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Facies Analysis of the Cyclic Dachstein Limestone Formation (Upper Triassic) in the Bakony Mountains, Hungary

Fazies-Analyse der zyklischen Dachstein-Kalke (Ober-Trias) des Bakony-Gebirges, Ungarn

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INTERNATIONAL SYMPOSIUM
ON TRIASSIC REEFS

SCHLÜSSELWÖRTER: SEDIMENTOLOGIE - KARBONATGESTEINE - CYCLOTHEME - UNGARN - BAKONY-GEBIRGE
OBER-TRIAS - NOR

SUMMARY

The cyclic development of the lower Dachstein Limestones (Norian) was studied in a 410 m thick sequence intersected by the borehole Porva Po-89 in the northern Bakony Mountains. Deviations from the ideal Lofer cyclothems described by FISCHER (1964) were found for a considerable part of the total of 138 cycles. Because of very slight erosion of the regressive member of the cyclothems (algal mat bed, B') the basic formula of the Hungarian Lofer cyclothems is d - A B C B' - d (see Fig. 1/1). Intracyclic anomalies, minor internal unconformities, or erosion may be responsible for the lack of members; most often member A is absent or strongly reduced. No megacycles comparable with those in the Northern Alps have been found.

The environmental interpretation is based on macroscopic and microscopic facies criteria (see Figs. 1 and 2) and on the comparison with Recent carbonates. The rocks of member A were formed within the supratidal zone and perhaps in the uppermost part of the intertidal zone. Member B was deposited within different parts of the intertidal zone. Carbonates of member C were formed within a shallow, subtidal lagoonal environment. The cyclicity of peritidal sedimentation seems to have been caused not by world-wide eustatic changes in sea-level but rather by minor climatic changes which might have been responsible for slightly changing rates of accumulation and evaporation.

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ZUSAMMENFASSUNG

Die zyklische Entwicklung der unteren Dachstein-Kalke (Nor) wurde in einer 410 m mächtigen, in der Bohrung Porva Po-89 (nördliches Bakony-Gebirge) durchteuften Karbonatfolge untersucht. Hierbei wurden in einem beträchtlichen Teil der 138 Zyklen Abweichungen von dem von FISCHER (1964) beschriebenen Modell der nordalpinen Lofer-Cyclotheme festgestellt: Bedingt durch die nur geringe Erosion des regressiven Gliedes des Cyclothems (Einheit B', Algenmatten-Kalk) wird das generelle Sedimentationsmuster der ungarischen Cyclotheme durch die Formel d - A B C B' - d beschrieben (Abb. 1/1). Einzelne Glieder können ausfallen, veranlaßt durch kleinere interne sedimentäre Diskordanzen oder durch synsedimentäre Erosion; am häufigsten fehlt die Einheit A. Megazyklen, wie sie für die nordalpinen Loferitzyklen postuliert wurden, konnten nicht festgestellt werden. Die Milieuinterpretation stützt sich auf die Auswertung makroskopischer und mikroskopischer Fazieskriterien (Abb. 1 und 2) und auf den Vergleich mit rezenten Karbonaten. Die Gesteine der Einheit A entstanden in der Supratidalzone, möglicherweise auch im obersten Abschnitt der Intertidalzone. Die Einheit B wurde in verschiedenen Bereichen der Intertidalzone gebildet, die Karbonate der Einheit C im flachlagunären Subtidal. Das zyklische Muster der peritidalen Sedimentation dürfte nicht durch weltweite eustatische Meeresspiegelschwankungen verursacht sein, sondern durch kleinere klimatische Schwankungen, welche für wechselnde Raten von Ablagerung und Evaporation verantwortlich gewesen sein könnten.

1 INTRODUCTION

The classical unit of Alpine Triassic described for the first time by PETERS (1854) in the Alps and first referred to as the "Dachstein Limestone Formation" by M. HANTKEN (1861), plays a significant role in the geological construction of the Transdanubian Central Range, and can be followed tracable as far as the Himalayas. Many authors have analyzed the stratigraphy and sedimentology of this formation. However, the environmental interpretation can not be regarded as satisfactory in the light of present-day sedimentological knowledge.

Bore hole Po-89, sunk in 1979 at Porva (northern Bakony Mountains), within the scope of the National Key Section Program, revealed a 410 m thick sequence, representing the lower part of the Dachstein Limestone and the underlying transitional unit between the Dachstein Limestone and the Hauptdolomit. The Dachstein Limestone is Norian in age on the basis of the macro- and microfossils. The objective of the sedimentological studies was a combined analysis of petrographical, geochemical and paleontological data with respect to their importance for facies reconstruction.

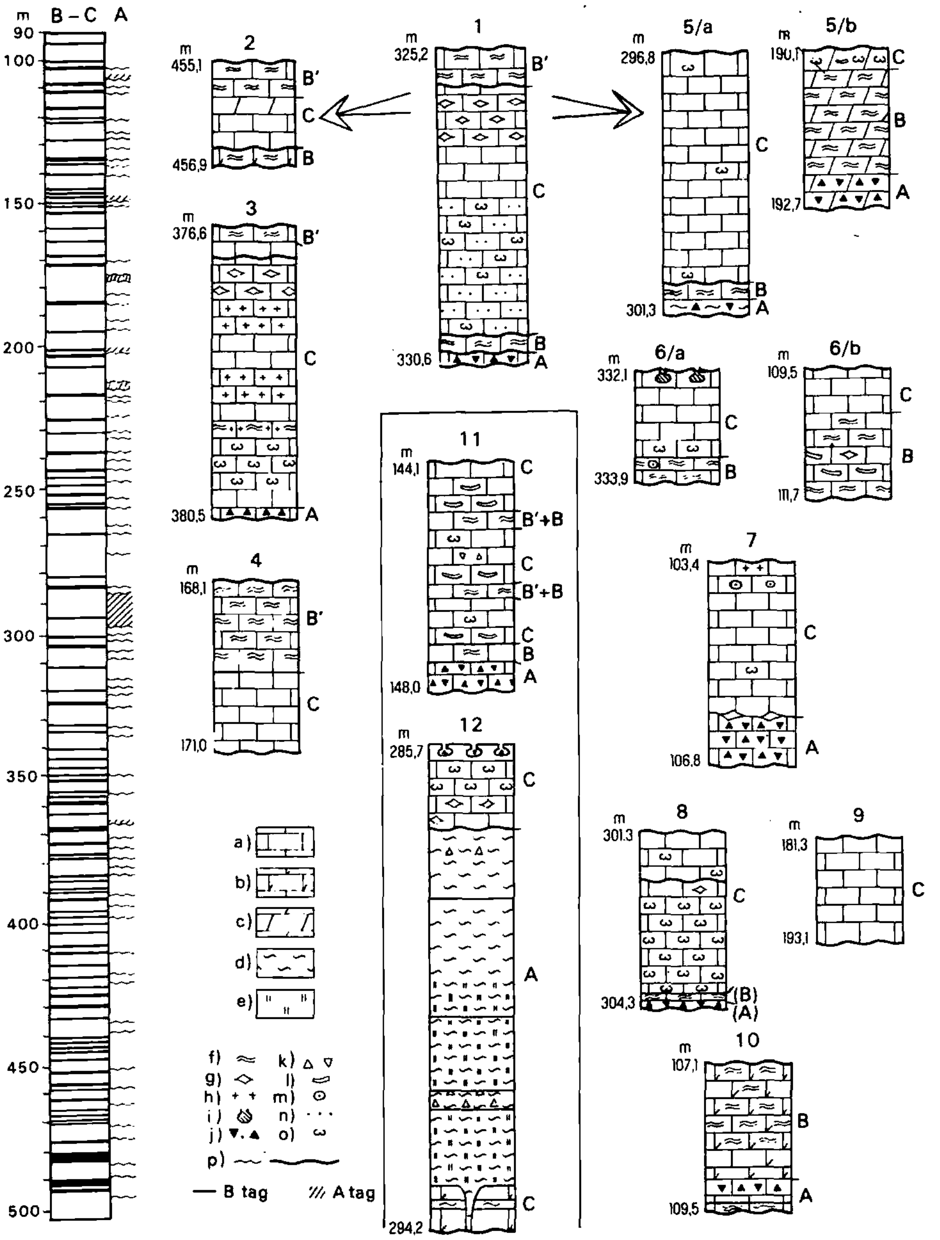

Fig. 1. Triassic section of the bore hole Po-89 (Porva, northern Bakony Mountains). Letters A, B and C indicate the members of the Lofer cyclothems. Legend: a - limestone, b - dolomitic limestone and calcareous dolomite, c - dolomite, d - marl, e - silt, f - algal mat, g - birdseye structures, h - shrinkage pores, i - red argillaceous cavity fillings, j - black intrabreccias, k - light-colored intrabreccias, l - soft pebbles derived from algal mats, m - oncoids, n - microfossils, o - megalodontid pelecypods, p - disconformity.

Trias-Profil der Bohrung Po-89 (Porva, nördlicher Bakony). Die Buchstaben A, B und C bezeichnen die Glieder des Lofer-Cyclothems. Signaturen: a - Kalk, b - dolomitischer Kalk und kalkiger Dolomit, c - Dolomit, d - Mergel, e - Silt, f - Algenmatten, g - Birdseyes-Strukturen, h - Schrumpfporen, i - rotes toniges Internsediment, j - schwarze intraformationelle Brekzien, k - hellgefärbte intraformationelle Brekzien, l - aus Algenmatten ableitbare, im weichen Zustand eingebettete Gerölle, m - Onkoide, n - Mikrofossilien, o - Megalodonten, p - Diskordanz.

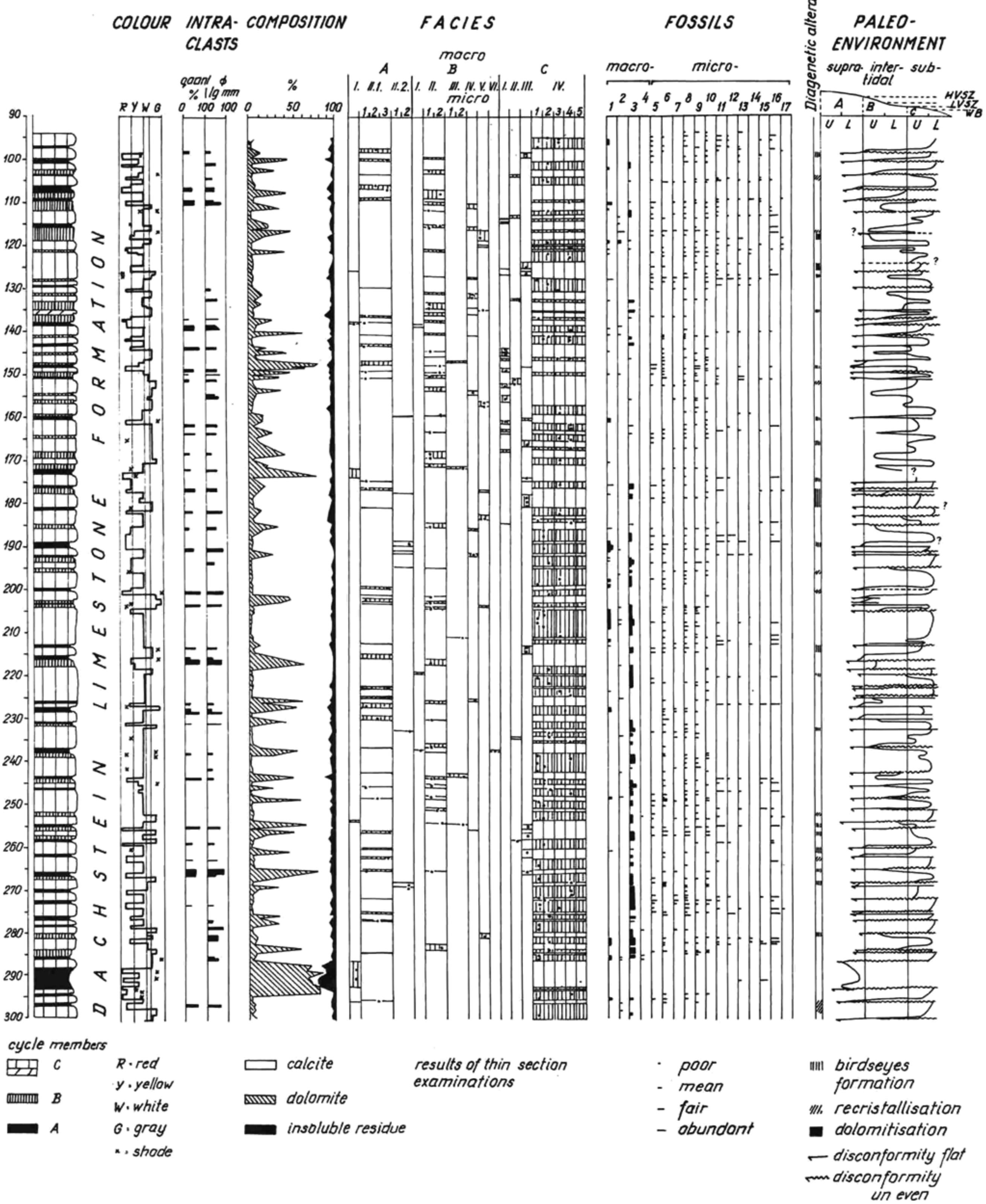

Fig. 2. Lithological, facies and paleontological characteristics as well as paleoenvironmental interpretation of the upper part of the bore hole Po-89, northern Bakony. The lithology is characterized by the rock color, size and abundance of intraclasts, and by the chemical composition of the rocks. The results of thin-section analysis are shown in the column "Facies" (numbers refer to the microfacies groups distinguished here. Fossils are indicated by numbers: 1 - mollusks, 2 - gastropods, 3 - megalodontid pelecypods, 4 - green-algae, 5 echinoderms, 6 - ostracods, 7 - gastropods, 8 - bioclasts of mollusks, 9 - indeterminable algal remains, 10 - *Globochaete*, 11 - nodosariid foraminifera, 12 - *Agathammina* and *Glomospirella*, 13 - *Trochammina*, 14 - agglutinated foraminifera, 15 - miliolid foraminifera, 16 - *Aulotortus*, 17 - variostomid foraminifera.

Lithologische, fazielle und paläontologische Merkmale sowie Milieuinterpretation für den oberen Abschnitt der Bohrung Po-89, nördlicher Bakony. Die Lithologie wird durch Gesteinschemismus beschrieben. Die Ergebnisse der Schliffanalysen sind unter "Facies" zusammengestellt (die Zahlen beziehen sich auf die im Text unterschiedenen Mikrofaziesgruppen). Fossilien sind durch die Nummern 1-17 bezeichnet (siehe oben).

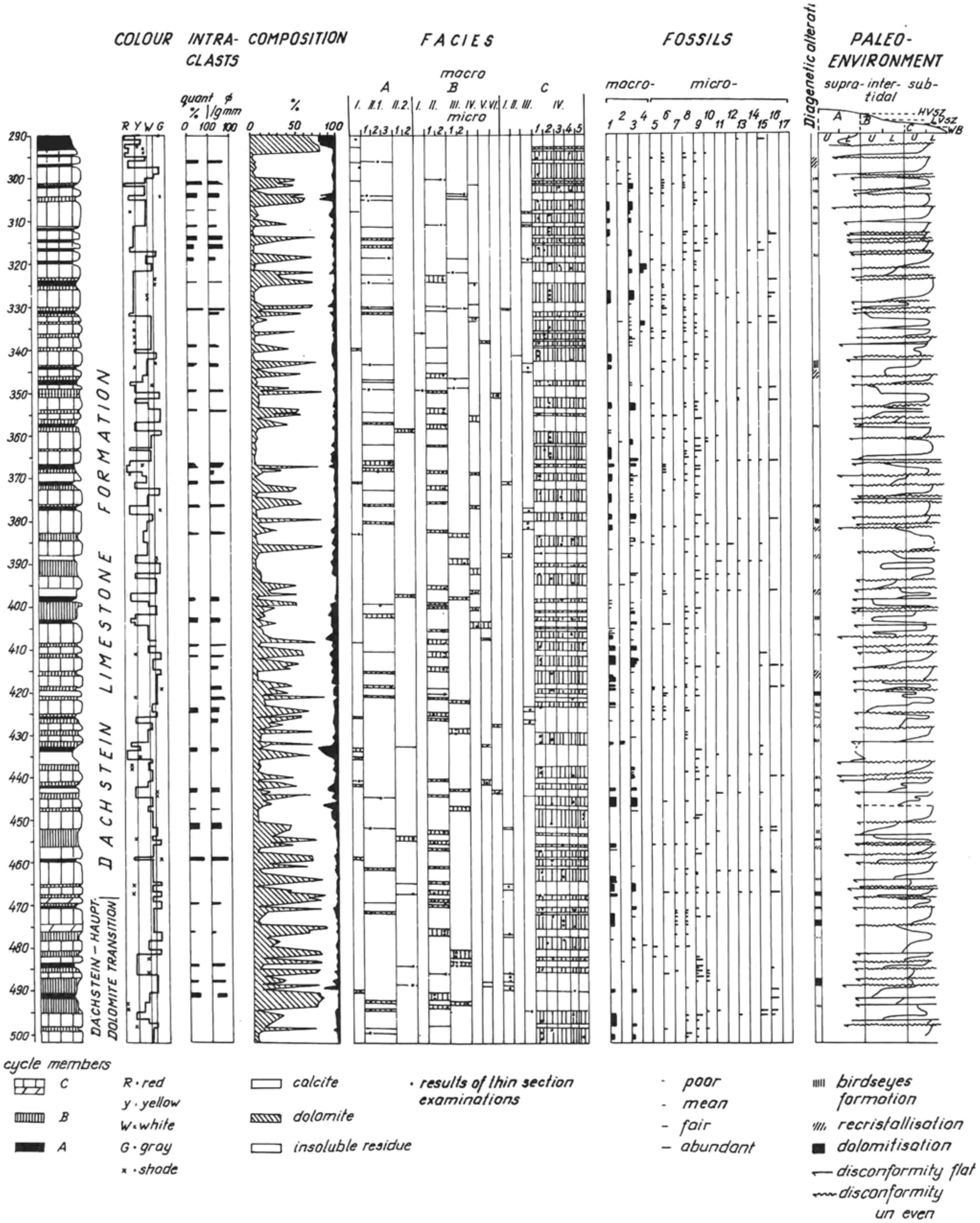

Fig. 3. Facies criteria and paleoenvironmental interpretation of the lower part of the bore hole po-89, northern Bakony. Same legends and numbers as in Fig. 2.

Fazies-Kriterien und Milieuinterpretation für den unteren Abschnitt der Bohrung Po-89, nördlicher Bakony. Signaturen und Numerierung wie bei Abb. 2.

2 GENERAL FEATURES OF CYCLICITY

Special attention was paid to the sedimentological characteristics indicating cyclic and non-cyclic deposition of carbonates.The cycles can easily be distinguished even with the naked eye; the basic pattern and the individual basic elements of their development are well known in the literature. The cycles studied are essentially in agreement with those described by SANDER (1936), SCHWARZACHER (1948, 1954) and by FISCHER (1964), in even more detail, as Lofer cyclothems from the Dachstein Limestone of the Northern Calcareous Alps.

During the macroscopic investigations 138 cycles were determined; various subtypes within cycles of substantially similar development could be differentiated (Fig. 1). Of special interest are deviations from the ideal cycle originally described by FISCHER (1964). The most significant deviations are as follows:

1. Denudation of the greater part of the cycles is weak in comparison with the Alps; thus, the elements of the regressive cycle originating from algal mats (symbol B') are rather different from those observed by FISCHER (1975) in the Alps. In fact, regressive cycles are not at all rare, but rather quite predominant. In this case the algal mat layer is followed by a disconformity and member A. The complete cycle of the above sequence can be regarded as a basic sedimentation pattern, which can be described by the formula d-A B C B'-d (Fig. 1, Type 1).

2. Owing to intra-cyclic anomalies in the sedimentation, minor internal unconformities, or erosion, any member may be absent within the cycle, or it may be atypical. Usually member A is absent or strongly reduced. The absence of member C or its total erosion is infrequent.

3. In several cases and generally in the upper part of the sequence, there is a cyclical development; but between the regressive and transgressive phases there are no ruptures or discordances. The unit can be described by the formula d-A B C B/ B'C B'-d (Fig.1,Type11).

4. Occasionally, other special elements can be observed in the Dachstein Limestone. Thus, for example, in member A a 2-6m-thick red silty marl layer (Fig. 1, Type 12) or, even more often, an originally evaporitic, porous dolomite of a Sabhka facies between members A and B can be observed.

The total thickness of the cycles varies between 0.3 and 8.5 m. SCHWARZACHER (1954) and FISCHER (1964) described regular patterns of 5 to 8 cycles with decreasing thickness towards the top and believed they could form megacycles. We have found no evidence of this, except for some indistinct traces in the lower part of the formation.

3 FACIES TYPES OF THE MEMBERS IN THE CYCLES

Based on macroscopic observations and microscopic analyses, the following types can be differentiated within members A, B and C (Figs 2 and 3):

Member A

1. Silty (dolo-) marl (often intraclastic)
2. Argillaceous carbonate (limestone, dolomite)
   - 2.1 intraclastic (plastotype)
     - 2.1.1 intraclastite
     - 2.1.2 bioclastic
     - 2.1.3 with a few intraclasts and bioclasts
   - 2.2 birdseye type
     - 2.2.1 pelmicrite
     - 2.2.2 intramicrite

Member B

1. Transition to member A
   - 1.1 silty micrite
   - 1.2 Pelmicrite without silt
2. Layered fabric, with algal mats
   - 2.1 crinkled
   - 2.2 flat
3. Layered fabric (with or without indistinct algal mats)
   - 3.1 finely layered pelmicrite
   - 3.2 micrite with indistinct sparite layers
4. Birdseye type (drusy fabric)
5. Transition to member C

Member C

1. Ragged algal mats
2. Oncoidal
3. Birdseye type
4. Light gray, microfauna-bearing carbonates with megalodontids
   - 4.1 biomicrite, biopelmicrite
   - 4.2 pelmicrite
   - 4.3 micrite
   - 4.4 intrapelmicrite
   - 4.5 drusy algal micrite, pelmicrite

4 ENVIRONMENTAL INTERPRETATION

Intensive sedimentological research in recent years has helped clarify in more detail the conditions of deposition in warm, marine shallow-water carbonate platforms, and tidal zones. Of special interest are investigations carried out on the Bahama Bank (GINSBURG & HARDIE 1975), in Shark Bay Australia (HAGAN and LOGAN 1975, WOODS & BROWN 1975), and in the Persian Gulf (SHINN 1973; EVAMY 1973; PURSER and LOREAU 1973; SCHNEIDER 1975).

The rocks of member A were formed within the supratidal zone and perhaps in the uppermost transitional part of the intertidal zone:

The thick red silty dolomarls (A.1.) are extremely terrestrial in character (upper part of the supratidal zone); they were not redeposited, during transgression phases. Intraclastic rock types of member A (A.2.1.) developed like present-day analogues in the lower part of the supratidal zone. Similar yellow and brown intraclastic rocks were described in Shark Bay. This part of the supratidal zone is flooded by seawater 10 to 20 times a year as a result of storms, during which breccias and micritic matrix including mixed marine microfossils as well as terrigeneous elements are redeposited.

Sediments with birdseyes structures (A.2.2.) underwent significant changes during early diagenesis: During the arid period dissolution of carbonates (cavity formation) occurs, followed by subsequent precipitation (radiaxial rim); later water flow might have been responsible for internal intrasedimentary infill and emergence for the formation of coarse sparite of freshwater origin.

Member B usually with layered fenestral structures (B.2.1.) and ragged algal mats, (B.4.) may represent the upper part of the intertidal zone. The flat and finely layered fenestral structures (B.2.2.) were formed in the lower part of the intertidal zone. The layered, non-fenestral types (B.3.) may be attributed to the same environment. Type B.1, forming a transition to member A, seems to have been formed at the upper boundary of the intertidal zone, while type B.6, transitional to member C, may have been formed near its lower boundary.

The carbonates of member C exhibit predominantly micritic matrix. Oolitic rocks or winnowed carbonates (grainstones), indicative of highly agitated environments are very rare. The different microfacies types were deposited in the shallow, non-agitated, photic waters of a subtidal back-reef-platform (lagoon). The ragged algal mats (C.1) represent in all probability the outer margin of the subtidal zone. A similar environment may be inferred for the oncolitic carbonates (C.2.), but higher water energies may have existed. All the other types were deposited in adjacent, only slightly different environments.

Dissolution and the formation of cavities took place to some extent during early diagenesis, in only weakly consolidated sediments, in connection with emergence. Larger cavities may develop by dissolution from flat desiccation cracks or from gas bubbles; these cavities became totally or partly filled with calcitic sparite precipitated either from marine water or meteoric freshwater. After complete lithification the cavities were redissolved and repeatedly infilled by sparite.

Recrystallization and dolomitization, found in the lower part of the sequence, are undoubtedly early diagenetic phenomena as indicated by their relation to the cycles. Dolomitization with recrystallization occurred when the loosely consolidated uppermost sediments of the cycle became exposed; because the incorporation of Ca in $CaSO_4$ precipitated in the sabhka-like environment, the interstitial water became strongly enriched in Mg^{2+}. The dolomitic portion occurs at the base of each cycle, because the penetration of infiltrating interstitial water was stopped by the pelitic basal layer or by the already consolidated layer underneath; thus the interstitial water of high Mg^{2+} content concentrated within a few decimetres above the base of the cycle.

The environmental model and the supposed depositional areas of the microfacies types are shown in Figs. 2 and 3. The interpretation of cyclical sedimentation very frequently observable in Upper Triassic platform carbonates, can not be regarded as definitively settled. The model, postulating world-wide eustatic changes in water level (FISCHER 1964), that is, epirogenic emergence-subsidence processes, is insufficient if we consider the hundreds of cycles included within the several thousand meter thick carbonate complex. It seems to be more reasonable to assume a steady rate of subsidence and somewhat changing rates of accumulation and evaporation.

In each case climatic factors may have been involved. There is no need to conclude that drastic changes took place; an alternation of relatively more arid and more humid periods might have had the same effect.

REFERENCES

EVAMY,B.D. (1973): The precipitation of aragonite and its alteration to calcite on the Trucial Coast of the Persian Gulf. In: PURSER,B.H. (ed.): The Persian Gulf. Berlin - Heidelberg - New York (Springer)

FISCHER,A.G. (1964): The Lofer Cyclothems of the Alpine Triassic.- Kansas Geol. Survey Bull. 169/1, 107-149, 38 Figs., Lawrence

-- (1975): Tidal deposits, Dachstein Limestone of the North-Alpine Triassic.- In: GINSBURG,R.N. (ed.): Tidal Deposits. 235-242, 3 Figs., Berlin-Heidelberg-New York (Springer)

FRIEDMAN,G.M. (1959): Identification of carbonate minerals by staining method.- J. Sed. Petrol. 29, 87-97, Tulsa

GINSBURG,R.N. & HARDIE,L.A. (1975): Tidal and storm deposits Northwestern Andros Island, Bahamas.- In: GINSBURG,R.N. (ed.): Tidal Deposits. 201-208, 16 Figs., Berlin - Heidelberg - New York (Springer)

HAGAN,G.M. & LOGAN,B.W. (1975): Prograding tidal-flat sequences: Hutchinson Embayment, Shark Bay, Western Australia.- In: GINSBURG,R.N. (ed.): Tidal Deposits. 215-222, 6 Figs., Berlin - Heidelberg - New York (Springer)

HANTKEN,M. (1861): Geologiai tanulmânyok Buda s Tata között (Geological studies from Buda to Tata).- Math. Term. Tud. Közl., 1, 213-277, 7 Figs., Budapest

PETERS,K. (1854): Die salzburgischen Kalkalpen im Gebiete der Saalach.- Jb. Geol. Reichsanst., 5, 116-142, 1 Pl., Wien

PURSER,B.H. & EVANS,G. (1973): Regional sedimentation along the Trucial Coast, SE Persian Gulf.- In: PURSER,B.H. (ed.): The Persian Gulf. Berlin - Heidelberg - New York (Springer)

PURSER,B.H. & LOREAU,J.P. (1973): Aragonitic, supratidal encrustations on the Trucial Coast, Persian Gulf.- In: PURSER,B.H. (ed.): The Persian Gulf. 343-376, Berlin - Heidelberg - New York (Springer)

SANDER,B. (1936): Beiträge zur Kenntnis der Anlagerungsgefüge (Rhythmische Kalke und Dolomite aus Tirol).- Tschermaks Min. Petrogr. Mitt. 46, 27-209, Leipzig

SCHNEIDER,J.F. (1975): Recent tidal deposits, Abu Dhabi, UAE, Arabian Gulf.- In: GINSBURG,R.N. (ed.): Tidal Deposits. 209-214, 5 Figs., Berlin - Heidelberg - New York (Springer)

SCHWARZACHER,W. (1948): Über die sedimentäre Rhythmik des Dachsteinkalkes von Lofer.-Verh. Geol. Bundesanst., 1947/10-12, 175-188, Wien

-- (1954): Die Großrhythmik des Dachsteinkalkes von Lofer.- Tschermaks Min. Petrogr. Mitt., 4, 44-45, Wien

SHINN,E.A. (1973): Recent intertidal and nearshore carbonate sedimentation around rock highs, E Quatar, Persian Gulf. In: PURSER,B.H. (ed.): The Persian Gulf. Berlin - Heidelberg - New York (Springer)