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FACIÈS, PALEOGEOGRAPHY AND DIAGENETIC EVOLUTION OF THE LADINIAN/CARNIAN VETERLÍN REEF COMPLEX, MALÉ KARPATY MTS. (WESTERN CARPATHIANS)

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Abstract: The Veterlín reef complex is formed by a 600 - 1200 m thick sequence of Upper Ladinian to Lower Carnian carbonates, which may be divided into slope megabreccia, calciturbidites and grain flow deposits, fore-reef detritic limestones, biogenic limestones of reef cores, and back-reef and organogenic cyclic, often dolomitized limestones. The article describes the microfacial, geochemical and biofacial features of individual zones, and the special features of the diagenetic development of the carbonate reef complex.

Key words: carbonate platform facies, sedimentology, reef progradation, biohermal buildups, limestone diagenesis, Middle Triassic, Western Carpathians.

Introduction

The thick masses of carbonates, forming a significant part of the Middle and Upper Triassic sedimentary record in the Mediterranean part of Tethys are attractive objects, not only for sedimentological and paleobiological studies, but also for global paleogeographical and paleotectonic speculation. Epting et al. (1976) mentioned the development of the Middle Triassic carbonate platforms of this district in connection with synsedimentary tectonic activity. Tensional strain at the end of the Ladinian, caused a structural differentiation of the original Alpine-Carpathian shelf, into a complex mosaic of elevations and depressions. This conclusion derives from the controversial "stationary" (tectonically controled, cf. Blendinger 1986) and dynamically tuned model (emphasizing the dynamics of actual sedimentary processes, cf. Bosellini et al. 1977; Bosellini 1984; Roeder 1987 etc.) of carbonate platforms of this age. Roeder (l.c.) already emphasized the four times greater speed of sedimentation on carbonate platforms, compared to basins, which could lead to the growth of a bathymetrical difference between the two parts of a sedimentary area of thousands of metres, even without the activity of endogennic tectonics.

The Ladinian and Lower Carnian carbonate platforms form a wide belt, along the margin of Tethys. The Southern Alps and the highest Austro-Alpine nappes of the Northern Alps and Western Carpathians, provide classic terrain for the study of them.

Regional setting

The northern part of the Malé Karpaty Mts. (Fig. 1) is formed by the thick Triassic carbonate masses of the Veterlín and Havranica Nappes. This tectonic body was originally connected with the overthrust of an original Paleo-Alpine nappe (Michalík 1984; Plašienka et al. 1991). Their sequence contains a record of a Middle Triassic differentiation process in the Alpine-Carpathian carbonate shelf. Its microfacial and geochemical characteristics are given by Masaryk (1987), Lintnerová & Masaryk (1988), Lintnerová et al. (1990) and Lintnerová & Hladíková (1992). The carbonate sequence consists of Anisian Gutenstein Dolomite (40 m), Anaberg Limestone (200 - 250 m), Steinalm Limestone (12 - 120 m), Zámostie Formation (30 - 40 m), Ladinian Reifling Formation (40 - 60 m) and the "Veterlín reef complex", formed in a carbonate platform (600 - 1200 m). The overlying beds of the last lithostratigraphic unit (Lunz Beds? Opponitz Limestone? Hauptdolomit?) were tectonically removed, elsewhere transgressively overlapped by Paleogene, or Miocene clastic sediments (Fig. 2). In the past we studied the problems of the Veterlín reef complex on the north west slopes of the Malé Karpaty Mts. (the Vajarská, Kršlenica, Čelo and Veterlín profiles), in the Brezová range (the Jablonica, Dobrá Voda, U Fajnorov profiles), and in the Beckov castle hill near Nové Mesto nad Váhom (Fig. 1).

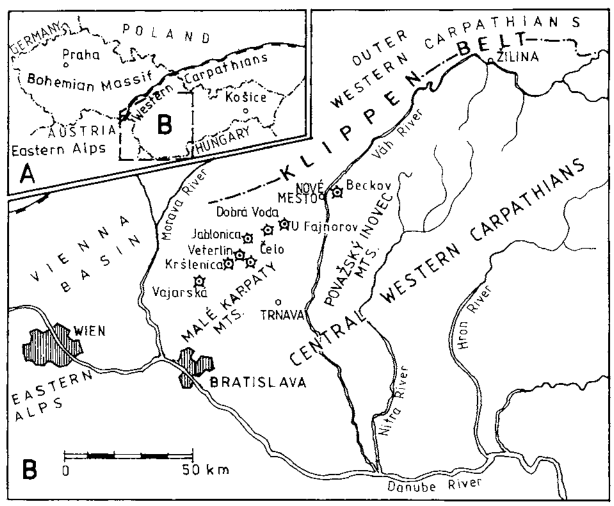

Fig. 1. Situation sketch of the area studied (A) and the sections of the Veterlín reef complex (B).

The sequence of this complex usually begins with well stratified organodetritic Grafenstein and Raming Limestone. Masses of mega-breccia, composed of large clasts (1 - 30 m in diameter) of organogenic limestones follow above them (Fig. 3). The clast-supported matrix is formed by small, mostly dolomitized clasts.

Facies and environments

Platform carbonates

Back-reef facies

Lithology and microfacies: Light grey to white massive and laminated limestones, dolomitized limestones and dolomites. Biosparitic, intrasparitic, and pelsparitic limestones (grainstone, rudstone and floatstone) contain micritized bio and lithoclasts. Part of the sequence was diagenetically dolomitized, and is formed mostly by planar, polymodal dolosparites (in the sense of Sibley & Gregg 1987) with ghosts of the original structure. The total thickness reaches 700 to 1000 m.

Geochemistry: The massive dolomitized parts are formed by coarse crystalline dolomite. Some samples have 15 to 20 % calcite in the network of veinlets and infilling. The molar % of $CaCO_3$ in the dolomite (X-ray diffraction analysis Goldsmith & Graf 1958; Lumsden 1979, 10 samples analysed) varies from 50 to 51.5 %. The composition of dolomite close to a stechiometric composition is a product of later diagenetic dolomitization. The values of microelements are more significantly undifferentiated (Sr: 65 - 100 ppm, Mn: 30 - 100 ppm, Fe: Na: 310 - 670 ppm). The quantity of Na is evidence of increased salinity of the dolomitization solutions (in comparison with sea water). It is not certain, whether these solutions originated in younger supratidal environments, or are buried residues of marine solutions.

Organisms: The species *Endothyronella wirzi* (Koehn-Zaninetti), *Agathammina austroalpina* Kristan-Tollmann & Tollmann, *A. iranica* Zaninetti et al., *Trochammina almtalensis* Koehn-Zaninetti are characteristic of the little diversified foraminifer association. Elements characteristic of a pure lagoon environment are missing from the association. Only strongly recrystallized tests of ? *Aulotortus praegaschei* (Koehn-Zaninetti) and ? *Pilammina gemerica* Salaj were identified. Mass occurrences of these species are characteristic of Ladinian to Lower Carnian platform facies, especially the Wetterstein Limestone of the Slovak Karst (Jendrejáková 1973; Salaj, Borza & Samuel 1983 etc.). However since our finds so far are supported by only one profile worked out in detail (I/82 Dubník, Masaryk 1987), it is not possible to generalize from them.

Dasycladacean algae, with typical fossils of lagoonal limestones, occur in two different association. *Teutloporella herculaea* (Stopp.) Pia, *T. aequalis* (Guemb.) Pia, *Aciculella bacillum* Pia, *Diplopora annulata* (Schafh.), and *Teutloporella nodosa* (Schafh.) Pia form one. The association is typical of the near-reef part of a lagoon. It is accompanied by solenoporacean and porostromate algae *Solenopora* sp., *Rivularia lissaviensis* (Borneman) Dragastan, *Micheldeania* cf. *americana* (Johnson) Dragastan. The sphinctozoa, *Girtyocoelia oenipontana* Ott, *Colospongia catenulata* Ott, *Vesicocaulis alpinus* Ott, *Folicatena cautica* Ott, *Solenolmia manon manon* (Münster) Senowbari Daryan & Riedel, the porostromate algae, *Rivularia* sp., *Tubiphytes obscurus* Maslov, ostracods, crinoids and bivalves are represented in the sponge-algae zone.

A second association includes the typical Carnian species *Andrusoporella duplicata* (Pia) Bystrický and *Griphoporella* sp. It is known so far from only one occurrence (Buček et al. 1991).

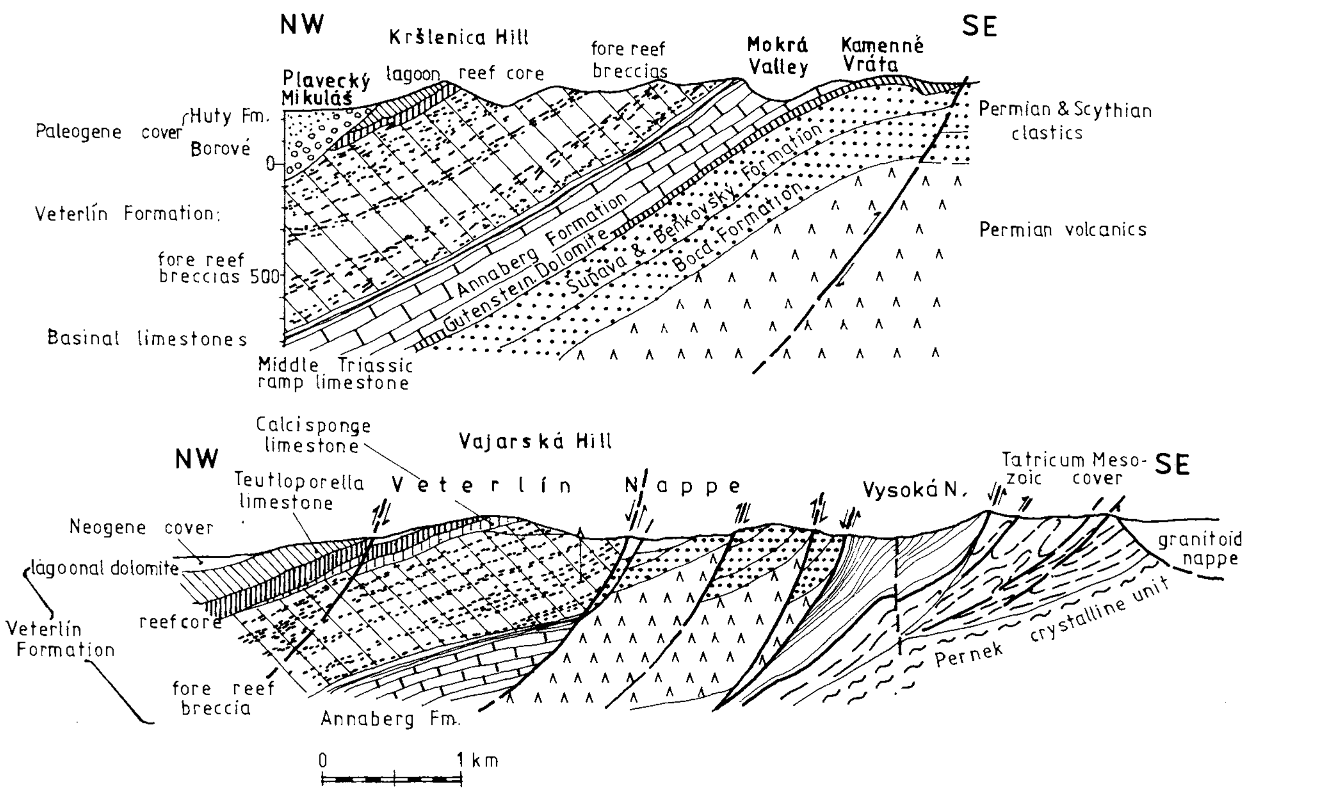

Fig. 2. Geological cross-sections of the Kršlenica Hill and the Vajarská Hill, consisting of the Veterlín reef coplex.

Depositional environments: Sediments of back-reef platforms and lagoons with prevailing coarse-detritic (sparitic) limestones originated in a highly energetic environment. Dasycladacean algae, which are also preserved occasionally in dolosparites, are a good indicator of environment. A community of miliolid foraminifers and dasycladacean algae (*Diplopora*) is characteristic of a lagoon facies, for which a less dynamic environment is characteristic (the central part of the lagoon). On the other hand, associations of calcareous sponges with dasycladaceans (*Teutloporella*) are characteristic of the more dynamic environment of the margin of the lagoon towards the reef platform (Ott 1967).

Reef facies

Lithology and microfacies: In the middle part of the Kršlenica profile (Fig. 4) the fore-reef coarse-clastic facies changes to to the body of the reef itself. In the main part of the reef, massive white-grey and cream biolithite limestones (bindstones and bafflestones) with organogenic structures prevail (Pl. I, 1,3). The biolithites are composed of scleractinid corals (framestones), found only in clasts of fore-reef breccia. Above these are massive coral-algal limestones gradually changing to bioclastic sparite limestones. The biodetritic sparites (grainstones, rudstones) are composed of peloids and skeletal grains (Pl. I, 2, 4-6).

Geochemistry: In the undolomitized organogenic (organoclastic) limestones of the reef margin, the Sr content (8 samples) ranges from 115 to 198 ppm; the values for Mn (20 - 70 ppm) and Fe (60 - 170 ppm) are very low and even. The content of Na is much lower than in the preceeding dolomites. However in some dolomitized limestones it is moderately raised. A significant decrease in Sr, compared to the supposed original composition of reef limestones is connected with the openess of the (early) diagenetic resp. of the diagenetic environment (the high porosity of reef bodies and the dynamic flow of solutions). The increased proportion of meteoric solutions, if their mixing (zone of dissolution) with sea water was not simply added. The content of $\delta^{13}C$ in rock samples (Lintnerová & Hladíková 1992), and in the cement of reef limestones (Fig. 6) was relatively high and vary little. The decrease in Sr, as also the negative movement of $\delta^{18}O$ could be influenced by solutions of marine origin.

Organisms: The prevailing biocomponents of the upper part of the Kršlenica profile are especially *Sphinctozoa*, and *Tubiphytes*, with fewer gastropods, brachiopods, echinoids and other groups of fossils. Foraminifers are scarce: isolated occurrences of *Ophthalmidium tori* Zaninetti & Broenimann, *Paraophthalmidium* sp., *Paleolituonella meridionalis* Luppert, *Galeanella* sp., *Agathammina austroalpina* Kristan-Tollm. & Tollmann, *Endothyra kuepperi* Oberhauser, *Duostomina turboidea* Kristan Tollmann, *D.* sp., *Turriglomina* sp. The community is characteristic of Carnian associations away from reef cores, typical reef elements are scarce.

Calcareous sponges, small colonial corals, dendroidal tubiphytes, colonies of the solenoporaceans, *Holcoelia toulai*, the massive hydrozoa ?*Disjectopora* sp., the porostromate algae, *Tubiphytes obscurus, Thaumatoporella parvovesiculifera* and *Ladinella porata*, represent primary builders of the reef.

Depositional environment: Part of the margin of the platform may be interpreted as a skeletal sandy shallow with a highly dynamic environment. The greater part of the platform margin had a reef character and the sediment was stabilized by colonial (binding and encrusting) organisms such as blue-green algae, calcareous sponges (*Sphinctozoa*) and *Tubiphytes*. The margin of the carbonate platform probably had the character of small isolated reef bodies, divided by skeletal-sandy shallows.

Fig. 3. Panoramatic view on the southern slope of the Kršlenica Hill, exposing upper slope megabreccia deposits and reef margin of the Lower Carnian Veterlín reef complex.

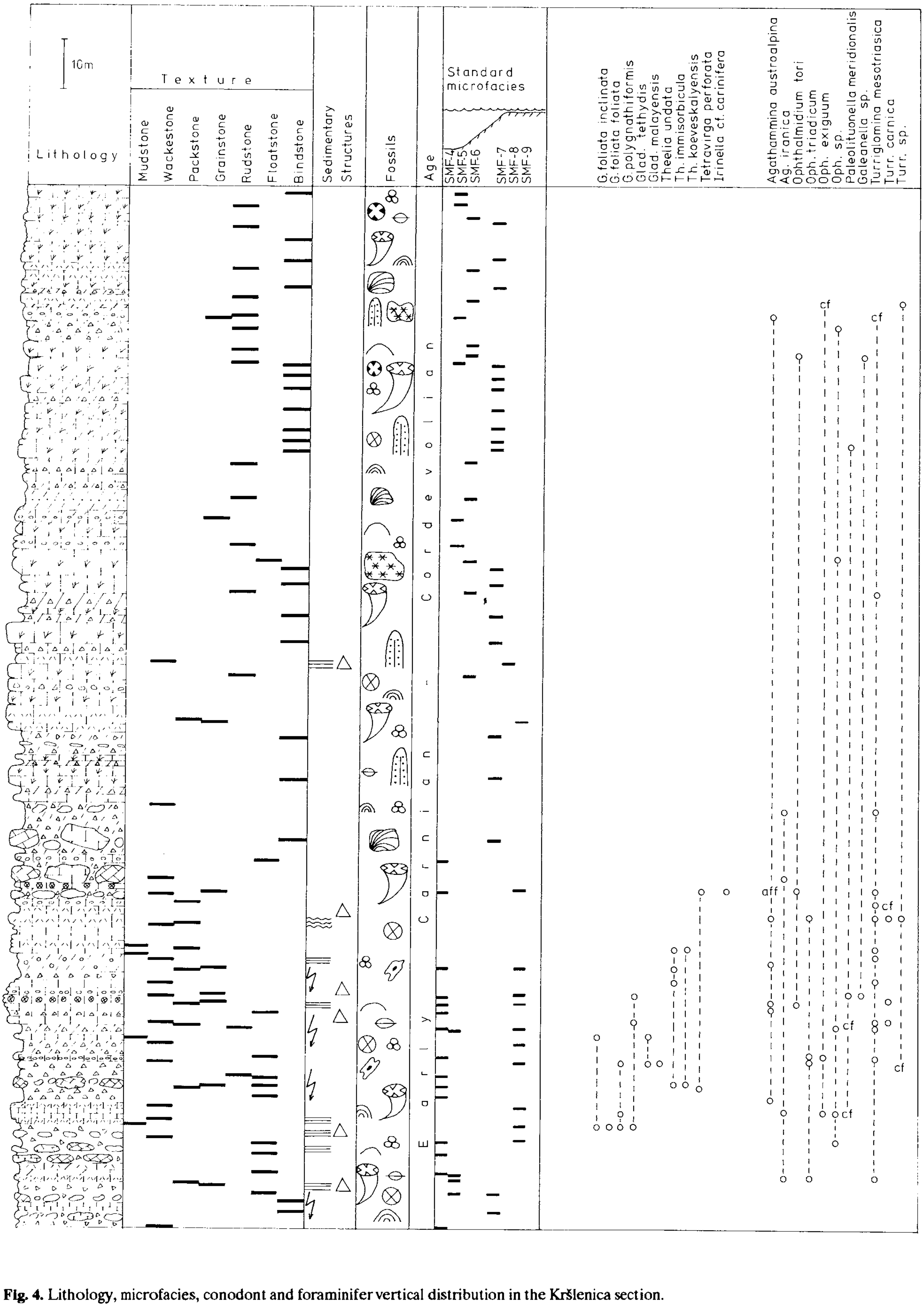

Fig. 4. Lithology, microfacies, conodont and foraminifer vertical distribution in the Kršlenica section.

Fore reef facies

Lithology and microfacies: Breccia and megabreccia are the most frequent type of facies in the upper, relatively steeper part of the platform slope. It occurs in the districts of Kršlenica, Veterlín, Čelo and Vajarská (Fig. 1). Coarse-detritic to breccia sparitic limestones (rudstones) with an average size of clasts of 0.5 - 3 *cm*, derived from the limestones of the platform margin, form the basic material of the breccia. Individual blocks, from the reef and near-reef zones, reach a size of up to 20 m . The composition of the clasts is relatively monotonnous, with white-grey and cream organodetritic and organoclastic limestones prevailing. The size of clasts increases in an upward direction, that is in the direction of the platform margin. The proportion of basic material to clasts is 4 : 1.

Detritic-breccia limestones contain large isolated blocks (0.1 - 10 m) of light organogenic and biodetritic limestones with reef organisms (Figs. 3, 5). They are formed by biosparitic and intrasparitic limestones (grainstone, rudstone), and only occasionally by micritic limestones (wackestone, packstone and floatstone). Apart from bioclasts of reef forming organisms and intraclasts, there are also microfossils and pellets in the detritus (Pl. II).

Geochemistry: The light organodetritic limestones attributed to the fore-reef facies are only slightly distinguished by their chemical composition. They are distinguished from the reef facies by increased values of Sr, and moderately raised IR (in the bore-hole MKBZ there is also the influence of silicification) dependent on the fall in the content of organo-clastic (reef) material. This dependence does not appear in the dolomitized limestones, where the content of Sr is lowered, but in places the Na content is increased. The higher Sr contents (170 - 230 ppm), both in the Kršlenica profile and in the bore-hole MKBZ, are associated with darker organodetritic limestones with micritic (recrystallized) basic material. In light limestones with detritus from reef-forming organisms (blocks in the breccia), the Sr content (100 - 170 ppm), and the contents of Mn, Na and Fe are unchanged.

Organisms: Thick "scarp" breccias with clasts of lagoon limestones (bore-hole MKBZ under Vajarská) contain an association of the foraminifers *Pilammina gemerica* Salaj, *Aulotortus pregaschei* (Koehn-Zaninetti), *Trochammina alpina* Kristan-Tollmann, and more rarely *Pilaminella kuthani* (Salaj), *Endothyra austrotriadica* Obenhauser, *Duostomina magna* Trifonova, *Diplotremina* sp. and others. Forms from basinal facies, *Lamelliconus cordevolicus* (Oberhauser) and *L. multivolutus* (Oberhauser) occur sporadically.

Communities from the upper part of the Beckov profile (Pl. IV, 5) have a different species spectrum, composed of small *Agathammina austroalpina* Kristan-Tollmann & Tollm., together with *A. iranica* Zaninetti et al. *Turriglomina* sp. and nodosariid forms are characteristic elements. We also noted *Pachyploides kleberebergi* (Oberhauser) and *P. iranicus* (Oberhauser), relatively rare in the Western Carpathians. Apart from *Agathammina*, *Ophthalmidium exiguum* Koehn-Zaninetti, *O.* cf. *tori* Zaninetti & Broenimann, *Valvulina azzouzi* Salaj, *Reophax* sp., *Trochammina tatasensis* Broen. et al., *Paleolituonella meridionalis* Luppert, *Galeanella* sp. and other forms occur in the Kršlenica profile.

The absence of *Turriglomina* and *Endothyranella* are characteristic of the association from the Veterlín profile. The miliolid forms *A. austroalpina*, *A. iranica*, *Gsolbergella spiroloculiformis*, *Ophthalmidium* sp., *O. tori*, *O.* cf. *fusiformis* form it. Finds of foraminifers of the subfamily *Spiriamphorellinae* (Buček 1989) indicates a Cordevolian - Julian age.

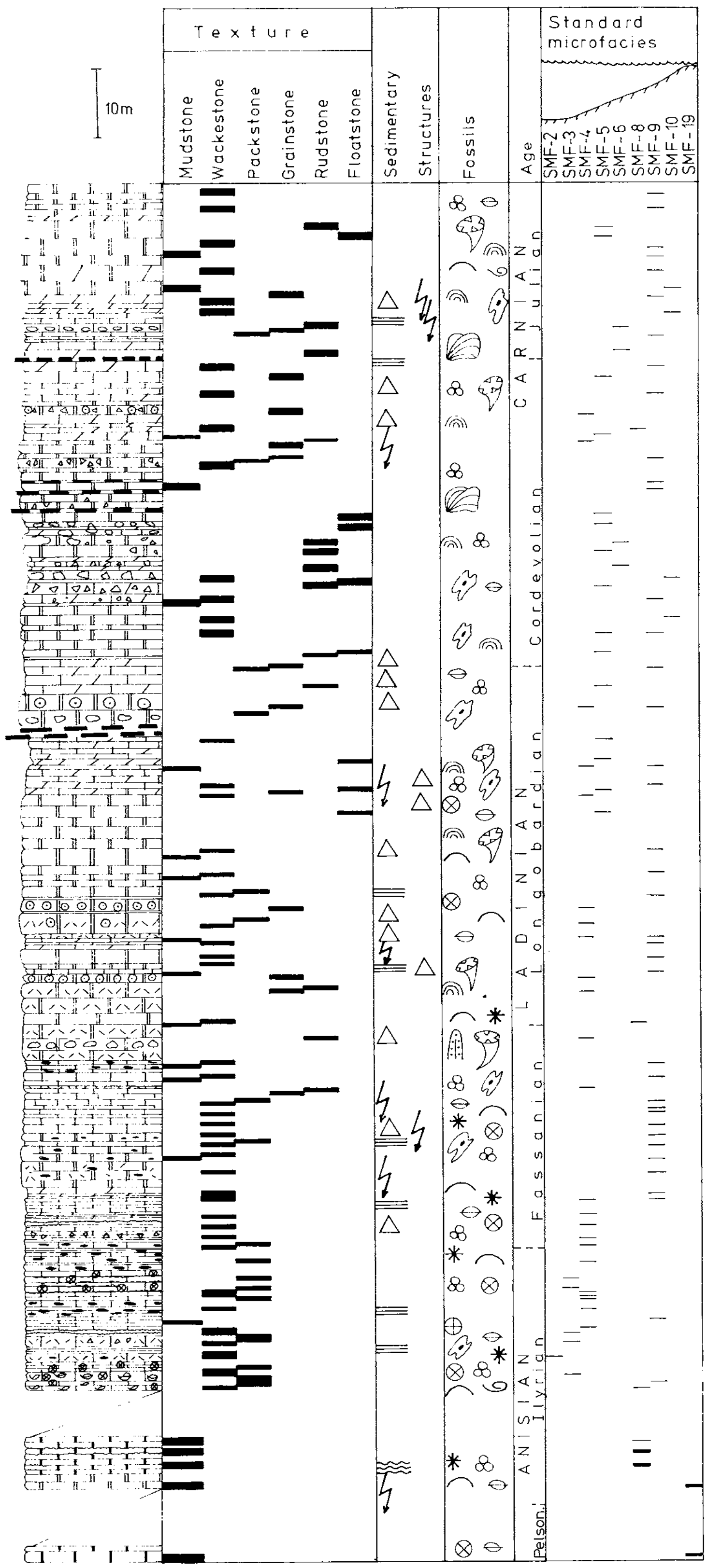

Fig. 5. Lithology and microfacies in the Beckov section.

Depositional environments: The lithofacies of coarse breccias and megabreccias represents sediments of an area closely under the margin of cliffs. Their chaotic arrangement and material dependence on the character of the platform margin are characteristic.

The lithofacies of detritic limestones with isolated blocks are characteristic of conditions of sedimentation of the upper part of the platform slope, and large blocks of reef limestones coming from the cliff margin, or near platform talus. In the case, that the platform margin had a character of skeletal-oolitic sands, the larger blocks and clasts of limestone may be completely lacking, as in the Beckov profile (Fig. 5).

Slope sediments

Lithology and microfacies: Dark-brown laminated limestones are a contrasting type of sediment, different from the neighbouring members of the sequence. Finely detritic calcarenites (grainstones) and micritic limestones (mudstones to wackestones) form a deposit in the middle of the breccia limestones in the Kršlenica profile (Figs. 2, 4) and Veterlín. Micritic and pelmicritic limestones with a low proportion of detritus and isolated deposits of calcareous graded calcarenites (grainstones) prevail. In the detritus, peloids, and granulated bioclasts and lithoclasts prevail (Pl. III). Foraminifers, crinoids, ostracods and microproblems are less represented.

Bedded laminated limestones with even bedding planes contain up to 20 % pelagic alochems (filaments, radiolarians, needle sponges and peloids). There are occasional nodular beds and cherts. This periplatform type of sediment consists of autochthonous basin sediments, and also of allochthonous detritic sediments. Biomicritic limestones (mudstone-wackestone), in which pelagic biomicrites and intramicrites alternating with biosparites and intrasparites (grainstones) prevail. Normal gradation, fine diagonal and parallel laminated intervals are characteristic of detritic sparitic turbiditic deposits of turbidites derived from the platform margin and slope. Detritic insets in the lower part of the formation are only a few centimetres in thickness, but in the upper part they reach some tens of centimetres. The limestones contain algal problematics, oncoliths, bioclasts and lithoclasts. The proportion of detritic limestones and the thickness of laminae gradually increases upwards, while the granularity and qualitative composition of alochems changes. Coarse-detritic biosparitic limestones (grainstone and rudstone), with shallow water organic detritus, from the reef and near-reef zones, prevail.

Geochemistry: The slope environment is reflected in the increasing IR (0 - 10 %), decreasing dolomitization and changes in the content of microelements. IR is formed by siliceous material and detritic clayey minerals. Increasing contents of Ba, B, Ti and V are connected with the increase in IR. The values for Sr (a total range of 100 to 300 ppm) are not increased in comparison to the values for fore-reef limestones. Only one sample from the Vrátno - east profile has an exceptionally high content (2000 ppm). The distribution of values of Sr does not indicate a change in the depth of sedimentation (the source material was similar). Changes in bathymetry and speed of sedimentation could be reflected in oxidation-reduction conditions, and therefore in the contents of Fe and Mn in the sediments. The content of Mn in the Vrátno - east (170 to 420 ppm) in comparison with lower values in profiles from the Biele Hory and Jablonica (60 - 120 ppm) could reflect relatively deeper water conditions. Limestones from the U Fajnorov quarry (120 - 200 ppm) have relatively higher and comparable contents of Mn. However we did not observe a similar or other dependence in the distribution of values for Fe (included in carbonates), although their range fluctuates enough (100 to 2000 ppm). The iron content is raised in deposits of black bituminous limestones (1.64 % Fe_2O_3) from the Jablonica quarry, where the Mn (690 ppm), Sr (430 ppm) and Ba (550 ppm) contents are also raised, with a relatively high degree of silicification of samples (11 %). The quantity of totally organic carbon in samples does not reach a value of 0.1 %. The direct dependence of the contents of Mn and Sr was also not confirmed, when both reflect changes in conditions of sedimentation.

Organisms: Organic remains are mostly redeposited, with foraminifers, crinoids, ostracods and micro-problematics among the better preserved. An association of conodonts (*Gondolella foliata inclinata* Kovács, *G. polygnathiformis* Budurov & Stefanov, *G.* cf. *foliata foliata* Bud. & Stef., higher *Gladigondolella malayensis* Nogami and *G. tethydis* (Huckr.)), sclerites of holoturians (*Priscopedatus* cf. *tyrolensis* Mostler, *Theelia koeveskalensis* Most., *Achistrum* sp., *Tetravirga perforata* Most., *Acanthotheelia* sp.), micro-problematics *Irinella* cf. *carinifera* (Kristan-Tollman), sclerites of ophiuroids, roveacrinids, sponge spicules, sea-urchin spines and fish teeth, comes from the Kršlenica profile (Pl. IV).

The foraminifer associations are relatively varied, with representatives of species of various facial zones. The alternation of pelagic micrites with allodapic detritic deposits is reflected in the species spectrum and total character of the paleo-association.

The community associated with the micritic limestones is limitted to nodosariid foraminifers, together with *Turriglomina mesotriasica*, appropriately small tests of *Agathammina austroalpina* and *A. iranica*. The association is characteristic of the lower part of the formation and is reminiscent of the associations of the Reifling and Grafenstein formations. In an upward direction, detritic limestone increases, and the character of the community also changes. The foraminiferal fauna has a mixed character of biocenose basins and shallow water (Pls. V - VI). *Turriglomina* and *Agathammina* are present. Ophthalmidia (*O. triadicum*, *O. fusiformis* and others) form a significant component. From elements characteristic of the reef core zone, *Paleolituonella meridionalis*, *Reophax* sp. appear most frequently, *Galeanella* sp. is rarer. Isolated tests are found, very close to the Norian species *Miliolipora* aff. *cuvilieri*, *Hydrania* aff. *dulloi* (in the Jablonica profile). The most frequent of the accompanying forms are the species *Trochammina alpina*, *Valvulina azzouzi* and *Endothyranella wirzi*.

Depositional environment: The dark laminated limestones originated in a period of slower sedimentation on the lower part of the platform slope. They have all the signs typical of proximity to the transition to a pelagic basin. In various proportions, single elements characteristic both of shallow water carbonate platform environment, and of relatively deep water sedimentation, are represented here. Allodapic deposits with normal gradation, oblique and parallel lamination, regularly alternating with deposits of pelagic micritic limestones originated from gravitational flows, reminiscent of turbidity currents. Coarse-clastic sediments without alternation and gradation, characteristic of the upper part of the formation, are probably products of submarine slides (mass and debris flows).

Basinal sediments

Lithology and microfacies: Basinal facies are only secondarily represented in the profiles studied, mostly in their lower parts (Figs. 4 - 5). Towards the basin alochthonous deposits rapidly lose detritic limestones. Micritic and finely detritic (occasionally laminated) nodular limestones (wackestone) and bituminous micrites (mudstones) with a clayey admixture and cherts, locally with deposits of dark claystones. Thin insets of allodapic graded bedded limestones are rare. Two basic lithofacies of the Reifling Formation ("Reifling Bankkalk" and "Reiflinger Knollenkalk" sensu Bechstädt & Mostler 1976) represent limestones of this type.

Geochemistry: A generally increased content of Sr (from 200 to 1100 ppm), in comparison with shallow water limestones is characteristic of Reifling limestones. However in the profiles described, this does not appear so significantly. A significant facies of basinal limestones is known from bore-hole DV-1 (Michalík et al. 1992).

Organisms: Basinal sediments most frequently contain radiolarians, filaments and sponge spicules. There are occasional fragments of foraminifers, ostracods, crinoids, globochoets and conodonts.

Depositional environment: The Reifling intra-platformal depression is marked by relatively deep-water carbonate sedimentation. The content of organisms, which had a share in the creation of the sediments "in situ", was in the range 15 - 20 % (filaments, globochaets, radiolarians), but the main part of the calcareous ooze was derived from the area of the carbonate platform. The fact, that in the central part of the this depression, distant from the platform margin, the proportion of clayey material increases, and there are frequent deposits of dark claystones, speaks in favour of confirming this. The calcareous ooze and detritus here were transported by turbidity currents, which represented the most distant transport mechanism tending towards the basin. The semi-isolated basin, with insignificant circulation of water (anoxic conditions) did not have a permanent connection with the open sea. The impoverished, little diversified macrofauna and microfauna chiefly document this.

Cement and diagenesis

Cavities filled with various generations of isopachic calcite cement and cavities with unstratified block filling of pure calcite are the most frequent diagenetic phenomena in the limestones of the Veterlín reef complex.

The first type answers to the cavities known as "evinosponge". This term was introduced to the literature by Stoppani (1858), who considered stratified filled cavities to be amorphous sessile incrustation fossils (fibrous sponges). Cosjin (1928) and Hofsteenge (1932) recognized the inorganic origin of "evinosponges", which according to them represent cavity cements. German (1971) described similar cavity structures, with various generations of fibrous calcite layers, from the Wetterstein limestones of the Northern Calcareous Alps, under the older name "Grossoolithen". The origin of "evinosponges" and "Grossoolithen" in conditions of marine-freatic and freatically-meteoric diagenesis is proved by studies of crystalline structure, cathodoluminescence and geochemistry by Brandner & Resch (1981), McKenzie & Lister (1983), Henrich & Zankl (1986), Jadoul & Frisia (1988), Frisia-Bruni et al. (1989) and others.

Brown coloured isopachic (palisade) calcite cement filled the reef structure of the Veterlín Limestone (calcareous sponges *Sphinctozoa*, small nodules of *Tubiphytes*, corals and others, Pl. VII). The evinospongal structure grew in various generations, in the larger cavities. Their contact with neighbouring limestones is regularly erosional, influenced by internal dissolution. Stratified isopachic and circumgranular cement are sharply placed on the irregular walls of cavities. More rarely the walls of cavities are micritised (evidently by algal micritisation), or covered by thin laminae of calcilutite (speleothemic micro-dripstone, Assereto & Folk 1980). The calcite of the isopachic cement is formed by polycrystalic agregates with pseudo-radiaxial habits.

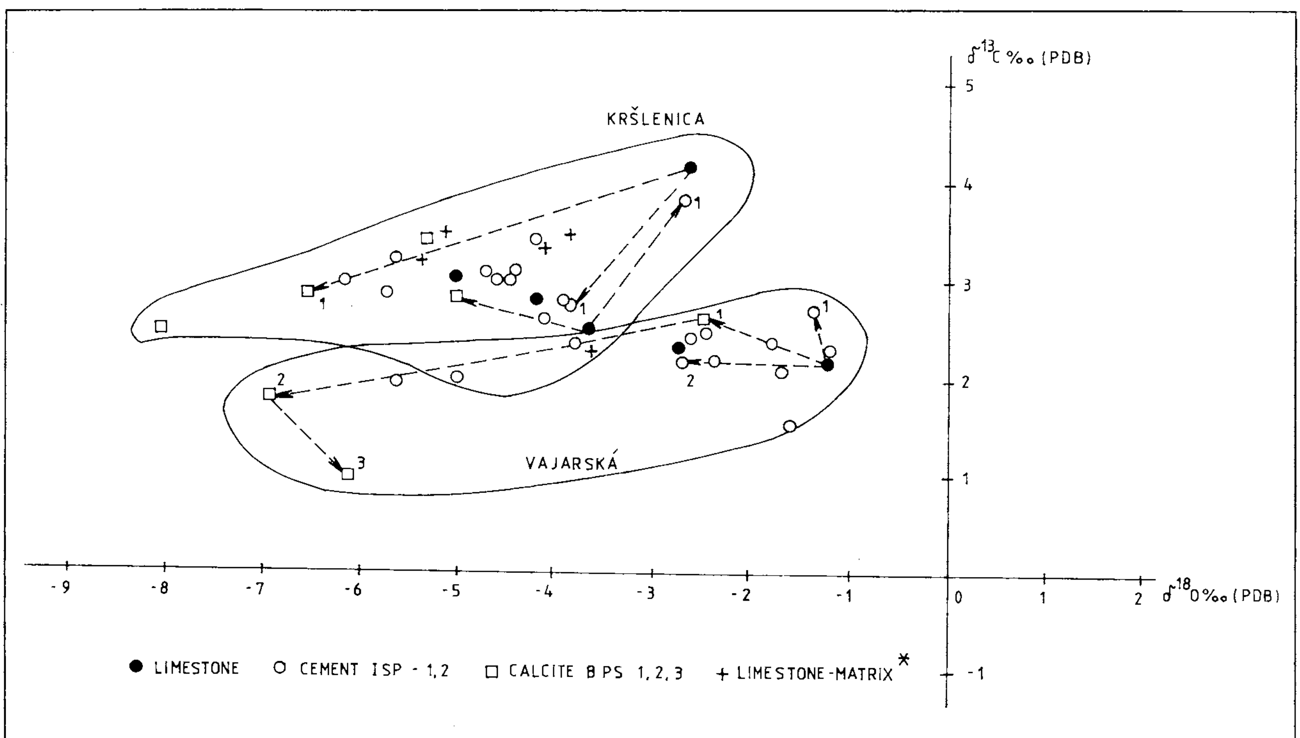

Fig. 6. Distribution of $\delta^{13}C$ a $\delta^{18}O$ (PDB) content from two localities documenting differencies in limestones, isopachous cements (ISP) a blocky calcite (BPS). Compared samples of limestone matrix from Kršlenica hill are denoted by crosses (Lintnerová & Hladíková 1992). Differencies in $\delta^{13}C$ a $\delta^{18}O$ content are denoted by broken lines: these limestone and cement samples characterize general trend of isotope distribution.

Radial crystals of isopachic cement have a divergent optical orientation (fasicular optic calcite). Primary individual and deposited neomorphic (cannibalistic) crystals are identifiable among them. Radial crystals of the initial cement, cut down the activity of dissolution and syntaxial growth at new points, are connected with the filling of the remaining pores. Meanwhile the crystals of isopachic cement are made impure, often found with cleavage of twin laminae, undulations and have irregular intercrystallic limitation, points of syntaxial growth are pure and scalenoedric limited. Rays of pseudo-radiaxial calcite have suture like intercrystalic areas in cross-section. The contact between two generations of isopachic cement is regularly syntaxial, or is marked by small scalenoid of dolomite. Whether pseudo-radiaxial calcite is actually the primary component of the isopachic cement is not entirely clear. Its crystallographic transformation from bundles of axial coincidental needles of metastable aragonite (composite crystals) is also possible. The original evinosponges have little stability and almost always succumb to paramarine inversion (Mazzullo 1980).

The remaining pore cavities (centres) are filled by coarse blocks of pseudosparite (BPS), that is rhombohedralic crystals of calcite. However, the final phase of calcite blocks is not always developed and the crusts of isopachic cement (opposite-radiaxial cement) come directly into contact. In special cases, cavities of polygonal form are filled by monocrystallic calcite blocks in Veterlín limestones in the the Kršlenica profile. These cavities do not have isopachic borders and their contact with the surrounding limestone is uncorrosive. The block calcite of the remaining pores sometimes enclose inclusions of microdolomite, which may be evidence of its origin by recrystallization from metastable high-Mg calcite. Filling by block calcite in the Veterlín limestones may represent burial cement. These cavities did not form a connected pump system in the reef, since their walls are not eroded by the circulation of water fluids and are not initially cemented. They are probably isolated eogenetic, and as such had to filled with marine cements. Although the block low-Mg calcite may not be precipitated from marine pore water (Frisia-Bruni et al. 1989), calcite blocks in the Veterlín limestones are paramorphose fillings of preexisting cement, or recrystallized from the remaining undersaturated solution (Mg penetrated to the surrounding sediment and was active in dolomitization).

Table 1: Different values of $\delta^{13}C$ a $\delta^{18}O$ (PDB) in one limestone sample and in cements (ISP - isopachoos sparite of the I. a II. generation), and in calcite BPS (blocky pseudosparite).

Sample	$\delta^{13}C$	$\delta^{18}O$	Sample	$\delta^{13}C$	$\delta^{18}O$
	‰(PDB)			‰(PDB)	
Vajarská limestone	2.2	-1.5	Kršlenica limestone	3.1	-5.0
cement ISP I	2.2	-2.7	cement ISP I	3.0	-4.6
cement ISP II	2.7	-1.4	calcite BPS	2.5	-8.0
calcite BPS-1	2.6	-2.5	cement ISP I*	2.8	-3.9
calcite BPS-2	1.8	-6.9	cement ISP II*	2.6	-4.1
calcite BPS-3	1.0	-6.1	calcite BPS *	3.4	-5.3

Sample	CaO	MgO	Sr	Na	Mn	Fe
			wt. %			*ppm*
Vajarská limestone	51.08	4.33	153	264	42	125
calcite BPS	52.80	0.44	311	108	29	70
calcite BPS	55.24	0.68	247	140	33	62
Kršlenica limestone	55.66	0.39	130	53	49	72
calcite BPS	55.52	0.27	145	79	230	166

* - another sample

BPS-1 corresponds to margin of a crystal, BPS-2, 3 is a center of the crystal. Data from two localities (Kršlenica Figs. 3, 4 and Vajarská) are correlated.
Content of CaO, MgO (wt. %), Sr, Na, Mn, a Fe was estimated by AAS method from homogenized limestone samples and from blocky pseudosparite, separated mechanically.

The isotopic composition of the cements (point sampling from polished slabs was studied in samples from two localities - Kršlenica (22 analyses - part of the profile formed by reef limestones comparison of analyses Lintnerová & Hladíková 1992) and Vajarská (18 analyses - lagoonal algal limestones). The contents of Ca, Mg, Mn, Fe, Sr, Na (Tab. 1) were followed in block calcite. The results of the analyses establish the differences in $\delta^{13}C$ and $\delta^{18}O$ of cements and fillings in comparison with the actual limestones and also determine the differentiation between the two localities mentioned (Fig. 6). The values for $\delta^{18}O$ from Vajarská are higher both in the cements and in the actual limestones (-3 to -1.2 ‰) than those from Kršlenica (-2.6 to 6.2 ‰), but on the other hand $\delta^{13}C$ is relatively lower (1.5 to 2.5 ‰) and (2.0 to 4.1 ‰) respectively.

Values (Tab. 1) from the filling of block calcite (Fig. 6) differed significantly from them. We can also follow the movement in the samples from Kršlenica. Differences also appear in the chemical composition of these fillings. Homogenized samples were analyzed (Tab. 1), so that they may not signalize changes in crystalization, as is recorded by isotopic composition. The margin of BPS calcite is less distinguished from the surrounding limestone in $\delta^{13}C$ and $\delta^{18}O$, than from the central part of the calcite (Tab. 1). The limestones and calcareous cements differ less completely in the values of $\delta^{13}C$ (e.g. a sample from Vajarská: $\delta^{13}C$ 2.0 to 2.4 ‰) than in the variation in $\delta^{18}O$ (-1.2 to -5.6 ‰). In part of the samples, we compared the substantial movement in $\delta^{13}C$ (limestones 4.1 ‰, cement 2.8 - 3.4 ‰), as also the negative movement in $\delta^{18}O$ (for the same samples from -2.6, and -3.9 to -4.5 ‰). The dissolution of cavity walls before the precipitation of isopachic layers betrays freatic conditions of diagenesis (Frisia & Bruni et al. 1989). The dolomitization of the walls of evinosponges (dolomitization in the the zone of mixing) may also be evidence of the perculation of meteoric water in the cavity system of the Veterlín limestones. The smaller difference in the content of $\delta^{18}O$ between the initial cement and the surrounding limestones may also reveal the influence of meteoric waters (filling of pores, but also recrystallization of limestones after the origin of sparite with a reduced isotopic composition). We may compare the values with $\delta^{18}O$ values from Upper Triassic aragonite tests, which Scherer (1977) quotes.

The reduction in the proportion of $\delta^{18}O$ in the younger generation of isopachic cement (ISP) could reflect an increase in the proportion of meteoric water (e.g. Kršlenica ISP I.: -4.7 ‰, ISP II.: -5.6 ‰, or ISP I.: -3.9 ‰, ISP II.: -4.1 ‰, Vajarská ISP II.: -1.2 ‰, ISP III.: -5.6 ‰.). The increase in $\delta^{18}O$ in isopachic cement (but especially in the cement of the remaining pores) is not covariant with changes in $\delta^{13}C$. Their values are on the whole comparable and do not reach negative values anywhere. However the decline of $\delta^{13}C$ to negative values is not mentioned even from the evinosponges of the Wetterstein limestones, which originated in conditions of meteoric or marino-meteoric diagenesis (cf. Frisia & Bruni et al. 1989; Kantor & Mišík in press, etc.). Therefore it is possible, that production of light C from soil CO_2 (plant metabolism, bacterial decomposition etc.) was minimal in conditions of the extensive Triassic carbonate platform.

On the other hand, constant contents of isotopes of C and declining isotopic proportions of O are often mentioned from buried cements (Walls et al. 1979; Dickson & Coleman 1980; Moldovanyi & Lohmann 1989, etc.). In buried cements, the isotopic composition is not controlled by the composition of pore waters (when this must also be taken into account), but by temperature (Hurley & Lohmann 1989). Meanwhile the proportion of isotopes of C are not more significantly influenced by temperature, the contents of light O are increased by about -2 ‰ for each 10 °C of temperature (Friedman & O'Neil 1977). These isotopic proportions also characterize the fillings of cavities in the Veterlín limestones.

The fact, that even for the block calcite from the filling of the Veterlín limestones, reliable isotopic evidence of meteoric alteration does not exist, is apparently in conflict with its crystallographic habits (Walkden & Williams 1991). However it is known, that some deeply buried cements have the same habits as some meteoric cements (Saller & Moore 1991). Block calcite, therefore, may also originate in conditions of deep burial, and the eogenetic transformation of metastable marine cements and also the partial drainage of $\delta^{18}O$ as a result of temperature alteration. The fact that the crystalographically homogeneous calcite blocks show significant differences in isotopic composition between the marginal and central parts (Tab. 1), and higher contents of Mg, and/or Sr, could be evidence of the redistribution structure of cavity fillings in the Veterlín limestones in conditions of deep burial. The clarification of the origin of the block calcites requires further study of the cements, and also a more exact division of the generations of cements (cathodoluminescence).

Discussion

The significant representation of megabreccia in the sequence described may be well described with the use of the "megabreccia sheet" model (Cook et al. 1972). Bosselini et al. (1977) described a similar Middle Triassic carbonate platform in the Southern Alps (Dolomites), bordered by a gravitational deposit (megabreccia sheet) on the margin of a basin, which was definitively filled during the Upper Ladinian to Lower Carnian.

The Ladinian basin in the original sedimentary area of the Veterlín and Havranica Nappes of the Malé Karpaty Mts. was characterized by the sedimentation of Reifling Limestones (with Partnach shales in the axial part, bordered by facies of Knolenkalk and Bankkalk). The depression was surrounded by reef facies, from which reef material originated, feeding scree cones and occasional fluxoturbidity currents. The growth rate of bioherms suddenly increased at the end of the Ladinian, when the depression was gradually filled by masses of reef detritus and the reef prograded through the former basin.

In contrast to the Southern Alps with preserved paleoslopes and related deposits of an old carbonate platform, finds from the Malé Karpaty Mts. do not allow study of the greater textural elements. Kenter (1990) gave the relationship between the angle of inclination of slopes of a platform, and the sediment fabrics of its sediments. Mudstones are able to maintain a slope with a gradient of only 5 %, wackestones and floatstones (mud- supported fabrics) up to 15 %, while types with grain-supported fabrics form slopes with gradients between 12 and 40°. Schlager & Camber (1986) emphasize the difference between slopes of carbonate platforms, which have a concave profile, and those which have a level or convex profile of silici-clastic slopes.

Hardened blue-green algae, porifers (calcisponges), microproblematics (tubiphytes), lived on the margin of Middle Triassic carbonate platforms, but only secondarily to corals (Fois & Gaetani 1980; Biddle 1981; Fois 1982; Roeder 1987). However the reef edge did not form a connected border. The submarine cemented margin of the platform was often broken and slid down the slope.

Biddle (1981) described from "Cipit boulders", two basic types of early diagenetic cement: radial fibrous and isopachic fibrous. Roeder (1987) mentioned palisaded cement as the most frequent from Pala di S. Martino.

Summary

1 - The Veterlín reef complex is a product of a carbonate platform, which gradually filled a deep depression in the southern part of the Alpine-Carpathian shelf, with its products, at the end of the Ladinian and beginning of the Carnian.

2 - The products of this prograding platform began with the deposition of calciturbidites, grainflows, which gradually changed to debris flow. Changes in grain size up to megabreccia indicate gradual change in the gradient of the paleoslope (locally up to 40°). Insets of micritic limestones indicate eustatic increases in sea-level and slowing down of sedimentation. They contain pelagic associations of conodonts and scleritic holoturians.

3 - The reef bodies did not form a connected border of the platform, but divided their zone of shallows with skeletal and oolitic calcarenites, which change without a break into slope sediments. The reefs formed associations of calcareous sponges, algae, tubiphytes, hydrozoa and corals. Dasycladacean algae grew on the back reef platform. The lagoonal detritic sediments were often affected by dolomitization.

4 - Petrographic and isotopic studies of cements show, that the diagenesis of the limestones of the reef complex took place in marine freatic conditions. Differences in textures and compositions of generations of cements, and partial dolomitization point to the existence of zones of mixing, or the creation of cements in conditions of burial of the sediments.

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Plate I: Platform margin facies.
Fig. 1 - algal bindstones *Cyanophyta* linings. Kršlenica section, sample No. 61, magnified 6x. Fig. 2 - sponge-algal rudstone. Kršlenica section, No. 29, 6x. Fig. 3 - algal-poriferal bindstone with sphinctozoans and cyanophytal algae. Veterlín section, No. 2, 6x. Fig. 4 - pseudo-peletal sparitic grainstone with cavities filled by blocky pseudosparite. Dubník section, No. 20, 6x. Fig. 5 - dolomitized limestone with relics of organic debris. Vajarská, BF-10 borehole, 19, 5x. Fig. 6 - selectively dolomitized oosparitic grainstone with algal oncoids. Vajarská, VBC 176 borehole, 6x.

Plate II: Fore reef facies.
Fig. 1 - coarse rudstone with fragments of reef forming organisms (*Sphinctozoa*). Matrix is formed by intrabiosparite (grainstone). Kršlenica section, No. 18, 6x. Fig. 2 - biointrasparitic grainstone with mikritized bio- and lithoclasts. Veterlín section, No. 13, 6x. Fig. 3 - laminae of grainstone in biomicrital limestone (wackestone) destroyed by bioturbation. Veterlín section, No. 30, 6x. Fig. 4 - pseudo-peletal biosparite (grainstone), intercalation in biomicrital limestone (wackestone). Jablonica section, No. 6, 13, 5x. Fig. 5 - dolomitized biomicrital limestone (wackestone) with ostracod and foraminifal relics. Jablonica section, No. 3, 13, 5x. Fig. 6 - detrital laminae disturbed by bioturbation in biomicrital limestone (wackestone). Veterlín section, No. 5, 6x.

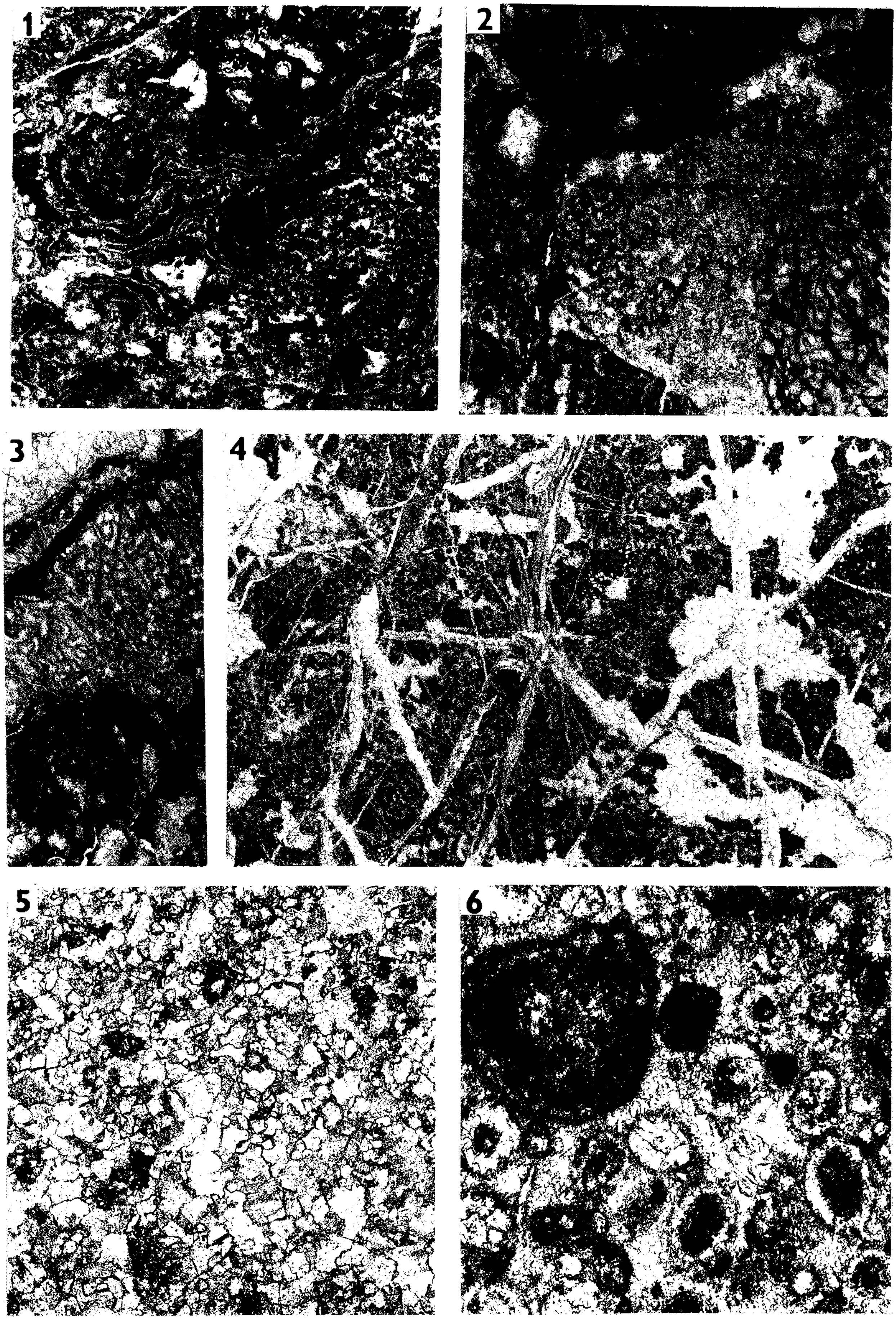
Plate III: Slope and basinal facies.
Fig. 1 - rudstone with relics of reef forming organisms. Mokrá Dolina Valley section, sample No. 38, 6x. Fig. 2 - detrital limestone with crinoids and fragments of reef forming organisms (wackestone). U Fajnorov section, No. 8, 6x. Fig. 3 - fine laminated biomicrite (wackestone) with relics of radiolarians and ostracods. Jablonica section, No. 11, 6x. Fig. 4 - gradationally bedded calcarenite (grainstone) in pseudo-peletal biomicrite (wackestone). Mokrá dolina Valley section, No. 10, 6x. Fig. 5 - biomicrital limestone with filaments and radiolarians (wackestone) and with fine current lamination. DV-1 borehole, No. 130, 6x. Fig. 6 - filament biomicrite (wackestone) with sporadic radiolarians. Jablonica Quarry, magnified 6x. Fig. 7 - detrital biosparite (grainstone) with mikritized bio- and lithoclasts. U Fajnorov section, No. 21, 20x.

Plate IV: Conodonts and holothurians.
Figs. 1-2 - *Gondolella foliata inclinata* Kovács, Kršlenica III-7/87, SEM 2937, 460x; Kršlenica 8, SEM 2953, 240x. Figs. 3-4 - *Gondolella foliata foliata* Budurov & Stef., Kršlenica III-6/87, SEM 2935, 2933, 290 and 240x. Fig. 5 - *Gladigondolella malayensis* Nogami, Kršlenica III-6/87, SEM 2930, 220x. Figs. 6-7 - *Gondolella polygnathiformis* Bud. & Stef., Kršlenica 19, SEM 2920, 2x. Fig. 8 - *Gladigondolella tethydis* (Huckr.), Kršlenica 19, SEM 2920, 240x. Fig. 9 - *Eocaudina liptovskae* Koz. & Mock, Kršlenica 24, SEM 2961, 320x. Fig. 10 - *Priscopedatus* cf. *tyrolicus* Mostler, Kršlenica III-1/87, SEM 2917, 440x. Fig. 11 - *Theelia koeveskalensis* Koz. & Mostl., Kršlenica 21- top, SEM 2962, 400x. Fig. 12 - *Theelia* sp., Kršlenica 16, SEM 2951, 350x. Fig. 13 - *Theelia undata* Mostler, Kršlenica III-4/87, SEM 2928, 500x. Fig. 14 - *Theelia immisorbicula* Mostl., Kršlenica 19, SEM 2960, 540x.
All the photo's taken by dr. I. Holický, SEM BS 600, Geological Institute, Slovak Academy of Sciences, Bratislava.

Plate V: Foraminifers of the slope and fore reef facies.
Fig. 1 - *Paleolituonella meridionalis* Luppert, Jablonica section, sample 2, 29x. Fig. 2 - *Valvulina zzouzi* Salaj, Jablonica No. 11, 115x. Fig. 3 - *Ophthalmidium* cf. *triadicum* (Kristan), Jablonica No. 10, 115x. Fig. 4 - *Reophax* aff. *tzankovi* Trifonova, Veterlín, No. 555, 115x. Fig. 5 - *Arenovidalina amylovoluta* Ho, Kršlenica III, No. 20. Fig. 6 - *Galeanella* aff. *paticae* Koehn-Zanin. & Broen., Kršlenica No. 19.

Plate VI: Foraminifers of the slope facies.
Fig. 1 - *Agathammina iranica* Broenn., Zanin., Bozorg. & Huber, No. 12. Fig. 2 - *Agathammina austroalpina* Kristan T. & Tollm., No. 12. Fig. 3 - *Lamelliconus turris* (Frentzen), No. 8. Fig. 4 - *Ophthalmidium fusiformis* (Trif.), No. 8. Fig. 5 - *Gsolbergella spiroloculiformis* (Oravec.-Scheff.), No. 8. Fig. 6 - *Oberhauserella aff. alta* Fuchs, No. 8.
All samples come from the U Fajnorov Quarry, II. level. Magnification 93x.

Plate VII: Algae, Sphinctozoa and problematics.
Fig. 1 - *Tubiphytes obscurus* Maslov in an recrystallized biomicrite (wackestone). Jablonica Quarry, 60x. Fig. 2 - relict of dasycladal alga in biosparite (grainstone). Kršlenica section, sample No. 53, 6x. Fig. 3 - codiacean alga in coarse detrital biosparite (rudstone). Jablonica Quarry, 6x. Fig. 4 - transversal section of sphinctozoan calcisponge (*Colospongia catenulata*). Vajarská Quarry, 20x. Fig. 5 - codiacean alga in coarse detrital biosparite (rudstone). Kršlenica section, No. 51, 6x. Fig. 6 - algal microproblematic in detrital limestone (floatstone). Jablonica section, sample No. 2, 20x. Fig. 7 - algal microproblematic in biosparite (rudstone). Kršlenica section, No.20, 6x. Fig. 8 - coralite cross-section in biosparite (grainstone). Kršlenica section, sample No. 53, 6x. Fig. 9 - tangential section of dasycladal algae (*Andrusoporella* sp.). Kršlenica section, No. 62, 6x. Fig. 10 - algae microproblematic in biogene limestone (bindstone). Kršlenica section, sample No. 42, 6x.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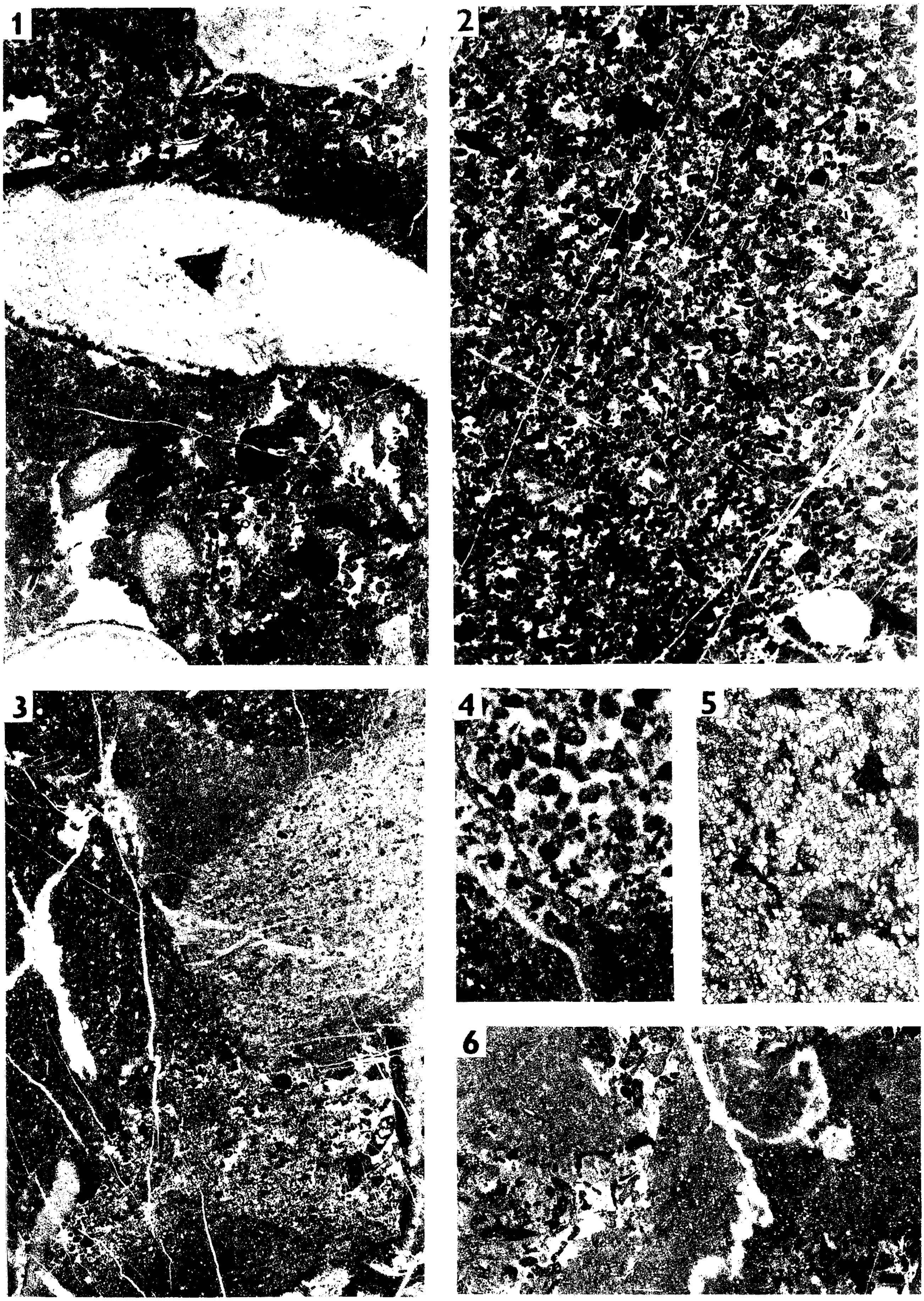

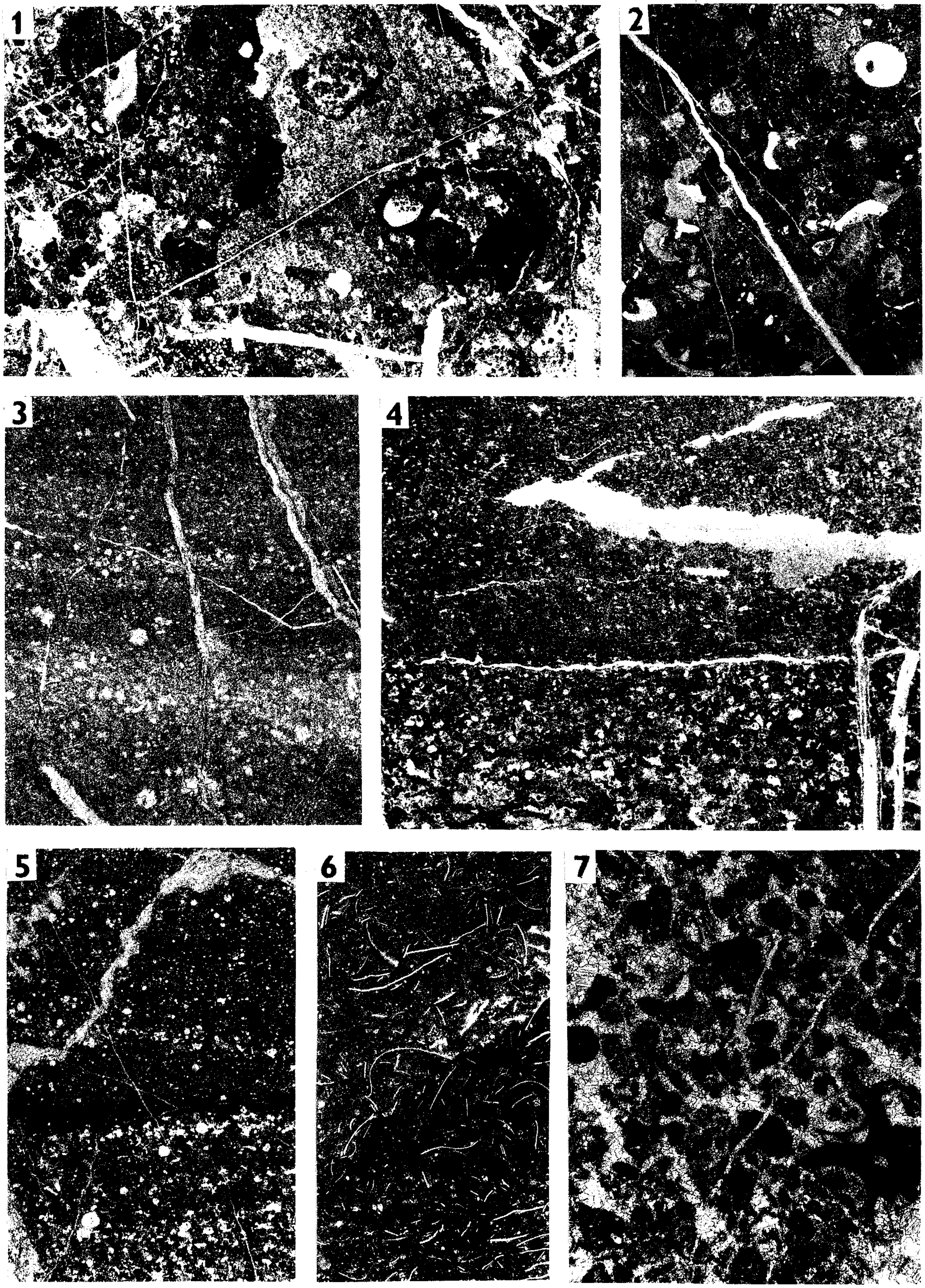
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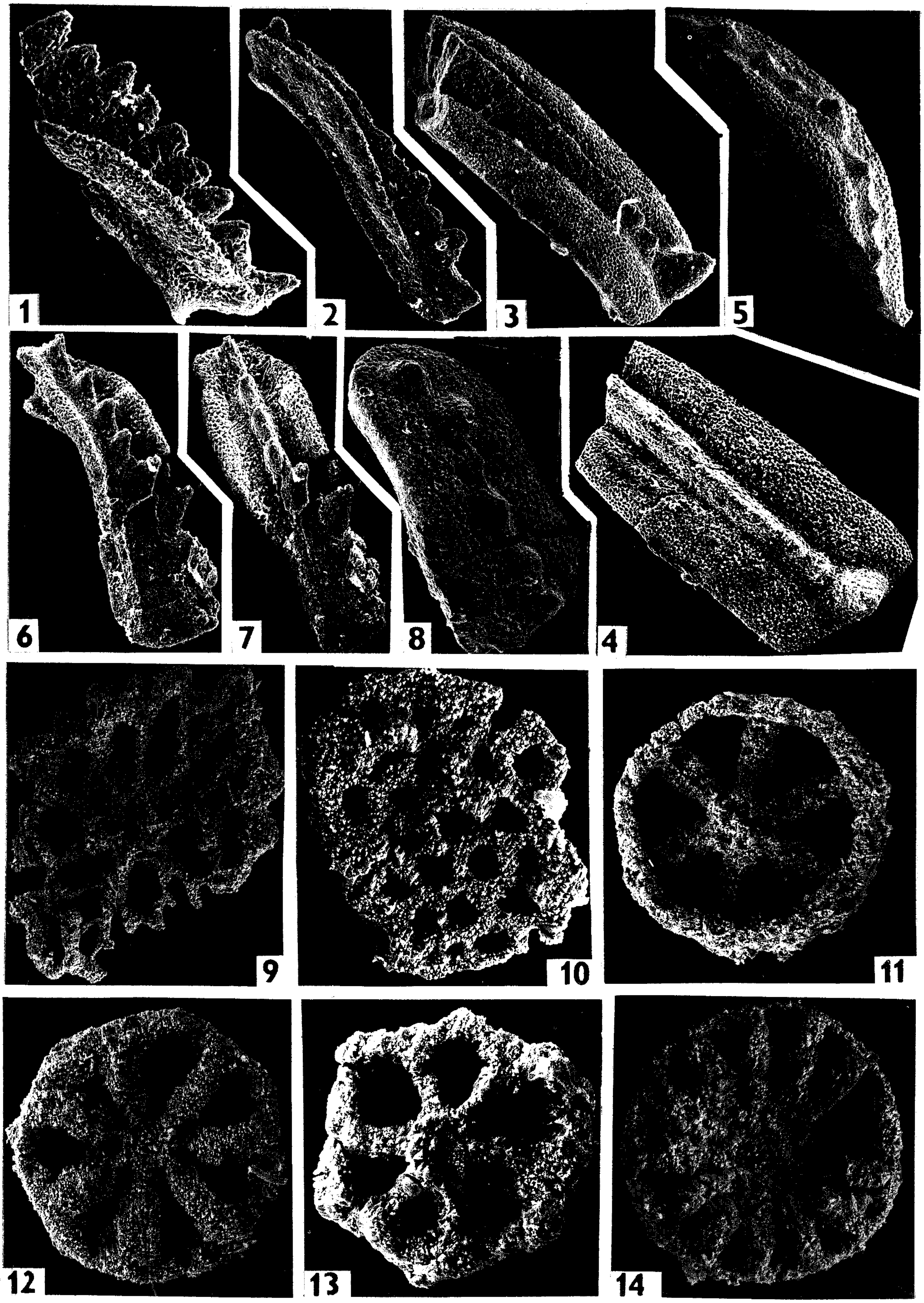

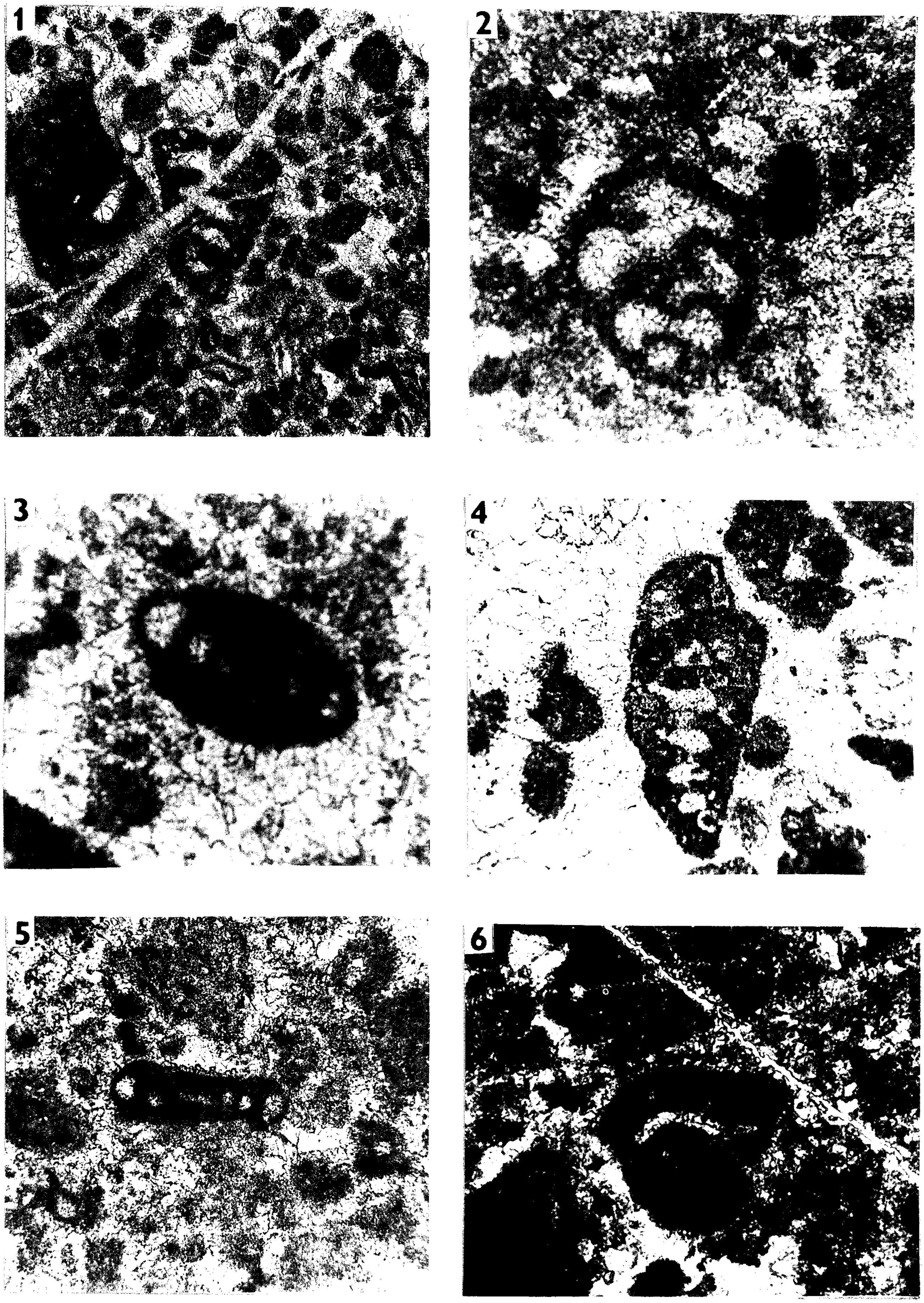
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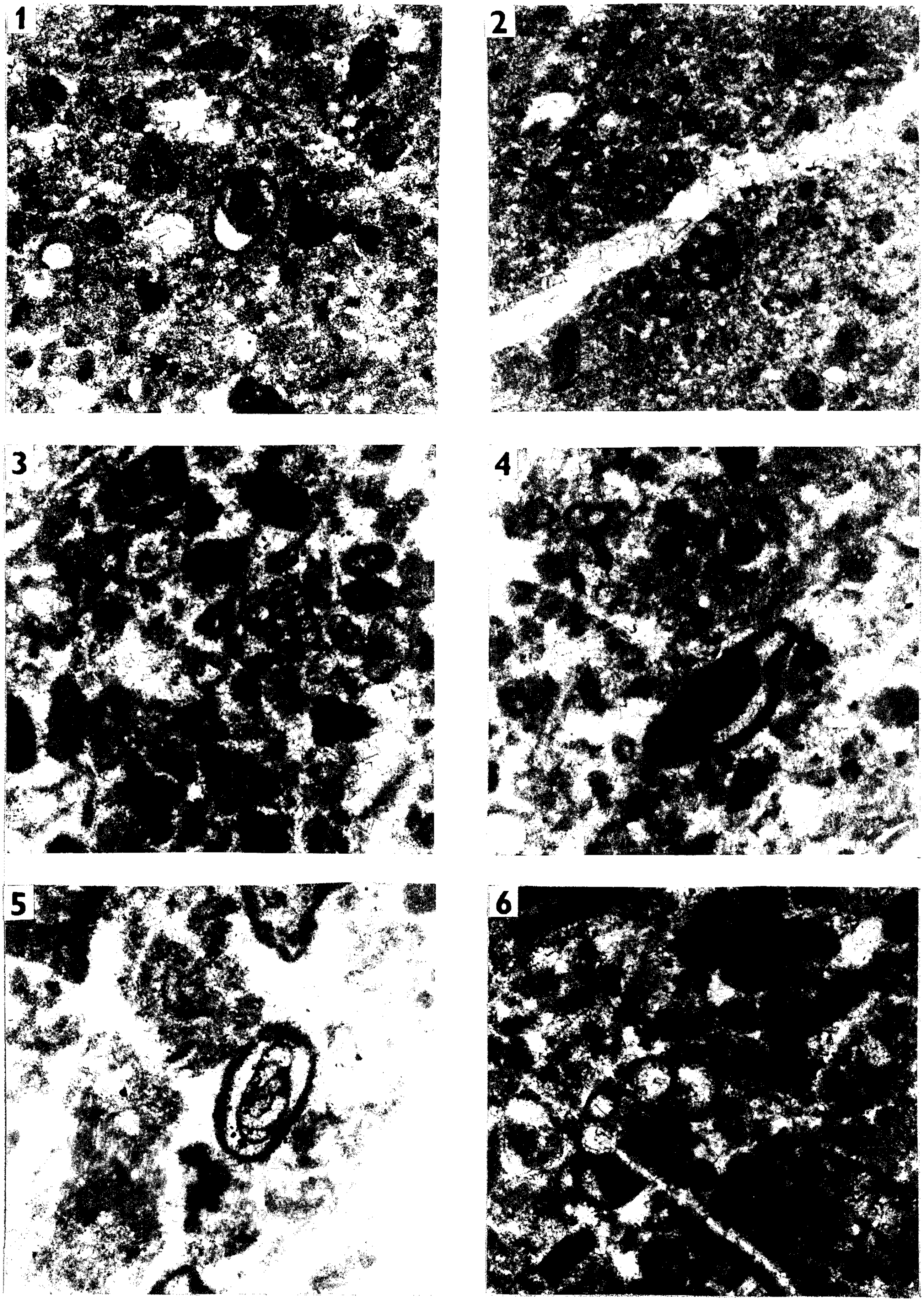

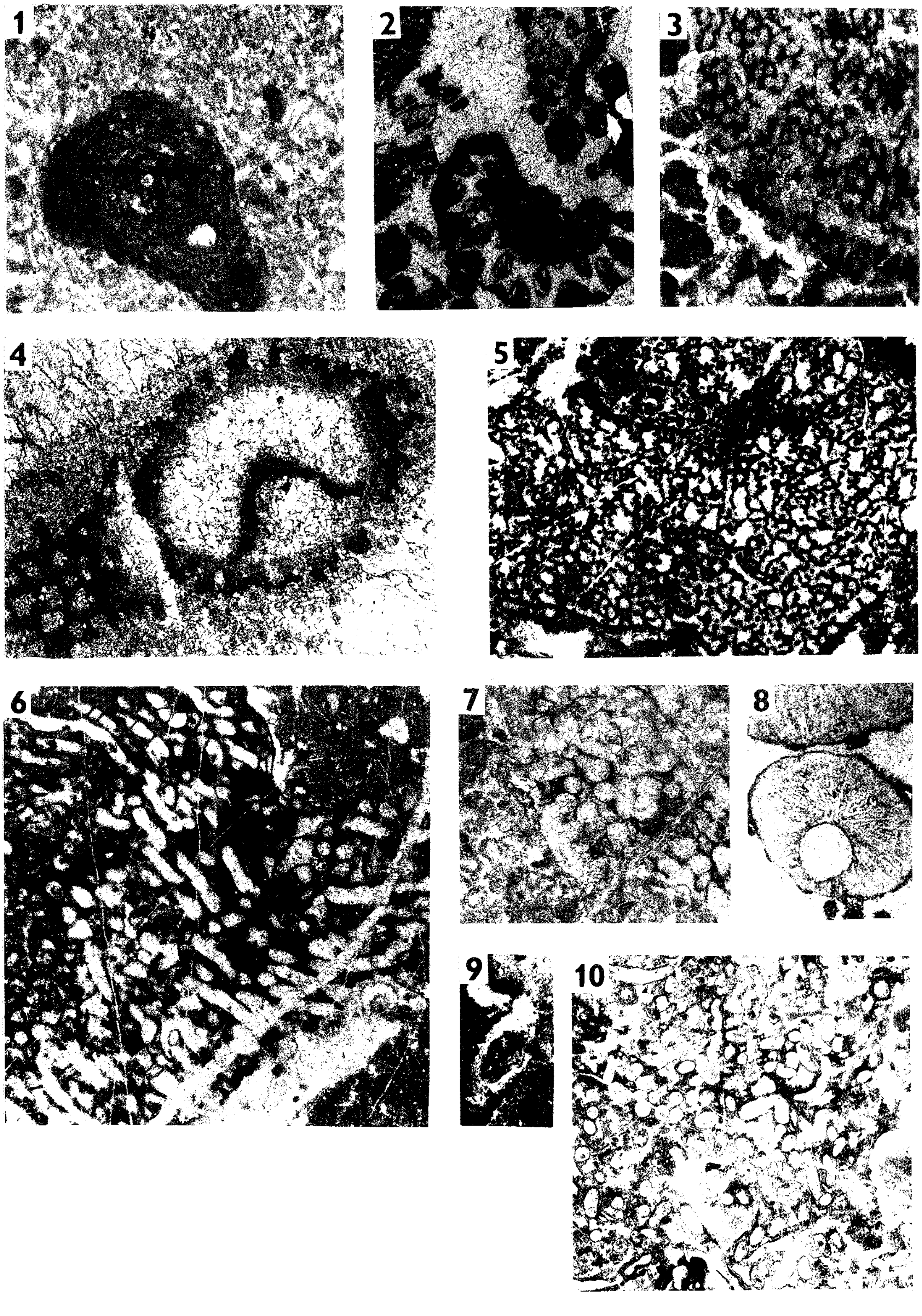
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References

Assereto R. & Folk R. L., 1980: Diagenetic fabrics of aragonite, calcite and dolomite in an ancient peritidal-spelean environment: Triassic calcare rosso, Lombardia, Italy. *J. Sedim. Petrol.* (Tulsa), 50, 2, 371 - 394.

Bechstädt T. & Mostler H., 1976: Riff-Becken Entwicklung in der Mitteltrias der westlichen Nördlichen Kalkalpen. *Zeitschr. Geol. Ges.* (Hannover), 127, 271 - 289.

Biddle K. T., 1981: The basinal Cipit boulders: indicators of Middle to Upper Triassic buidup margins, Dolomite Alps, Italy. *Riv. Ital. Paleont. Strat.* (Milano), 86, 4, 779 - 794.

Blendinger W., 1986: Isolated stationary carbonate platforms - the Middle Triassic (Ladinian) of the Marmolada area, Dolomites, Italy. *Sedimentology*, 33, 159 - 183.

Bosellini A., 1984: Progradation geometries of carbonate platforms: Examples from the Triassic of the Dolomites, northern Italy. *Sedimentology*, 31, 1 - 24.

Bosellini A., Castellarin A., Rossi P. L., Simboli G. & Sommavilla E., 1977: Schema sedimentologico e stratigrafico per il Trias Medio della val di Fassa ed aree circonstanti (Dolomiti Centrali). *G. Geol.* (Bologna), 2, 42, 83 - 108.

Brandner R. & Resch W., 1981: Reef development in the Middle Triassic (Ladinian and Cordevolian) of the Northern Limestone Alps near Innsbruck, Austria. In: Toomey D.F.(Ed.): *European Fossil Reef Models. Spec. Publ. Soc. Econ. Paleont. Miner.* (Tulsa), 30, 203 - 231.

Cook H. E., McDaniel P. N., Mountjoy E. W. & Pray L. C., 1972: Allochtonous carbonate debris flows Devonian bank ("reef") margins, Alberta, Canada. *Canad. Soc. Petrol. Geol. Bull.* (Calgary), 20, 439 - 497.

Cosijn J., 1928: De geologie van de Valle di Olmo al Brembo. *Leid. Geol. Meded.* (Leiden), 2, 251 - 324.

Dickson J.A.D. & Coleman M. L., 1980: Changes in carbon and oxygen isotope composition during limestone diagenesis. *Sedimentology*, 27, 107 - 118.

Epting M., Unland W., Schmidt K. & Christodoulides A., 1976: Middle Triassic sediments of selected regions in the Southern Alps (Italy) and their significance for paleogeographic and paleostructural evolution. N. Jb. Geol. Paläont. Abh. (Stuttgart), 151, 1, 1 - 30.

Fois E. & Gaetani M., 1980: The northern margin of the Civetta buildup evolution during the Ladinian and the Carnian. Riv. Ital. Paleont. (Milano), 86, 3, 469 - 542.

Fois E., 1982: The Sass da Putia carbonate buildup (Western Dolomites): biofacies succession and margin development during the Ladinian. Riv. Ital. Paleont. Strat. (Milano), 87, 4, 565 - 598.

German K., 1971: Calcite and dolomite fibrous cements (Grossoolith) in the reef rocks of the Wettersteinkalk (Ladinian, Middle Trias), Northern Limestone Alps, Bavaria and Tyrol. In: Bricker O. P. (Ed.): Carbonate cements. J. Hopkins Press, Baltimore, 185 - 188.

Goldsmith J. R. & Graf D. L., 1958: Relation between lattice constraints and composition of the Ca-Mg carbonates. Amer. Miner. (Washington), 43, 84 - 101.

Friedmann I. & O,Neil J. R., 1977: Compilation of stable isotope fractionation factors of geochemical interest. In: Fleischer M. (Ed.): Data in Geochemistry (6th). U.S. Geol.Survey Prof.Paper 440 K, 12 p.

Frisia-Bruni S., Jadoul F. & Weissert H., 1989: Evinosponges in the Triassic Esino Limestone (Southern Alps): Documentation of early lithification and late diagenetic overprint. Sedimentology, 36, 685 - 699.

Henrich R. & Zankl H., 1986: Diagenesis of Upper Triassic Wetterstein reefs of the Bavarian Alps. In: Schroeder J.H. & Purser B.H. (Eds.). Springer-Verlag, Berlin, 245 - 268.

Hofsteenge G. L., 1932: La géologie de la Valée du Brembo et ses affluents entre Lenna et San Pellegrino. Leids. Geol. Meded. (Leiden), 4, 25 - 82.

HurleyY N. F. & Lohmann K. C., 1989: Diagenesis of Devonian reefal carbonates in the Oscar Range, Canning Basin, Western Australia. J. Sedim. Petrol. (Tulsa), 59, 1, 127 - 146.

Jadoul F. & Frisia S., 1988: Le Evinosponge: Ipotesi genetiche di cementi calcitici nella piattaforma Ladinica delle Prealpi Lombarde (Alpi Meridionali). Riv. Ital. Paleont. Strat.(Milano), 94, 1, 81 - 104.

Kantor J. & Mišík M., in press: Some features of the C and O isotope composition in Mesozoic and Tertiary limestones and dolomites in Western Carpathians. Záp. Karpaty, Sér. Geol. (Bratislava) (in Slovak).

Lintnerová O. & Hladíková J.,1992 :Distribution of O and C isotopes and microelements in the Triassic limestones of the Veterlín Unit, Malé Karpaty Mts.: diagenetic interpretation. Geol. Carpathica (Bratislava), 43, 4, 203 - 212.

Lintnerová O., Masaryk P. & Martíny E., 1988: Trace elements distribution in Triassic carbonates from the Veterník and Havranica Nappes (the Malé Karpaty Mts.). Geol. Zbor. Geol. carpath. (Bratislava), 39, 3, 301 - 322.

Lintnerová O., Masaryk P. & Kátlovský V., 1990: Relationship between natural radioactive elements (Th, U, K) and Triassic carbonate lithofacies in Hronicum and Silicikum of Malé Karpaty Mts.. Geol. Zbor.. Geol. carpath. (Bratislava), 41, 3, 275 - 294.

Lumsen D.N., 1979: Discrepancy between thin section and X-ray estimates of dolomite in limestone. J. Sedim. Petrol. (Tulsa), 49, 429 - 436.

Masaryk P.,1987: Microfacial characteristics of the Triassic sequences of the "higher nappes", Biele Pohorie Hills in the Malé Karpaty and their correlation with the basement of the Vienna Basin. Knih. Zem. Plynu Nafty, Misc. Paleont. (Hodonín), 6a, II, 1, 153 - 189 (in Slovak).

Mazzullo S. J., 1980: Calcite pseudospar replacive of marine acicular aragonite, and implications for aragonite cement diagenesis. J. Sedim. Petrol. (Tulsa), 50, 2, 409 - 422.

McKenzie J. A. & Lister G., 1983: Origin of alternating calcite and dolomite void filling cements (Grossoolites) in Middle Triassic reefs of the Northern Limestone Alps near Innsbruck, Austria. I.A.S. 4th Europ. region meeting Abstr., Split, 156 - 157.

Michalík J., 1984: Some remarks on the interpretation of geological development and structure of the northwestern part of Malé Karpaty Mts. (Western Carpathians). *Geol. Zbor. Geol. carpath.* (Bratislava), 35, 4, 489 - 504.

Moldovanyi E. P. & Lohmann K. C., 1984: Isotopic and petrographic record of phreatic diagenesis: Lower Cretaceous Sligo and Cupido Formations. *J. Sedim. Petrol.* (Tulsa), 54, 927 - 985.

Ott E., 1967: Segmentierte Kalkschwämme (Sphinctozoa) aus der alpinen Mitteltrias und ihre Bedeutung als Riffbildner im Wettersteinkalk. *Abh. Bayer. Akad. Wiss., math.-nat.Kl.,n.F.* (München), 131, 1 - 96.

Plašienka D., Michalík J., Kováč M., Gross P. & Putiš M., 1991: Paleotectonic evolution of the Malé Karpaty Mts. - An overview. *Geol. Carpathica* (Bratislava), 42, 4, 195 - 208.

Roeder K. H., 1987: Evolution of the Early Ladinian paleoslope of the Pie di San Martino-San Lucano (Dolomites, Italy). *G. Geol.* (Bologna), 3, 49, 1, 51 - 61.

Saller A. H. & Moore C. H., 1991: Geochemistry of meteoric calcite cements in some Pleistocene limestones. *Sedimentology*, 38, 601 - 621.

Sibbley D. F. & Gregg J. M., 1987: Classification of dolomite rock textures. *J. Sedim. Petrol.* (Tulsa), 57, 967 - 975.

Schlager W. & Camber O.,1986: Submarine slope angles, drowning unconformities and self-erosion of limestone escarpments. *Geology* (Boulder), 14, 762 - 765.

Stoppani A., 1858: Les pétrifications d'Esino ou description des fossiles appartenants au dépot supérieur des environs d'Esino en Lombardie. *Paléont. Lombarde* (Milano), 1, 360.

Walls R. A., Mountjoy E. W. & Fritz P.,1979: Isotopic composition and diagenetic history of carbonate cements in Devonian Golden Spike reef, Alberta, Canada. *Geol. Soc. Amer. Bull.* (Boulder), 90, 963 - 982.