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SMALL-SCALE CYCLIC SEDIMENTATION IN THE EARLY GIVETIAN OF THE GÓRY ŚWIĘTOKRZYSKIE MOUNTAINS: COMPARISON WITH THE ARDENNE SEQUENCE

Alain Preat[1] & Grzegorz Racki[2]

[1] *Laboratoire de Sédimentologie et Géodynamique des Bassins, Université Libre de Bruxelles, 50, Avenue F.D. Roosevelt B-1050 Bruxelles (Belgium)*

[2] *Laboratory of Paleontology and Stratigraphy, Silesian University, ul. Będzińska 58, 41-200 Sosnowiec (Poland)*

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Abstract: In the section of the Lower Givetian limestones exposed in the Jurkowice-Budy quarry (eastern Góry Świętokrzyskie) 6 shallowing-upward small-scale cycles (thickness ranging from 0.5 to 3.3 m; average 1.5 m) are identified. Each cycle consists of a subtidal to lower-intertidal muddy unit overlain by an upper-intertidal to supratidal unit with extensive dia- genetic overprint, recording progradation processes. Non-erosive discontinuities separate successive conformable cycles. Distinguishing autocyclic from allocyclic processes is ambiguous in the lagoonal-peritidal sequence. Likely, the sedimentation was primarily controlled by local subsidence, pulses of which were counterbalanced by algal production. Climatically induced (in the frame of the Milankovitch cycles), very low-amplitude sea-level oscillations (less than 2 meters?) and short lag times (between 1000 yr and 5000 yr?) during deepening at the base of each cycle might also contributed to the sedimentary record.

Key words: Góry Świętokrzyskie Mountains, Middle Devonian, Kowala Formation, small-scale cyclicity

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INTRODUCTION

The Jurkowice-Budy quarry is a well-known exposure of the Givetian carbonates (see Baliński, 1973; Racki, 1993) located in the eastern part of Kielce region in the southern Góry Świętokrzyskie (Fig. 1). Lagoonal-peritidal sediments of this section accumulated as repetitive, prograding sequences, and passed laterally into low-relief stromatoporoid and algal-microbial mounds. The area is located within a vast stromatoporoid-coral undiferrentiated plat-

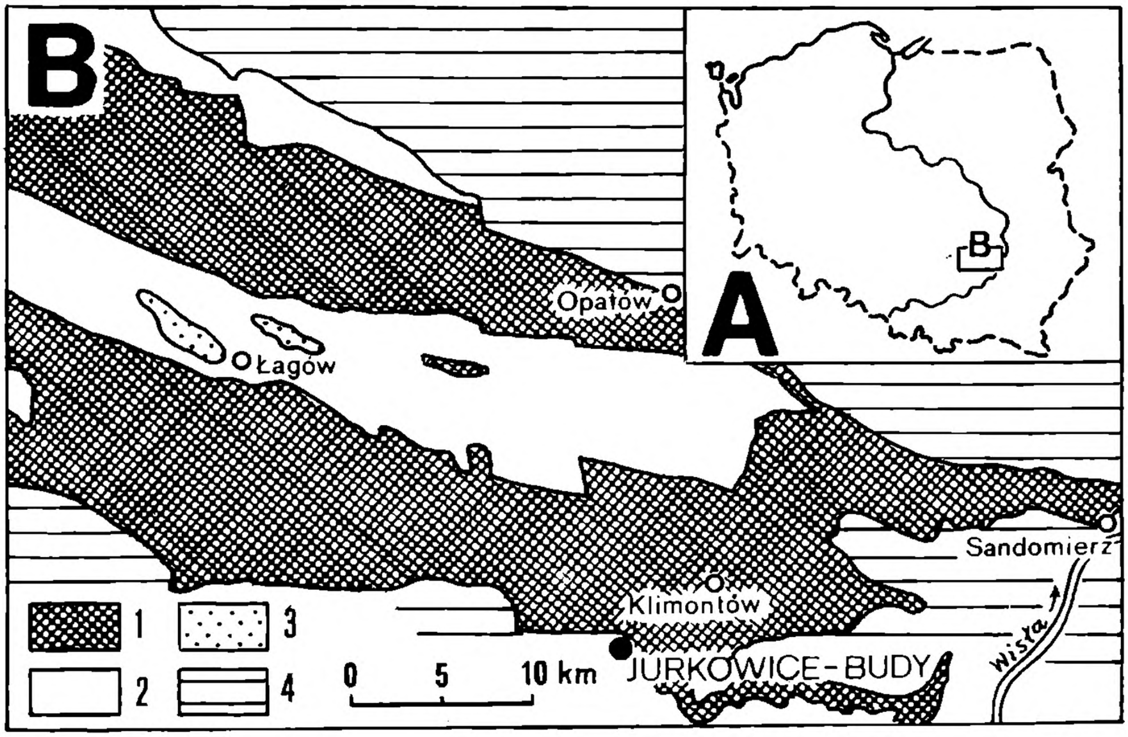

Fig. 1 Location of the Jurkowice-Budy quarry in the Góry Świętokrzyskie (adopted from Racki, 1993, fig. 2). *1* – Lower Paleozoic, *2* – Devonian, *3* – Carboniferous, *4* – post-Variscan cover

form where open marine influences were restricted to the marginal shoal belt (Stringocephalus biostromal bank sensu Racki, 1993).

The purpose of this paper is to describe cyclicity in the Givetian limestones of Góry Świętokrzyskie, using the lower portion of the section from Jurkowice-Budy as an example, and to compare this cyclicity with that of the French-Belgian platform. To enable reliable comparisons, the locality has been studied with the same methods as those used for the Ardennes by Preat (1984) and Preat & Mamet (1989).

The article presents first results of cooperation between Authors, and G. Racki is responsible for "Stratigraphic setting", A. Preat for "Microfacies analysis" and "Cyclicity", and the final discussion is joint.

STRATIGRAPHIC SETTING

The measured Early Givetian sequence in the south-westernmost part of the small active Jurkowice-Budy quarry comprises lowermost interval of the Kowala Formation built of stromatoporoid-coral dolostones and limestones, mostly the basal strata of the Stringocephalus Beds, i.e. sets A-E of Racki (1993). The exten- sive sheet-like bodies with abundant biostromal accumulations replaced earlier cyclic dolomitic-biostromal deposits of a sabkha-type (unit I of Narkiewicz, 1991); the oldest exposed strata at Jurkowice-Budy include grey and light grey dolo-micrites or fine dolosparites, frequently marly and laminated. Age of the bottom (pre-Stringocephalus) interval remains some-what uncertain due to poor biostratigraphic evidences; Racki (1993) considers the strata as close to the Eifelian/Givetian boundary whilst Stringocephalus firstly appears within the set C (Fig. 2). The dominantly grey, well-bedded calcilutite-biostromal sequence with subordinate marly interbeds (for details see Kaźmierczak, 1971; Narkiewicz, 1981; Racki, 1993) is marked by the "frozen front" of mesogenetic dolomitization (see Narkiewicz 1991: Pl. 3), evidenced by irregular occurrences of yellowish-brownish crystalline dolostones with faunal relics.

Special emphasis in the present study is paid on the lithologies present in the sequence portion exhibiting minor rhythmic pattern that forms a regressive member (sets C-D) of the oldest larger-scale shoaling-upward unit recognized in the Kowala Formation (subcycle G-Ia in Racki, 1993; see also Racki *et al.*, 1993). Two thin brachiopod coquinite intercalations with *Rensselandia* and scattered crinoid debris have been only locally established within unreplaced relic of megafossil-impoverished limestones (set A) in crystalline dolostones; the deposits represent an open marine incursion in the shelf lagoon, may be corresponding to the initial deepening event of the transgressive-regressive (T-R) cycle If in the scheme of Johnson *et al.* (1985), near the Eifelian-Givetian boundary. Higher in the sequence the stromatoporoid-coral limestone (set B) is followed by *Amphipora*-bearing beds (set C) and more and more numerous calcilutite units with rare megafossils but marked by diversity of fenestral fabrics and laminated horizons (set D). However, rapid transitions into coral-enriched accumulations were observed within the latter set; this is also true for the overlying "reefal" thick set E, considered as the basal part of the next major cyclic unit G-Ib in regard of differentiated fossil assemblage associated with the main builders (brachiopods, gastropods, calcareous microfossils, crinoids etc.; see Baliński, 1973; Racki, 1993; Racki & Soboń-Podgórska, 1993). Stratigraphically younger thick lagoonal deposits, resembling the sets C-D but with thicker shaly interbeds (set F), are presently quarried in the eastern part of the outcrop being inaccesible for detailed study.

MICROFACIES ANALYSIS

Thirteen major microfacies (MF1 to MF13), established by Preat (1984) and Preat & Mamet (1989), has been used as the standard facies succession to the comparative analysis. The microfacies recognized in the Jurkowice-Budy quarry are very similar to those of Ardennes. Microfacies MF1 and MF2 of the open marine facies belt, and MF7, MF8 and MF10 of channelized bodies within the back-reef zone are missing. Otherwise, one more microfacies MF 13 is present in the basal part of the Polish succession (near the Eifelian-Give-

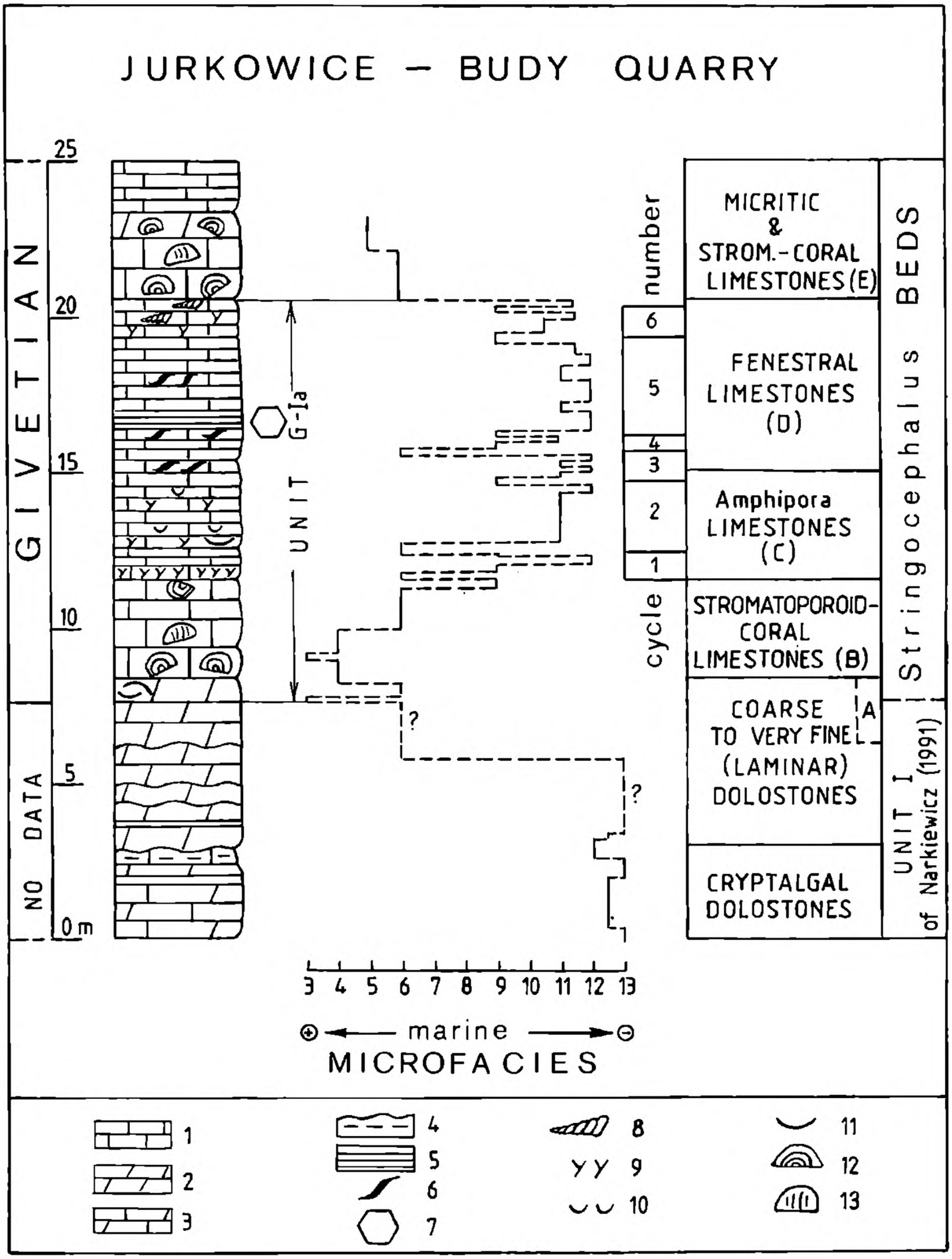

Fig. 2 Lithological column, sequence of microfacies and identification of depositional cycles in the Lower Givetian strata of the Jurkowice-Budy quarry. The microfacies succession presented in terms of the Ardenne standard scale (MF3 to MF13; Preat & Mamet, 1989); half values correspond to transitional microfacies varietes (see Pl. V: 3-4). Lithologic sets A-E taken from Racki (1993) and refer to the undolomitized sequence of the Kowala Formation: *1* – limestone, *2* – dolosparite, *3* – dolomicrite, *4* – nodular-argillaceous intercalation, *5* – cryptalgal laminite, *6* – fenestrae, *7* – mud-cracks, *8* – gastropods, *9* – amphiporids, *10* – ostracods, *11* – brachiopods, *12* – massive stromatoporoids, *13* – corals

tian boundary?) which in Belgium is known only from the Upper Givetian and corresponds to hypersaline (pre-evaporitic) environment (Preat & Rouchy, 1986).

The following review summarizes the main characters of the facies present in shallow-shelf sediments of the Jurkowice-Budy succession. The sequence has been sampled "bed by bed", and 60 thin sections have been prepared from the 23.5 m thick section (Fig. 2).

Microfacies 3 (MF3) – shallow fore-reef environments

This is a bioclastic packstone-floatstone composed of very thin-bedded (less than 1 cm thick) layers of "shell hash" (Pl. I: 1) which displays low-angle cross-stratification. Skeletal fragments consist of angular to subangular, medium to coarse, sand-size coral (mostly Tabulata) and mollusc grains with a few crinoid ossicles, dendroid stromatoporoids and other reef-builders (partially micritized), tubiform kamaenid and issinellid green algae (Parasiphonocladace). The Jurkowice-Budy microfacies is comparable with MF3a of Preat & Mamet (1989).

Microfacies 4 (MF4) – "reef" complexes

This is a partly dolomitized biostrome composed of diversified corals and stromatoporoids and a few brachiopods. Stromatoporoid growth forms are subspherical or massive. Most colonies are in place and have locally constituted a rigid organic framework (framestone). They range from 10 cm to 30 cm in diameter, and are accompanied by a few similarly sized massive tabulate and fasciculate rugose colonies, and small isolated thamnoporids. The facies corresponds to MF4a described by Preat & Mamet (1989).

Microfacies 5 (MF5) – high energy peri-reefal environments

The medium-bedded (up to 2.5 m thick), upper part of the section consists of stromatoporoid-coral rudstone, dolomitized in places. Stromatoporoid growth forms include subspherical and tabular varieties, and their subangular to subrounded fragments may exceed 30 cm in size. Corals are represented by fragmented colonies of fasciculate rugosans and scattered tabulates. Some stromatoporoid bioclasts are encrusted with other stromatoporoids or micritized. Cavities of the framework are filled with a skeletal grainstone, with bioclasts consisting of molluscan and brachiopod shells. Some molluscan fragments show numerous microperforations, but are not micritized. Rounded to subrounded micrite grains (algal peloids ?) are also present. Common dolomite crystals are hypidiotopic to slightly idiotopic, medium- to coarse-grained (up to 200 μm). This microfacies is similar to the MF5 of Preat & Mamet (1989).

Microfacies 6 (MF6) – low energy peri-reefal environments

These are *Amphipora*, gastropod and ostracod floatstone (Pl. I: 2-4). In some deposits, abundant *Amphipora* sticks may have formed a frame indicating former bafflestone-type sediments. However, the sticks are commonly flat-lying and generally concen- trated on bedding planes. The matrix varies from a bioturbated peloid wackestone to packstone with a few broken corals. Calcispherids (mainly *Calcisphaera*, and *Parathurammina*), *Bisphaera* and *Irregularina* are not very abundant. Peloids seem to be related to disintegration of algal mats dominated by nodular growth forms of the codiacean *Bevocastria*(?), in association with very abundant undetermined calcitic sponge spicules (Pl. I: 4). This microfacies is very close to MF6 of Preat & Mamet (1989).

Microfacies 9 (MF9) – restricted lagoonal environments

Three varieties of this microfacies are present at Jurkowice-Budy, two of them being very similar to MF9 Belgian microfacies and the symbols used here follow Preat & Mamet (1989), i.e. MF9d, MF9h. The third one is quite different and has been given its own name (MF9m, "m" for mudstone). These microfacies con- stitute thin to medium (0.3 - 0.4 m) regular beds.

MF9d: bioturbated ostracod-kamaenid wackestone (Pl. II: 1) with a few calcispherids and very rare *Amphipora*. The ostracod fauna is composed of abundant leperditiids (Pl. II: 2). A few fenestrae are scattered; their horizontal sizes are rarely greater than twice the vertical dimension (Pl. III: 1).

MF9h: bioturbated sponge-algal wackestone-packstone with a few *Amphipora* sticks (Pl. II: 3), ostracods, pelecypods(?) and problematic tubiform fossil *Evlania*. Algal remains include mainly nodular masses of *Bevocastria* and scattered tubular specimens of dasyclad kamaenids, and are associated with common sponge spicules. The first green algae encrust *Amphipora* branches, or form thin irregular mats, the sediment becoming progressively a bindstone. *Bisphaera* is present and seems to perforate the partially dissolved amphiporid skeletons.

MF9m: bioturbated ostracode mudstone-wackestone with rare calcispherids, as well as kamaenid and proninellid algae. Micrite is extremely dense except of the burrowed zones where geopetal infilling is present and composed of a very fine-sized microspar.

Microfacies 11 (MF11) – spongiostromid-algal upper-intertidal environments

This microfacies consists of wackestone-packstone and bindstone composed of sponge-algal (*Bevocastria*) association with a few diminutive ostracods. Three diagenetic varieties are present within microfacies: the first one is dominated by dissolution processes (MF11d), the second by fracturing (MF11f) and the third by recrystallization of the matrix (MF11r).

MF11d: the dissolution processes are expressed in partial removal or replacement with sparite of micritic matrix, aragonitic mollusks shells, as well as Amphipora sticks. Dissolution vugs may be as large as 1 cm in diameter. The vugs consist of abundant irregular and a few near-vertical tubular fenestrae (0.1 - 0.2 x 1 - 2 cm) which are partly filled with crystal silt, radiaxial fibrous and coarse sparry calcite (Pl. II: 4). These cements are often partly to completely replaced by coarse to very coarse crystalline equant (up to a few millimeters) baroque dolomite showing typical curvature of cleavage and twin planes. Infilling of clayey material is sporadically observed within the irregular fenestra. Some fracturing is also present and shows at least three phases. The dominantly calcite-filled fractures of the first phase are very thin, relatively irregular and frequently connect dissolution vugs. The two other phases are characterized by larger fractures, with a strong near-vertical component, the second phase preceding the format-ion of the baroque dolomite, while the third phase cuts it.

MF11f: fracturing becomes the dominant character. Its first phase is generally well-developed, with numerous thin irregular veins connecting all early diagenetic textures. A few glaebule-like peloids are found within this microfacies.

MF11r: irregular and extensive microsparitization develops a clotted micrite fabric composed of dense micrite peloids (microglaebules) with irregular crumbly fractures.

Microfacies 12 (MF12) – restricted supratidal environments

The microfacies MF12 is composed of laminites similar to those described by Preat & Boulvain (1987) and Preat & Mamet (1989) in the Lower Givetian of Belgium. Among the 6 types recognized by these authors (MF12a to MF12f), the Jurkowice-Budy laminites are similar to MF12a, b, c and d and are described here jointly as MF12LA. Three other variants of MF12 developed in the succession, which are absent in the Lower Givetian of Belgium. These are brecciated mudstone-wackestone (MF12BR), "loferite" wackestone-packstone (MF12LO) and completely "dissolved" packstone-grainstone (MF12DG). Noticeably, the diagenetic features are particularly pronounced within these peculiar microfacies.

MF12LA: layering is very thin (i.e. on a 0.1 mm to millimetric scale), and two major layer types are present, very similar to those of the Andros Island (Bahamas) described by Hardie & Ginsburg (1977) as smooth flat lamination and disrupted flat lamination (Pl. III: 2). The sediments of the first type show an alteration of relatively well-sorted peloid sand laminae and clotted mud laminae with very small domes (of algal or stromatolitic origin?). The sandy laminae are strongly discontinuous laterally on a few millimeters scale and appear highly lenticular in the sediments of the second type. Intraclast chips and irregular peloids occur frequently and are associated with mud-cracked muddy laminae, tiny horizontal sheet cracks, horizontal fenestrae (annelid burrows?) and vertical to oblique tubular fenestrae (root molds?).

MF12BR: extensive fracturing may progressively transform the sediments (sponge-algal mudstone-wackestone) into a collapse breccia formed by foundering of cave roofs (Pl. IV). Characteristic features include also the mixing of various types of cavi- ty sediments (crystal silt, clay material). Numerous thin irregular fissures were colonized by iron-oxidizing microorganisms (fungi? and/or bacteria?) similar to those described by Mamet & Boulvain (1988). Irregular and tabular fenestrae are common and some of them suggest presence of roots. Enigmatic palaeomicrocodiacean algae (Mamet & Roux, 1983; Mamet & Preat, 1985) are also present either isolated within the matrix, or as dense assemblages which infill thin fractures.

MF12LO: peloidal loferites consist largely of microglaebules linked with large and very fine fenestrae (Pl. III: 3-4); they are typically associated with the preceding microfacies. A few "black pebbles", ranging in size from tens of microns to two hundreds micron, are identified too. Irregular and tabular fenestrae suggest original presence of roots and shrinkage pores.

MF12DG: peloidal, lumpy and bioclastic (debris of brachiopods, molluscs, crinoids, partly to completely dissolved amphiporids and *Bisphaera*) microsparitized packstone to well-cemented grainstone (Pl. V: 1-2). Bladed to slightly acicular isopachous cement rims and syntaxial medium- to coarse-grained sparite have precipitated in shelter and interparticle pores. Drusy calcite mosaic fills the remaining pore system.

Microfacies 13 (MF13)

MF13: very fine crystalline unfossilliferous and silty dolomudstones. Thin mud-cracked fractures are associated with a few small root molds(?) and a few pseudomorphs after sulphate minerals. Irregular peloids and microglaebules are also noted (see Pl. V: 3 - 4).

CYCLICITY

Sequential analysis (Fig. 2) clearly shows that the Stringocephalus Beds at Jurkowice-Budy record cyclic carbonate sedimentation within the lagoonal part of a shelf. The regressive phase (i.e. 11.6 m - 20.4 m interval) contains 6 cycles which form shoaling-upward sequences similar to the Ardenne regressive rhythms described by Preat & Mamet (1989), although the lower and upper parts of the Góry Świętokrzyskie cycles are more contrasted. Despite such limited rhythm number, the average range thickness of individual cycle is 1.5 m and is similar to those reported by Wong & Oldershaw (1980) from the Canadian Devonian reef interior sediments (Alberta) and from the French-

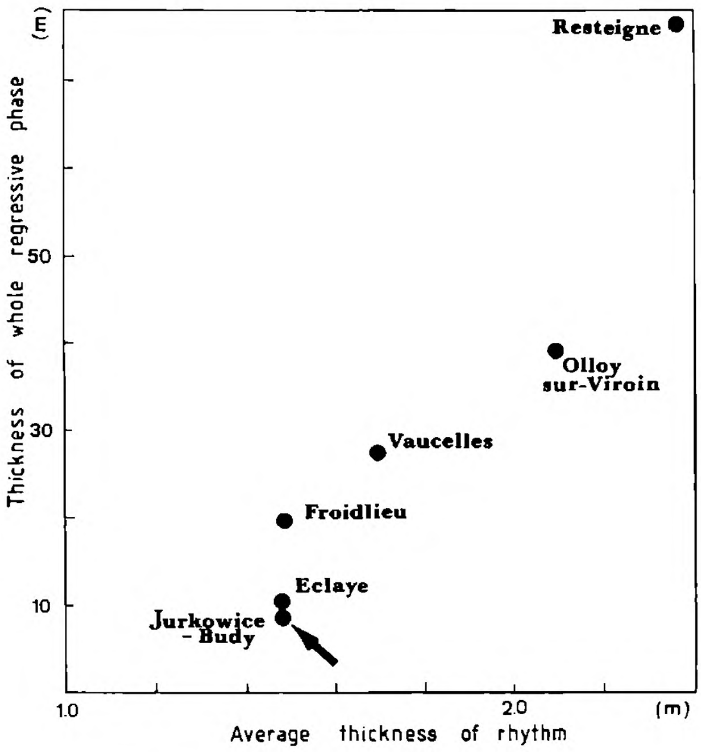

Fig. 3 Average thickness of the Early Givetian elementary regressive rhythm as a function of the 4th and 5th lagoonal phases of the Ardenne succession (Trois-Fontaines Formation, southern border of the Dinant Basin; Preat & Mamet, 1989, fig. 7) and as function of thickness of whole lagoonal phase at Jurkowice-Budy

Belgian carbonate platform (Fig. 3), as well as from the Late Givetian lagoonal *Amphipora*-dominated sequences of the western Góry Świętokrzyskie (Racki, 1993). The lower part of a typical cycle consists of microfacies MF6 or MF9 (mudstone, wackestone and floatstone), and its upper part shows diverse fenestral microfacies MF11 and MF12 (fenestral, peloidal and brecciated packstone, and laminites). Sedimentary structures are lacking in the lower part except for burrows while early diagenetic structures are the rule in the upper part of a cycle. Fenestrae appear to originate in different ways but are generally considered typical of the intertidal and supratidal zones (Grover & Read, 1978). Their close association with probable pedogenic structures, such as glaebules, subhorizontal cracks, extensive dissolution processes, root molds, palaeomicrocodiacean algae within the matrix and within irregular veins, supports this interpretation. Diagenetic features indicate that much of the alteration of the pore systems of the lagoonal sediments was early, and occured during development of each individual cycle.

Microfacies analysis suggests a subtidal low-energy environment with poor circulation in the lower part of the cycles. The faunal and microfloral diversities were low as a result of probably important variations in temperature and salinity: the biotope is either dominated by *Amphipora* with subordinate ostracods and calcispherids, or by nodular codiaceans and calcisponges with a few kamaenids or only by the leperditiid ostracods. The high mud content of these microfacies is indicative of quiet conditions. As it was suggested above, variable peritidal regime is inferred for the upper part of the cycle. Non-erosional discontinuities separate successive conformable cycles.

Sediments of the cycles document progradation from lower-intertidal to supratidal microfacies over subtidal ones in the same upward-shoaling manner as suggested by Wong & Oldershaw (1980) for similar Devonian rocks. They are equivalent to the "elementary regressive rhythms" of Preat & Mamet (1989). As in those cases, the cyclicity in sediments of the Jurkowice-Budy lagoonal phase can be explained by variation in the rate of *in situ* production of carbonate sediments. Generally low agitation and restricted circulation support this hypothesis. No evidence of significant transport from the bank margins has been observed. Consequently, the model for the development of cyclicity in this sequence is derived from the autogenic model proposed by Wong & Oldershaw (1980) and developed by Preat & Mamet (1989): the environment was subtidal with optimum for carbonate production, subsequently carbonate sedimentation outpaced subsidence, and subtidal areas were gradually replaced by intertidal to supratidal marshes. It resulted in a drastic decrease of carbonate production, and therefore subsidence finally outpaced sedimentation and subtidal conditions had been reestablished.

On the other hand, Read *et al.* (1986) have developed computer models for generation of carbonate cycles. At least some of the Góry Świętokrzyskie thin "elementary regressive rhythms" (maximum up to a few meters thick) could obviously result from low-amplitude sea-level oscillation of a few meters (less than 2 meters?) and short lag times (between 1000 yr and 5000 yr?) during deepening phase. Following these authors, non-erosive discontinuites reflect sea-level drop balanced by subsidence and basinward migration of the shoreline not exceeding tidal-flat progradation.

IMPLICATIONS AND DISCUSSION

The average thickness of the Jurkowice-Budy cycles (viz. 1.5 m) has been plotted against the complete thickness of the rhythmic sequence (i.e. 8.8 m) in Figure 7 of Preat & Mamet (1989). It seems that Jurkowice-Budy data well correspond with the coeval Ardenne depositional pattern (Fig. 3) which might indicate that a paleohigh was present in the region under study. Each of the inferred Early Givetian "tilted blocks" from the Ardennes was an area of peculiar carbonate sedimentation under steady subsidence and stable sea level, and it is not possible to correlate specific cycles between adjacent blocks because their number also varied.

The cyclic sedimentation could have occurred during a prolonged stillstand in the early Givetian, although Johnson *et al.* (1985) suggest even a general eustatic fall ("upper T-R cycle If regression") for this time interval. Facies progradation may possibly be explained by patchy shallowing up to the sea level producing a mosaic facies pattern in which tidal-flat cycle caps did not extend from one island to another (James, 1984).

In consequency, the rhythmic sedimentation of the lower Stringocephalus Beds in the Jurkowice-Budy area is assumed to be primarily controlled by local (block-related?) subsidence which were in turn counterbalanced by carbonate production. Eustasy seems essentially to be of secondary importance but significant tidal and probably terrestrial overprinting of subtidal facies suggests some contribution of sea-level fluctuations to the final sedimentary record (Strasser, 1991, fig. 2). More detailed discrimination of autocyclic from allocyclic factors in the studied succession remains disputable (see also Racki, 1993), and high-resolution correlation in the regional scale is needed. On the other hand, such interpretation constraint is frequent in lagoonal-peritidal sedimentary systems marked by complex interferences of controlling mechanisms. As discussed by Strasser (1991), both the carbonate production and high-frequency sea-level variation are induced by orbitally driven climatic cycles, which reflect the hierarchy of the Milankovitch cycles, and superimpose local tectonic, and depositional autogenic processes. Lastly Goldhammer *et al.* (1993) concluded that composite cyclicity of platform carbonates might have been forced by random sea-level changes, as an alternative to autocyclic progradation and/or Milankovitch-driven glacio-eustatic phenomena.

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Streszczenie

MAŁOSKALOWA CYKLICZNA SEDYMENTACJA WE WCZESNYM ŻYWECIE GÓR ŚWIĘTOKRZYSKICH: PORÓWNANIE Z SEKWENCJĄ ARDENÓW

Alain Preat & Grzegorz Racki

Sześć małoskalowych cykli o charakterze sekwencji spłycających się ku górze zostało rozpoznanych w profilu wapieni dolnego żywetu kamieniołomu

Jurkowice-Budy (wschodnia część Gór Świętokrzyskich; fig. 1-3, pl. I-V). Miąższość tych cykli waha się od 0,5 do 3,3 m; przeciętnie 1,5 m. Składają się one z niżejpływowych do dolno-śródpływowych mulistych osadów przykrytych przez bardziej płytkowodne, nawet ponadpływowe ogniwo silnie zmienione przez procesy wczesnodiagenetyczne.

Rozróżnienie roli czynników auto- i allocyklicznych w rytmicznej depozycji żywetu świętokrzyskiego nie jest możliwe. Przypuszczalnie sedymentacja była głównie kontrolowana przez glonową produkcję węglanu wapnia. Ten pospolity w lagunowych partiach dewońskich szelfów węglanowych sposób depozycji mógł być też powodowany niewielkimi fluktuacjami poziomu morza rzędu kilku (?mniej niż 2) metrów i krótkotrwałym opóźnieniem sedymentacji (rzędu 1000 do 5000 lat) w fazach pogłębiania inicjujących poszczególne rytmy; taki eustatyczno-klimatyczny mechanizm depozycyjny nawiązuje wprost do cykli Milankovicza.

EXPLANATION OF PLATES

Plate I

Microfacies MF3 (1) and MF6 (2-4); Lower Givetian, Jurkowice-Budy

1 — "Shell hash" floatstone containing subangular, sand-size, poorly-sorted skeletal grains of massive and encrusting stromatoporoids (lower left corner), tabulates (thamnoporids), molluscs and echinoderms; set B, 9.1 m from the base of the section
2 — Well-sorted, medium-grained bioclastic packstone matrix in a coral-stromatoporoid floatstone; the grains are dominantly subangular fragments of *Amphipora*, other stromatoporoids, tabulates, molluscs, brachiopods and cylindrical green algae (parasiphonocladaceans); set D, 15.35 m from the base of the section
3 — Peloidal aspect of micrtite within dissolved zones, with a few *Bisphaera*, partially dissolved *Amphipora* fragments and ostracods in sponge-algal (with kamaenids and nodular codiaceans) amphiporid wackestone-packstone; set B, 10.8 m from the base of the section
4 — Same thin-section as 3; assembled spicules in micrite matrix

Plate II

Microfacies MF9 (1-3) and MF11 (4); Lower Givetian, Jurkowice-Budy

1 — Slightly bioturbated calcispherid and ostracod wackestone with *Kamaena*; set D, 15.8 m from the base of the section
2 — Same slide as 1; wackestone with disarticulated ostracod valves (Leperditicopida) and dense micritic matrix outside of bioturbated zones
3 — *Amphipora* packstone; dense micritic matrix contains abundant partly dissolved *Amphipora* fragments, and few kamaenids, calcispherids and ostracods; set C, 14.7 m from the base of the section
4 — Dense micritic mudstone with irregular cavities partially filled with peloidal wackestone and sparry calcite and dolomite; early irregular fracturing connects the dissolution vugs; late

fracture system cutting across all early diagenetic features, particularly the irregular fractures, is also present; set C, 14.2 m from the base of the section

Plate III

Microfacies MF9d (1), MF12LA (2) and MF12LO (3-4); Lower Givetian, Jurkowice-Budy

1 — Calcispherid-kamaenid-ostracod mudstone-wackestone with large irregular fenestra (up to 6 mm in lenght) infilled mostly with fine micritic internal sediment; numerous fine-grained skeletal (partially dissolved amphiporids and molluscs) fragments within the matrix; set B, 11.7 m from the base of the section
2 — Laminite showing basic alternation of smooth flat, relatively well-sorted sandy laminae with abundant lumps, peloids and fine-grained debris of ostracods, molluscs, calcispherids and crinoids, and clotted mud laminae; sandy laminae have lenticular shape and show relatively sharp boundaries with mud laminae, note dessication cracking of upper muddy lamination; set D, 16.4 m from the base of the section
3 — Peloidal loferite from ostracod-kamaenid-calcispherid mudstone-wackestone; alveolar texture consisting of a complex network of micrite frames partially filled by microsparitic and blocky calcite cements, and irregular concentric nodules (lower part of the photograph); set D, 15.3 m from the base of the sec-tion
4 — Same thin-section as 3; micritic matrix with dispersed skeletal grains and rare detrital quartz

Plate IV

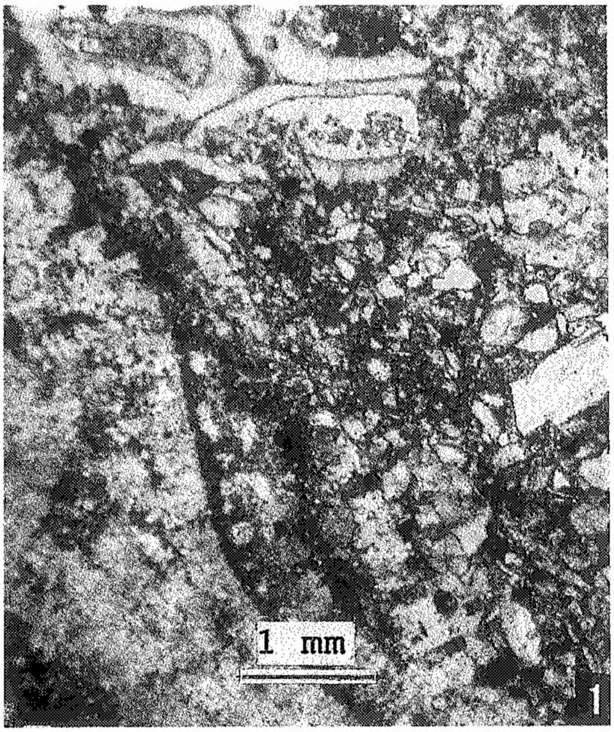
Microfacies MF12BR (1, 3-4) and transitional variety between MF12BR and MF13 (2); (?)Eifelian-Givetian passage beds (1-2) and Lower Givetian (3-4), Jurkowice-Budy

1 — *In situ* collapse breccia composed of poorly sorted, angular micritic blocks (peloidal mudstone-wackestone) floating in medium- to coarse-grained microsparitic "cement"; 3.15 m from the base of the section
2 — Clotted packstone composed of peloids and small glaebules within a strongly recrystallized microsparitic matrix and numerous irregular fractures forming a complex network; complicated pattern of cracking around and within grains and former matrix; 2.9 m from the base of the section
3 — Irregular and relatively large cracks enlarged by corrosion activity of palaeomicrocodiacean algae in a dense sponge-calcispherid wackestone; set D, 16.5 m from the base of the section
4 — Same sample as 3 showing scattered ostracods and irregular globular palaeomicrocodiacean aggregates within a dense mudstone

Plate V

Microfacies MF12DG (1-2) and transitional variety between MF12 and MF13 (3-4); Lower Givetian (1-2) and (?)Eifelian-Givetian passage beds (3-4), Jurkowice-Budy

1 — Fine-to medium-grained, moderately-sorted peloidal and bioclastic (*Amphipora*, ostracods, molluscs) grainstone; bladed and equant calcite cement is abundant; some grains are micritized and strongly altered; loose and irregular packing is probably due to early diagenetic total grain dissolution and partial collapse of sediment; set D, 20.65 m from the base of the section
2 — Detailed view of altered grains from same thin-section as 1
3 — Microsparitized dolomicritic matrix (mottled texture) showing incipient differentiation into poorly sorted irregular micrite nodules of glaebule, probably in result of subaerial exposure and partial desiccation; 1.5 m from the base of the section
4 — Same slide as 3 displaying a rounded clast with irregular laminae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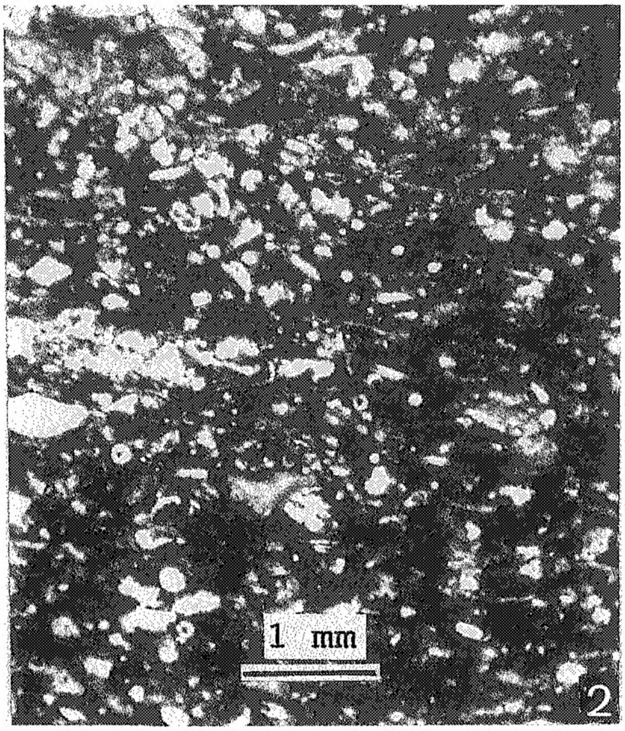
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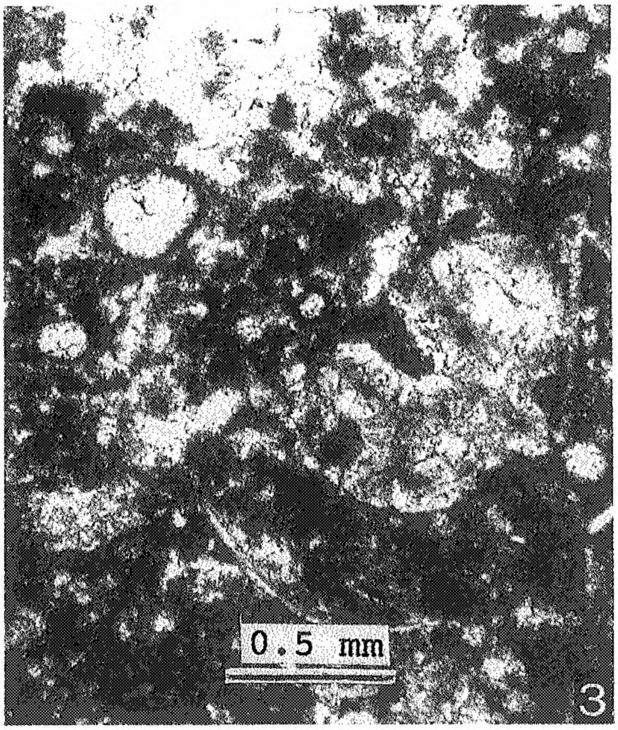
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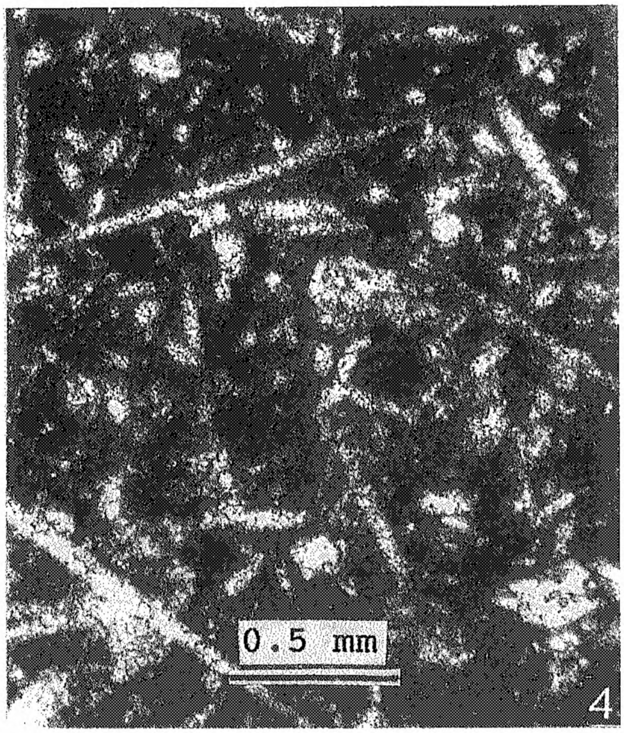
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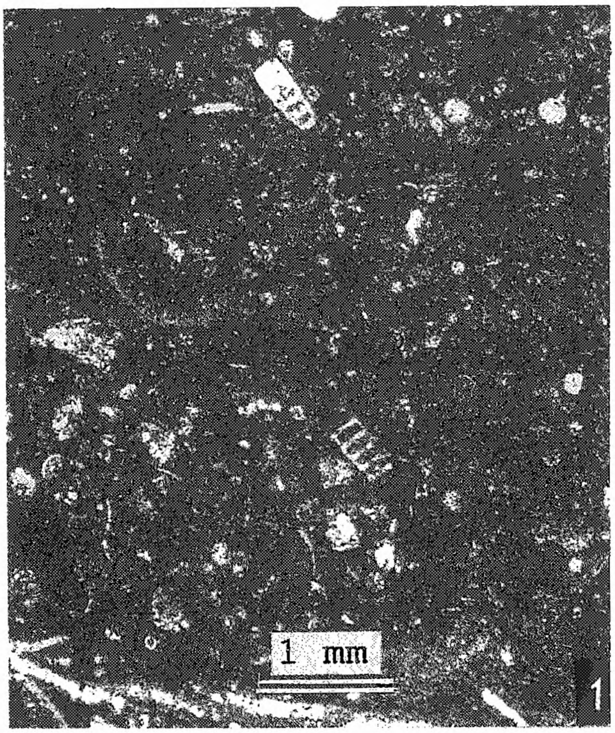
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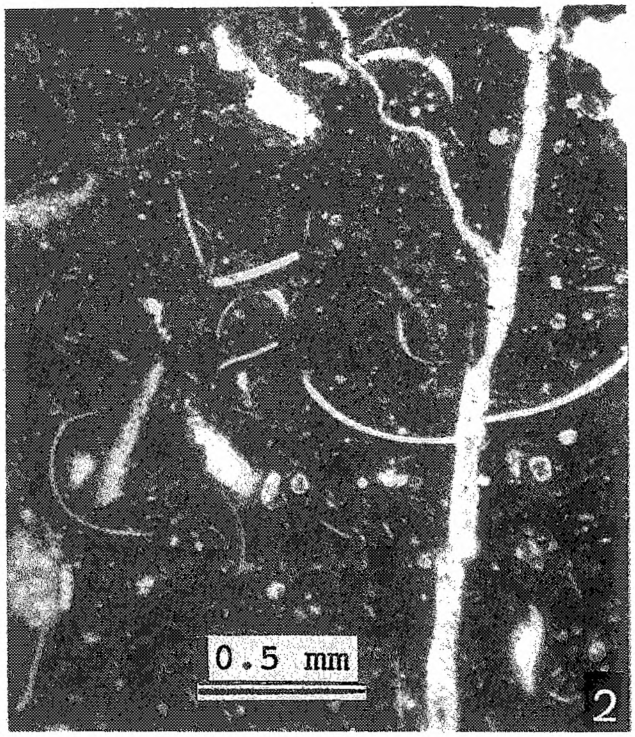
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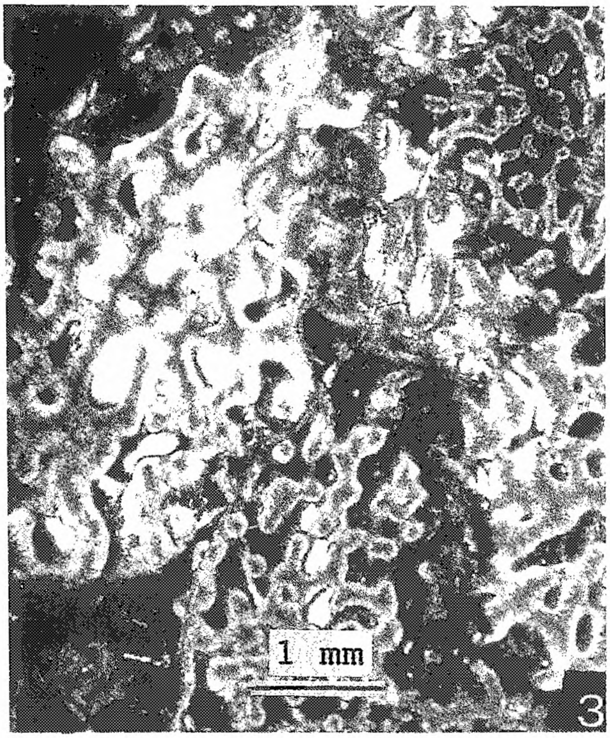
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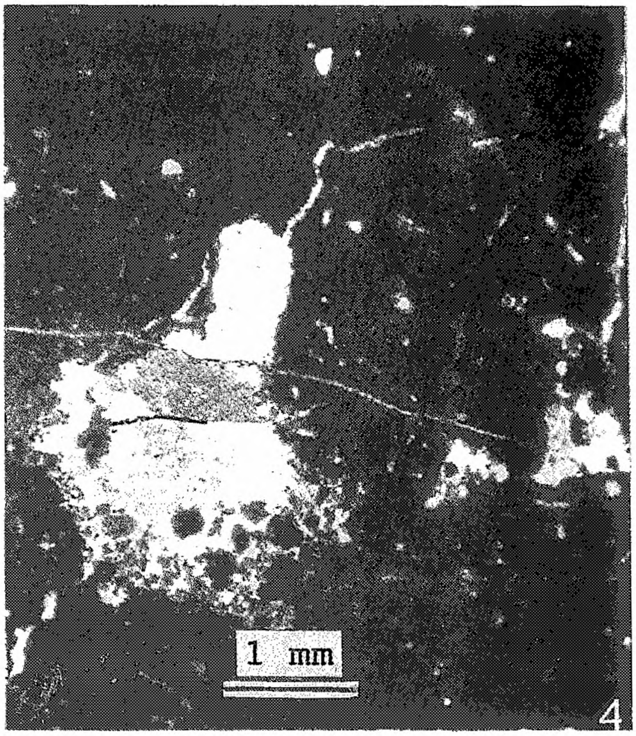
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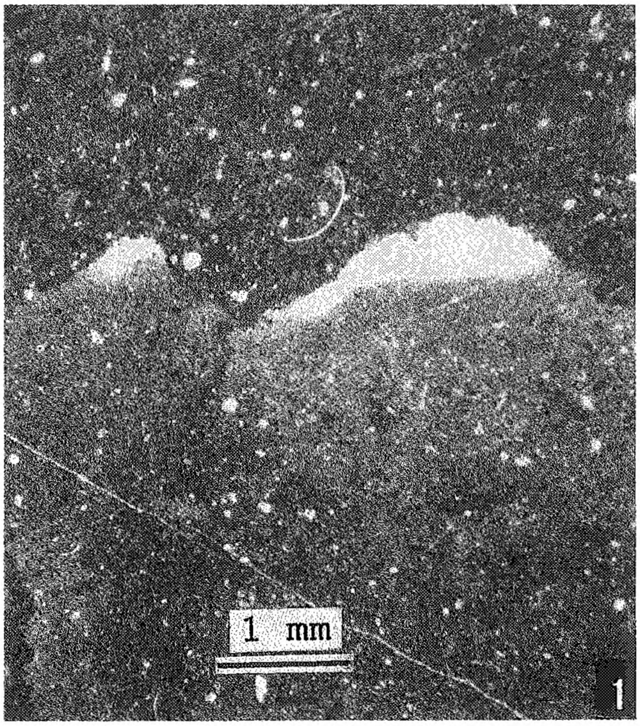
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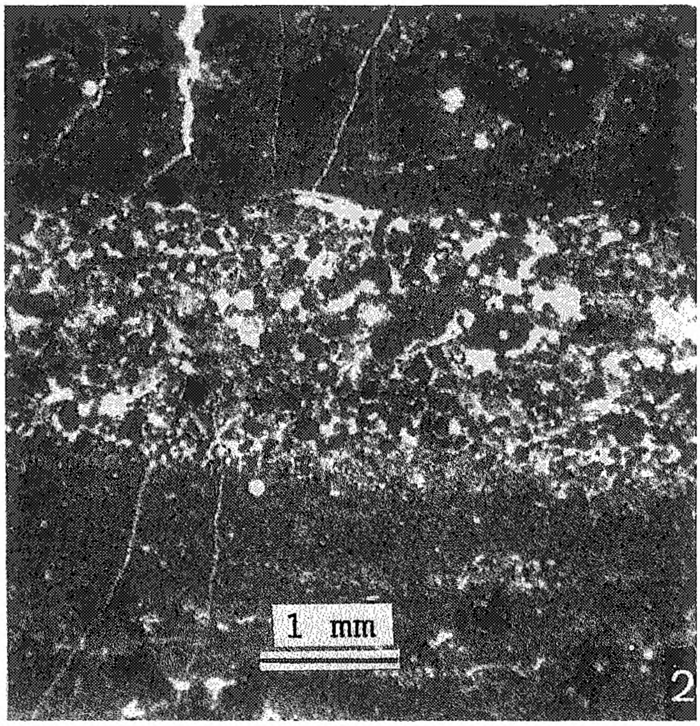
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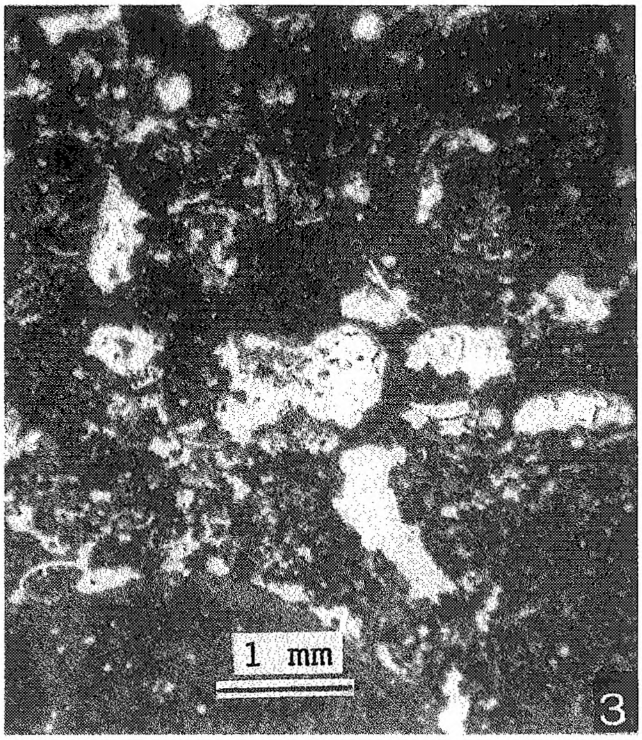
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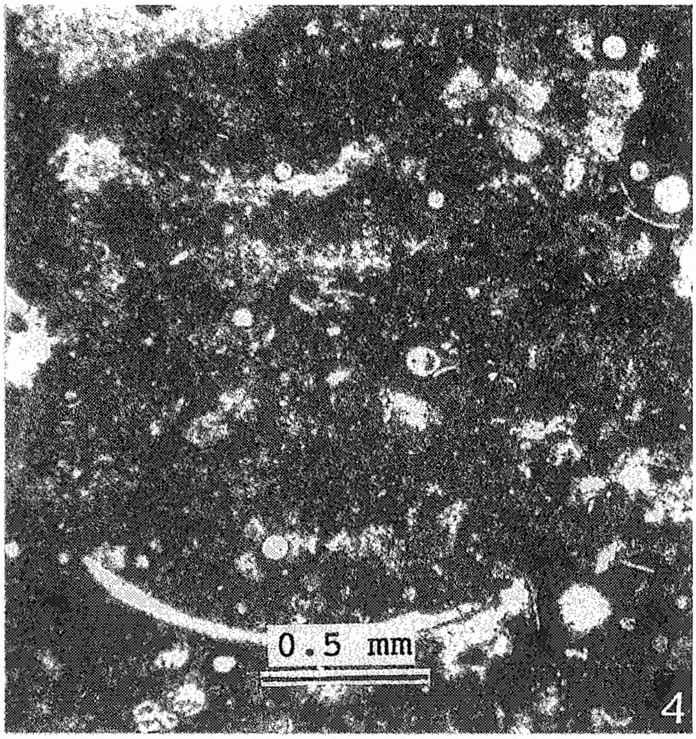
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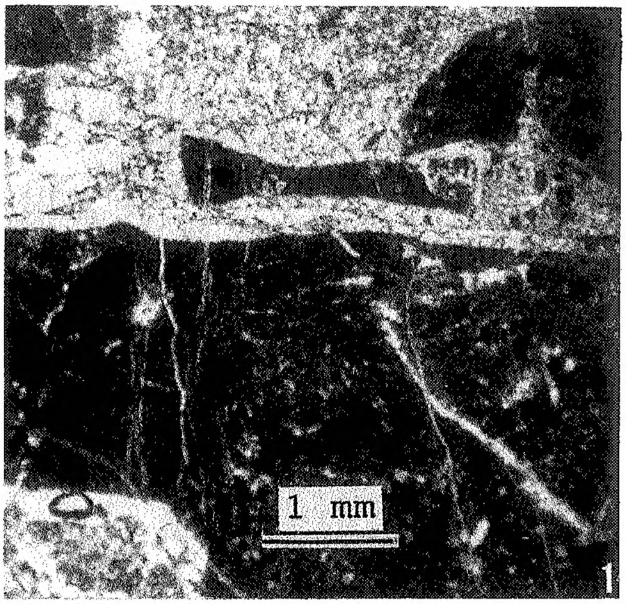
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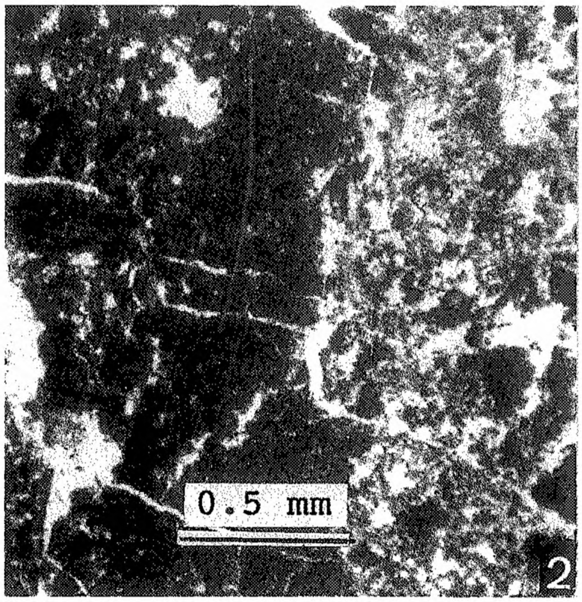
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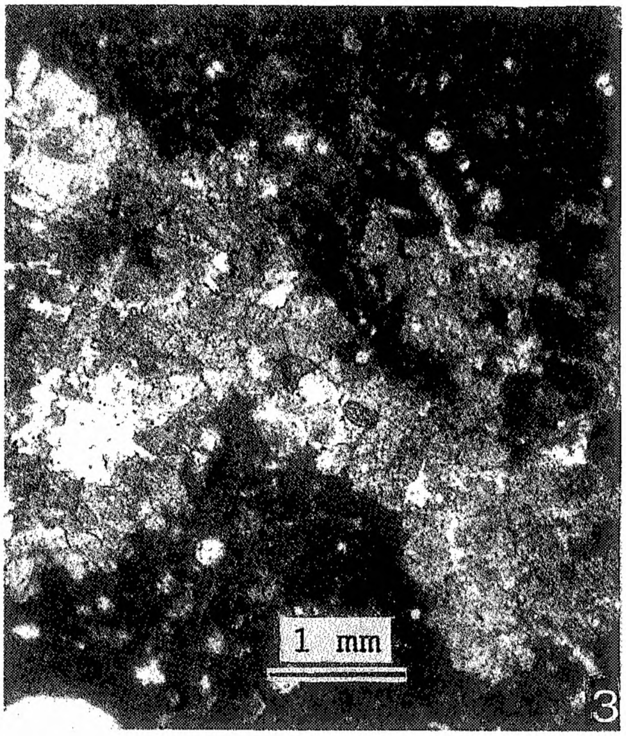
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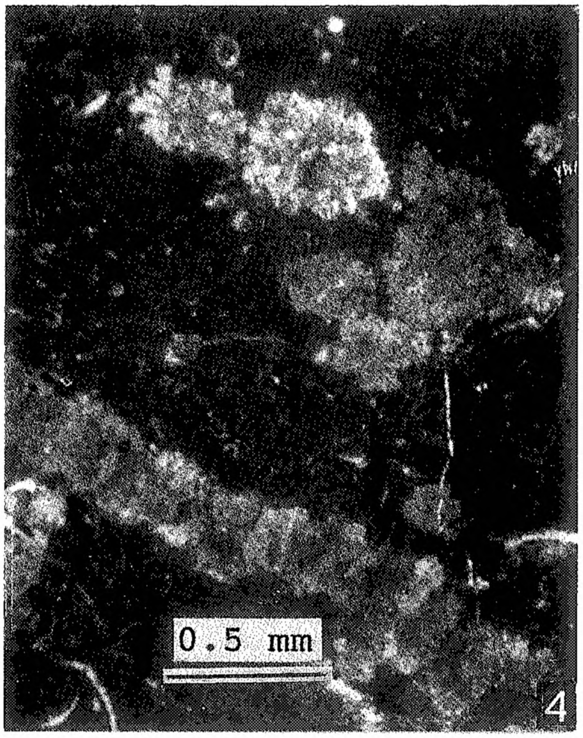
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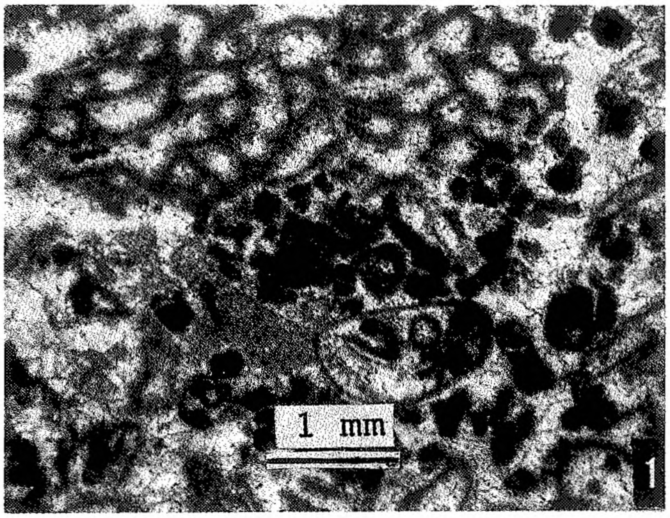
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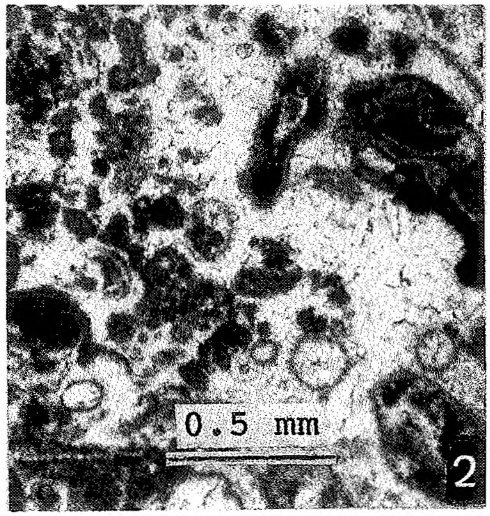
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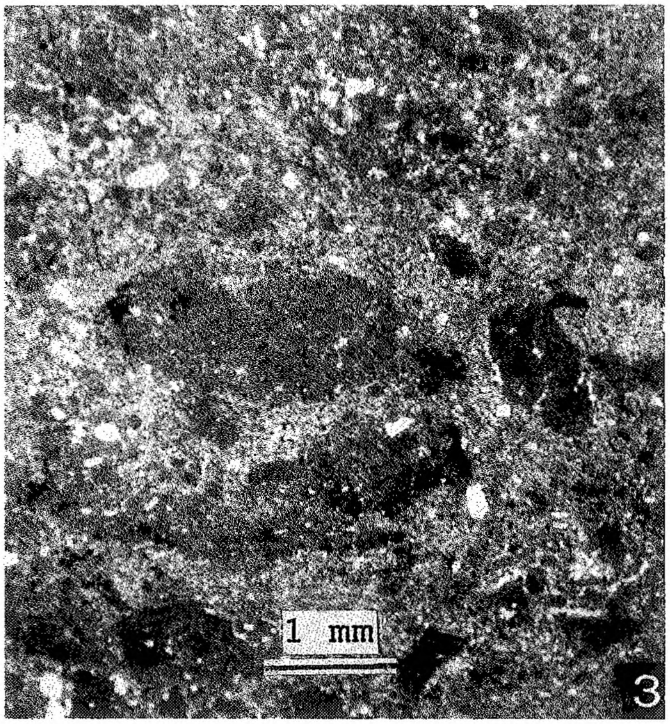
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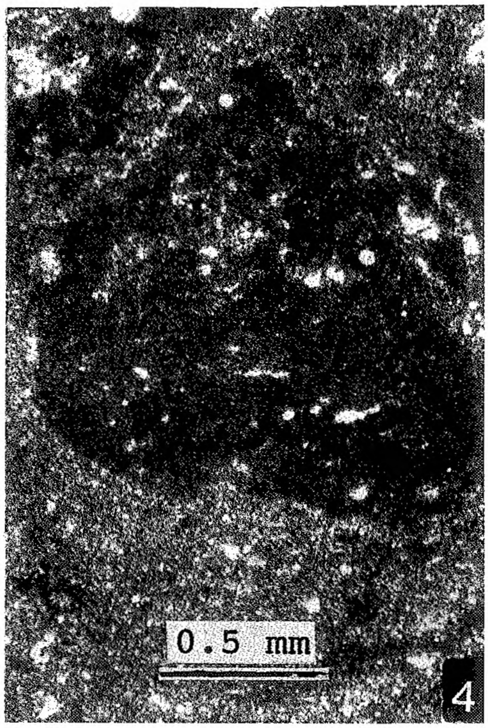
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