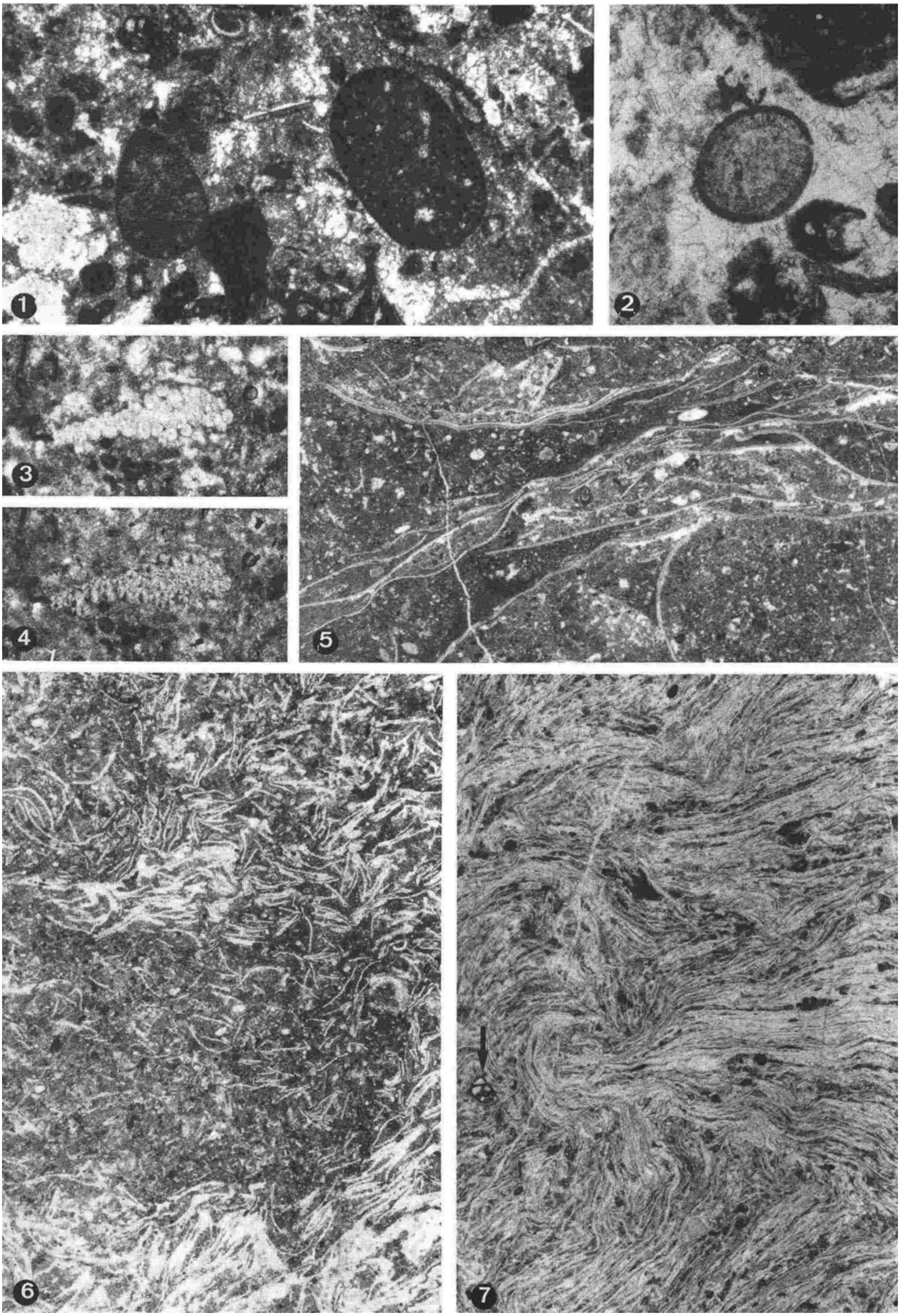

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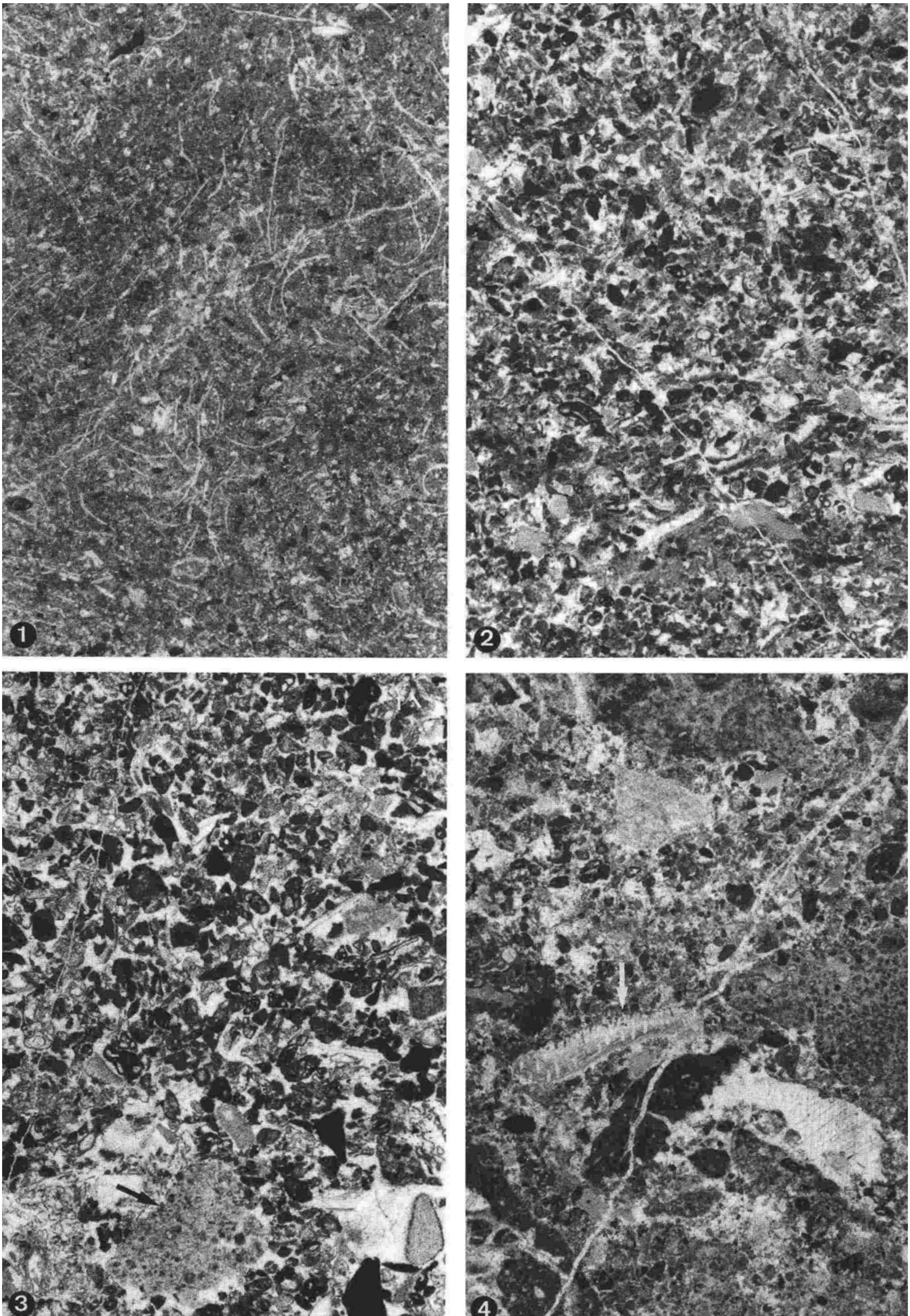
Plate 68 Microfacies types of the Lacke section, clusters C - G (Norian, Northern Calcareous Alps)

Fig. 1. Representative thin-section microphotograph cluster C. Note the high portion of embedding sediment and occurrence of platform as well as open ocean originated grains (Sample 4.19.1). x 12.5

Fig. 2. Representative thin-section photomicrograph cluster D. This large cluster is characterized by an increase in shallow reef and platform interior input and a decrease of embedding sediment (Sample 0.1). x 12.5

Fig. 3. Representative thin-section photomicrograph cluster E. The abundance of platform derived material, especially the relative increase of platform interior grains, is characteristic for this cluster. Some small clasts present (arrow), (Sample 11.17). x 12.5

Fig. 4 Representative thin-section photomicrograph cluster G. Note the abundance of large intrareef and cemented clasts (arrow). Also visible here evidence of boring of the brachiopod fragment with pseudopunctate structure (arrow). Notice the increase in grainsize from cluster D to G (Sample 19.1). x 12.5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