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Synsedimentary disturbances in Middle Triassic carbonates of the Holy Cross Mts

ABSTRACT: A number of synsedimentary disturbances resulting from mass movements, mainly unstable laminar systems, and occasionally mud flows, were noted in the Lower Muschelkalk of the Holy Cross Mts. The origin of these structures is discussed in the background of sedimentary conditions prevailing during the Lower Muschelkalk.

INTRODUCTION

In the Lower Muschelkalk deposits of the western and south-western parts of the Mesozoic margins of the Holy Cross Mts, the authors noted structures related to synsedimentary disturbances in carbonate deposits (Fig. 1) of the Wellenkalk series and lower part of the Łukowa Beds (according to lithostratigraphy by Senkowiczowa 1957). These deposits are of Lower Anisian age, as results from the conodont identifications by Trammer (1972).

Acknowledgements. The authors are greatly indebted to Prof. Dr. S. Dżułyński and Dr. J. Głazek for helpful discussions in the field and critical reading of the manuscript.

INTRAFORMATIONAL CONGLOMERATES

In the section of the Wellenkalk series, exposed in the quarry at Wincentów (*cf.* Fig. 1), three layers of intraformational conglomerates consisting of flat pebbles of micritic limestones were noted (Fig. 2*a, b, c*).

The matrix is represented by calcarenite consisting of bioclasts (crushed pelecypod, gastropod and brachiopod shells and echinoderm fragments); moreover, phosphate fragments of fish, and detrital quartz were noted. The surfaces of intraclasts are pitted by echinoderm fragments and, occasionally, by other intraclasts (*cf.* Radwański 1965).

Layer *a* is underlaid by stratified micritic limestone with traces of scouring at its topside. Intraclasts of the layer *a* are actually autochthonous, being almost identical to the underlying limestone. The structure of the conglomerate is nearly flat-parallel.

Layer *b* does not exhibit any preferred orientation of flat pebbles; some of the pebbles are perpendicularly oriented (*cf.* Fig. 2). Spatially, the layer *b* is of flattened lenses shape, underlaid by lumpy limestone significantly differing from the intraclasts; hence, the allochthonous character of these intraclasts may be inferred.

The structure of layer *c* is somewhat ordered. Besides intraclasts of consolidated limestone, there also occur intraclasts formed of semi-consolidated limestone. Layer *c* is underlaid by undisturbed micritic limestones. As in the case of layer *b*, an allochthonous origin of the intraclasts may be inferred.

The discoid shape of intraclasts, as well as their poor orientation or even lack of orientation (layer *b* and *c*) suggest that material of conglomerates might have been transported in the form of mud flows (*cf.* Szulczewski 1968).

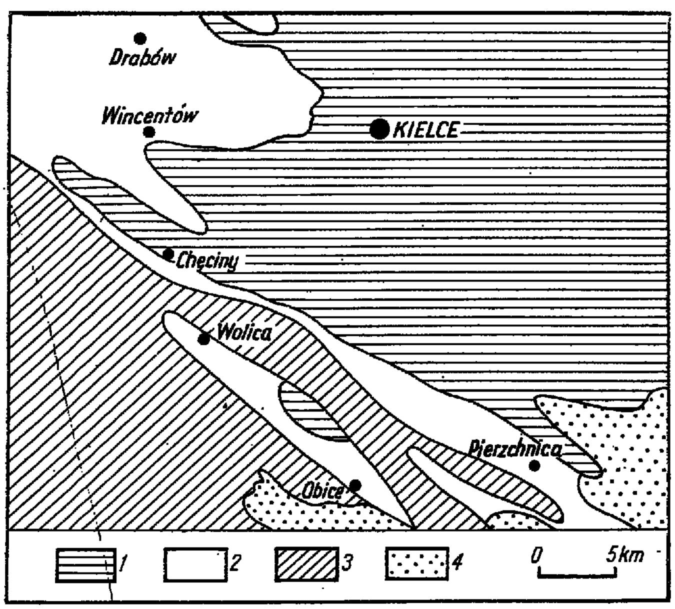

Fig. 1

Location map of the profiles bearing synsedimentary disturbances in the Muschelkalk of the Holy Cross Mts

1 Palaeozoic, 2 Triassic, 3 Jurassic and Cretaceous, 4 Miocene

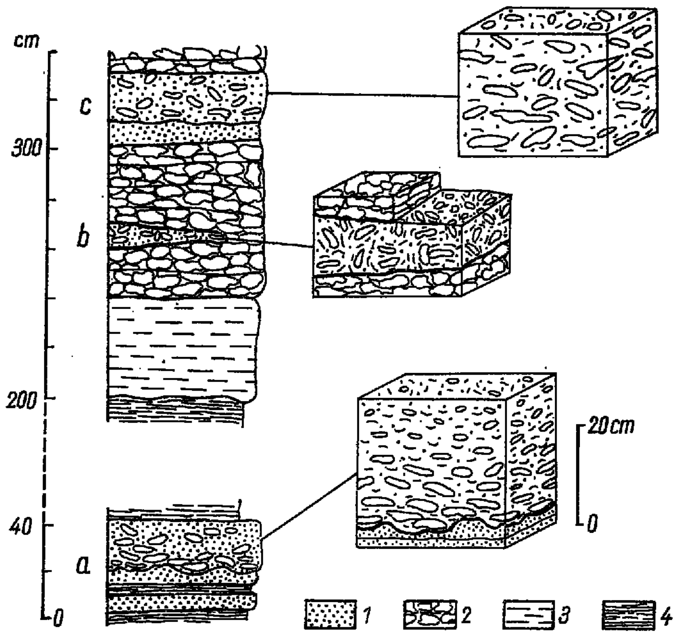

Fig. 2

Intraformational conglomerates (layers *a*, *b*, *c*) in the Wellenkalk at Wincentów
1 micritic limestones, *2* crumpled limestones, *3* marly limestones, *4* marls

DEFORMATIONAL STRUCTURES

Deformational structures in the Wellenkalk

The Wellenkalk series consists of crumpled limestones alternating with thin- and medium-bedded, grained limestones (commonly organo-detrital, the bioclasts of which are represented by detritus of shells and crinoids), and marly limestones and marls.

In a small quarry at Pierzchnica (*cf.* Fig. 1), a disturbed layer of laminated micritic limestones, passing upwards into calcarenite, was noted. The layer is broken into plates overlying disturbed marly limestones (Pl. 1).

In a quarry at Wolica (*cf.* Fig. 1), ovate structures built of stratified calcarenite were noted in stratified marly limestone (Fig. 3; Pl. 4, Fig. 1).

The structures noted at Pierzchnica and Wolica presumably resulted from systems with reverse density stratification (*cf.* Anketell & al. 1970). Structures geometrically similar to these were recently described by Schwarz (1970, 1971) from the Lower Muschelkalk ("Muschelsandstein") of the Zweibrücken area (SW Germany), in the terms of load deformations.

In the upper part of the section of the Wolica quarry (*cf.* Fig. 1), stratified, disturbed calcilutite is overlaid by irregular blocks of unstratified calcirudite (Pls 2 and 3). Thin layers of calcarenite covering these structures are adjusted to their upper surfaces (Pl. 2, Fig. 2; Pl. 3). This case may be explained by the activity of strong current, resulting in scouring of calcilutite layer; later, a current, presumably still the same one, deposited a calciruditic material. This resulted in the calcirudite overlying an uneven surface and being of variable thickness. The calcirudite

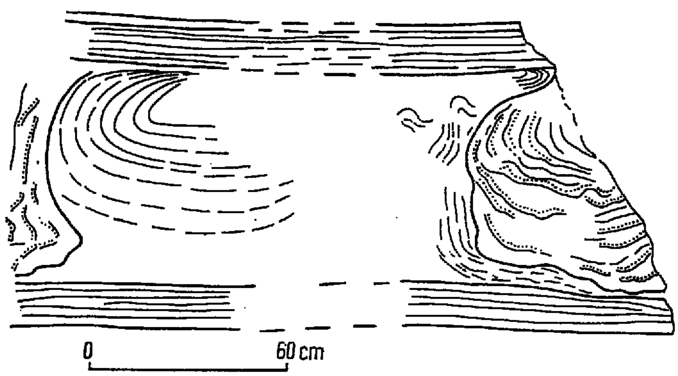

Fig. 3

Deformational structure in the Wellenkalk at Wolica (right part of the structure is presented in Pl. 4, Fig. 1)

together with the upper part of the underlying calcilutite formed an reverse density system, which, ultimately, led to the breaking up of the calcirudite layer into irregular blocks. The size of adjoining blocks was determined by original differentiation in thickness. The observed morphology of the substrate of calcirudite blocks is partly of primary, erosional origin (Pl. 2, Fig. 2; Pl. 3, Fig. 2, left side), and partly a result of successive deformations (diapire squeeze — Pl. 3, Fig. 2; folding of laminae — Pl. 3, Fig. 1). Similar structures were described from the Lower Muschelkalk in the environs of Jena in terms of layer broken into parts as a result of current activity (Ziegenhardt 1966).

Crumpled limestones are common deposits of the Wellenkalk series, and their origin is related to unstable laminated systems. These limestones differ from those of the Silesian Upland (the origin of which was recently discussed by Bogacz & al. 1968) in smaller rate of disturbances, which presumably resulted from the lesser thickness of marly layers alternating micritic limestones.

Deformational structures in the Łukowa Beds

The Łukowa Beds are represented by thick-bedded micritic limestones with thin alternations of grained, commonly detrital limestones; whereas contribution of marly limestones is notably smaller than this in the Wellenkalk series.

In the quarry at Wolica (*cf.* Fig. 1), *c.* 4 m above the top of the Wellenkalk, a disturbed complex of micritic limestones with calcilutite alternations occurs (Fig. 4). These disturbances are similar both to structures originating in reversed density systems (*cf.* Anketell & al. 1970),

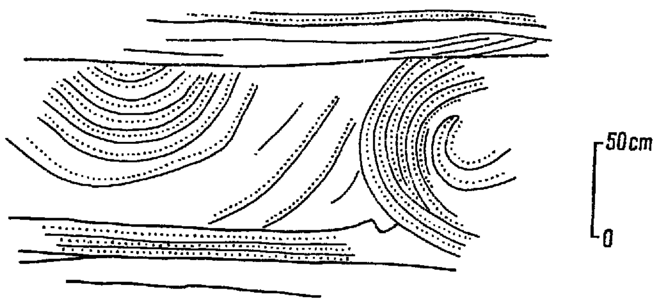

Fig. 4

Disturbed complex comprising a few layers in the Łukowa Beds at Wolica

as well as to slump structures (*cf. e.g.* Hadding 1931, Książkiewicz 1958). Similar structures were also noted by Rek (1970) in a quarry at Obice.

In the quarry at Wincentów (*cf.* Fig. 1), fragments of micritic limestone surrounded by laminated calcirudite were noted (Fig. 5).

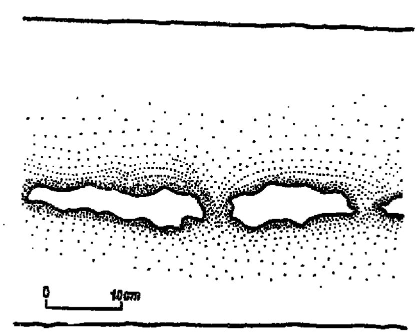

Fig. 5

Torn-out fragments of micritic limestone in the Łukowa Beds at Wincentów

Calcirudite gradually passes, down- and upwards in the layer into micritic limestone. It seems that the structure is genetically similar to that experimentally produced by Anketell & al. (1970, Fig. 17) in horizontally immobile system.

In the exposure at Drabów (cf. Fig. 1), a highly complicated structure, which originated in reversed density system, was noted by Bialik (1971); here, two complexes differing in plasticity of deformation structures and content of smaller-scale structures may be distinguished (Figs 6—8; Pl. 4, Figs 2 and 3; Pls 5 and 6).

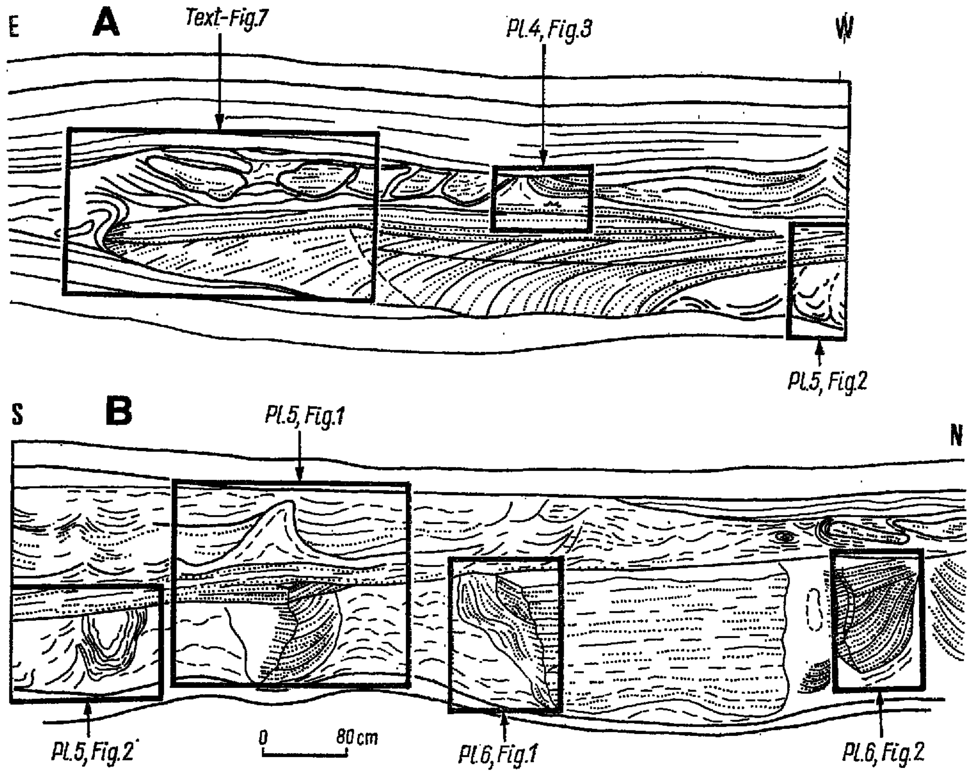

Fig. 6

Highly complicated deformational structure in the Łukowa Beds at Drabów
A southern part of the outcrop, *B* western part of the outcrop

The lower complex, characterized by a higher degree of plasticity at the time of deformation, includes sunken blocks of calcarenites with cross- and parallel-beddings and bearing typical up-bending of margins (Fig. 6*B*; Pl. 5, Fig. 1; Pl. 6, Figs 1 and 2), and marly limestones, pushed upwards by these blocks (Fig. 6*B*).

The upper complex, consisting of micritic limestones, calcarenites and calcilutites, exhibited lower degree of plasticity during the deformations than the lower one. Here, diapire structures (Fig. 6*A* and *B*; Pl. 4, Fig. 3; Pl. 5, Fig. 1; Pl. 6, Fig. 3) and fragments of broken layers (Figs 6 and 7; Pl. 4, Fig. 2) are common. Similar diapire structures have recently been obtained by McKee & Goldberg (1969) in experiments consisting in a loading of laminated mud by a sandy layer of differential thickness in quiet water.

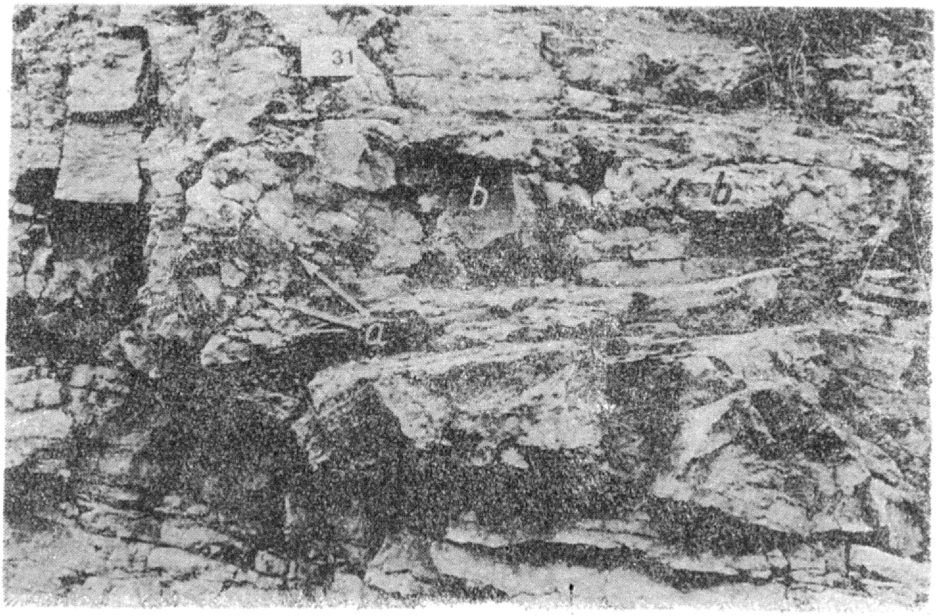

Fig. 7

Detailed view of the outcrop (southern part) at Drabów (*cf.* Fig. 6*A*); folding of the layer in front of a translocating deposit (*a*) and torn-out fragments of a layer from the upper disturbed complex (*b*) are visible

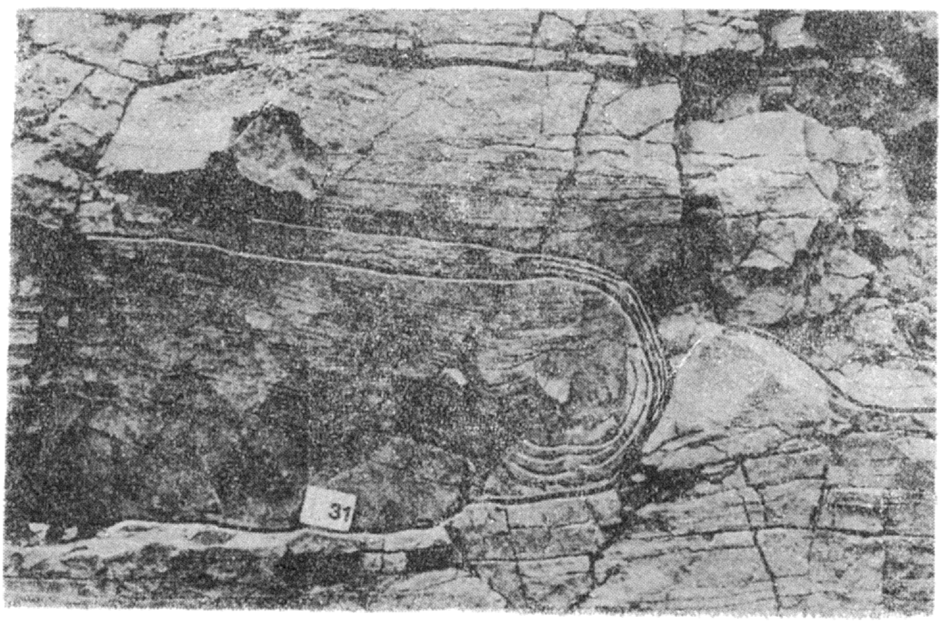

Fig. 8

Detailed view of the outcrop (northern part) at Drabów; a squeezing-in of the overlying layers under the head of a translocating slab from the lower complex is visible

Some small-scale, horizontal translocations are observed in the lower complex, which is evidenced by the folding of layers in the front of the translocating slab of the deposit (Figs 6*A*, 7), more steep cross-bedding (Fig. 6*A*) and underthrust of overlying bed under the front of the slab (Fig. 8).

GENERAL CONCLUSIONS

Structural deformations of the deposits, commonly observed in the Wellenkalk and Łukowa Beds of the investigated area primarily resulted from the existence of reversed density systems. Presumably, these systems originated owing to lithological differentiation of the deposits.

The recorded deformational structures cannot be fully compared with the experimental models of Anketell & al. (1970), because the latter structures were obtained in simple, two-laminar trigger systems with mechanical properties univocally determined. Moreover, deformations in unstable systems may result in regular forms only when layers are statistically uniform; even slight nonuniformity of layers, *e.g.* due to change either in sedimentary or deformation conditions, may result in extreme complication of disturbances (*cf.* Anketell & al. 1969). The difficulties in comparison result also from insufficient exposition of the disturbed layers for study on their spatial distribution (*e.g.* Figs 3 and 4; Pl. 1 and Pl. 4, Fig. 1).

The most probable impulses releasing sediment, being in the state of disequilibrium in the area studied, were the bottom currents. Traces of their action, such as great abundance of organodetrital material, erosional furrows, intraclasts, cross-bedding and (*vide* Kaźmierczak & Pszczółkowski 1969) erosional truncation of the enteropneustan burrows are often noted within the Wellenkalk and Łukowa Beds. However, the lack of subaqueous slump structures is a striking feature here. Presumably, sea-bottom gradients were too small and currents were not strong enough to form lateral undercuts. Mud flows from Wincentów, discussed above, were of local importance, evidencing merely local irregularities in the sea-bottom morphology.

It should be noted that the deformational structures discussed in the present paper are typical for the sedimentary conditions prevailing during the Lower Muschelkalk not only in the Holy Cross area itself but in the whole Polish-German basin (*cf. e.g.* Ziegenhardt 1966; Schwarz 1970, 1971).

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REFERENCES

ANKETELL J. M., CEGŁA J. & DŻUŁYŃSKI S. 1969. Unconformable surfaces formed in the absence of current erosion. — Geologica Romana, vol. 8. Roma.

— , — & — 1970. On the deformational structures in systems with reversed density gradients. — Rocz. P. T. Geol. (Ann. Soc. Géol. Pol.), vol. 40, no. 1. Kraków.

BIALIK A. 1971. Ret i wapień muszlowy w okolicy Piekoszowa (graduate paper, Institute of Geology of the Warsaw University — unpublished). Warszawa.

BOGACZ K., DŻUŁYŃSKI S., GRADZIŃSKI R. & KOSTECKA A. 1968. Origin of crumpled limestone in the Middle Triassic of Poland. — Rocz. P. T. Geol. (Ann. Soc. Géol. Pol.), vol. 38, no. 2/3. Kraków.

CEGŁA J. & DŻUŁYŃSKI S. 1970. Systems with reversed density gradient and their occurrence in periglacial zones. — Acta Univer. Wratisl., No. 124 (Studia Geogr. 13). Wrocław.

HADDING A. 1931. On subaqueous slides. — Geol. Fören. Stockh. Förh., Bd. 53, H. 4. Stockholm.

KAŹMIERCZAK J. & PSZCZÓŁKOWSKI A. 1969. Burrows of Enteropneusta in Muschelkalk (Middle Triassic) of the Holy Cross Mountains, Poland. — Acta Palaeont. Pol., vol. 14, no. 2. Warszawa.

KSIĄŻKIEWICZ M. 1958. Submarine slumping in the Carpathian Flysch. — Rocz. P. T. Geol. (Ann. Soc. Géol. Pol.), vol. 28, no. 2. Kraków.

McKEE E. & GOLDBERG M. 1969. Experiments on formation of contorted structures in mud. — Bull. Geol. Soc. Amer., vol. 80, no. 2. Boulder.

RADWAŃSKI A. 1965. Pitting processes in clastic and oolitic sediments. — Rocz. P. T. Geol. (Ann. Soc. Géol. Pol.), vol. 35, no. 2. Kraków.

REK I. 1970. Zdjęcie geologiczne triasu w obrębie antykliny żajączkowskiej przy zastosowaniu metody fotointerpretacji (graduate paper, Institute of Geology of the Warsaw University — unpublished). Warszawa.

SCHWARZ H. U. 1970. Zur Sedimentologie und Fazies des Unteren Muschelkalkes in Südwestdeutschland und angrenzenden Gebieten. — Diss. Tübingen.

— 1971. Facies analysis of shallow marine carbonates (Lower Muschelkalk, Middle Trassic). *In:* Sedimentology of parts of Central Europe. Guidebook, VIII International Sedimentological Congress 1971 in Heidelberg. Frankfurt a.M.

SENKOWICZOWA H. 1957. The Muschelkalk on the southern slope of the Święty Krzyż Mts, between Czarna Nida and Chmielnik. — Biul. IG (Bull. Inst. Geol.) 122. Warszawa.

SZULCZEWSKI M. 1968. Slump structures and turbidites in Upper Devonian limestones of the Holy Cross Mts. — Acta Geol. Pol., vol. 18, no. 2. Warszawa.

TRAMMER J. 1972. Stratigraphical and paleogeographical significance of conodonts from the Muschelkalk of the Holy Cross Mts. — *Ibidem,* vol. 22, no. 2.

ZIEGENHARDT W. 1966. Frühdiagenetische Deformationen im Schaumkalk (Unterer Muschelkalk) des Messtischblattes Plaue (Thüringen). — Geologie, Bd. 15, H. 2. Berlin.

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SYNSEDYMENTACYJNE ZABURZENIA OSADÓW WĘGLANOWYCH TRIASU ŚRODKOWEGO GÓR ŚWIĘTOKRZYSKICH

(Streszczenie)

W dolnym wapieniu muszlowym południowej i zachodniej części obrzeżenia mezozoicznego Gór Świętokrzyskich (fig. 1) stwierdzono występowanie rozmaitych zaburzeń synsedymentacyjnych, które zawdzięczają swe powstanie najprawdopodobniej głównie odkształceniom układów o niestatecznym warstwowaniu gęstościowym (fig. 3—8, pl. 1—6; *por.* Anketell & al. 1970, Cegła & Dżułyński 1970). Bodźcem, który powodował uruchomianie osadów znajdujących się w stanie równowagi nietrwałej, były tutaj zapewne prądy. Częste występowanie takich zaburzeń, przy braku typowych osuwisk, prowadzi do wniosku, że dno pozbawione było większych pochyłości w skali regionalnej, a prądy nie były aż tak silne, aby tworzyć większe podcięcia erozyjne. Wytępujące miejscami spływy błotne (fig. 2) wskazują na obecność jedynie niewielkich nierówności dna o charakterze lokalnym

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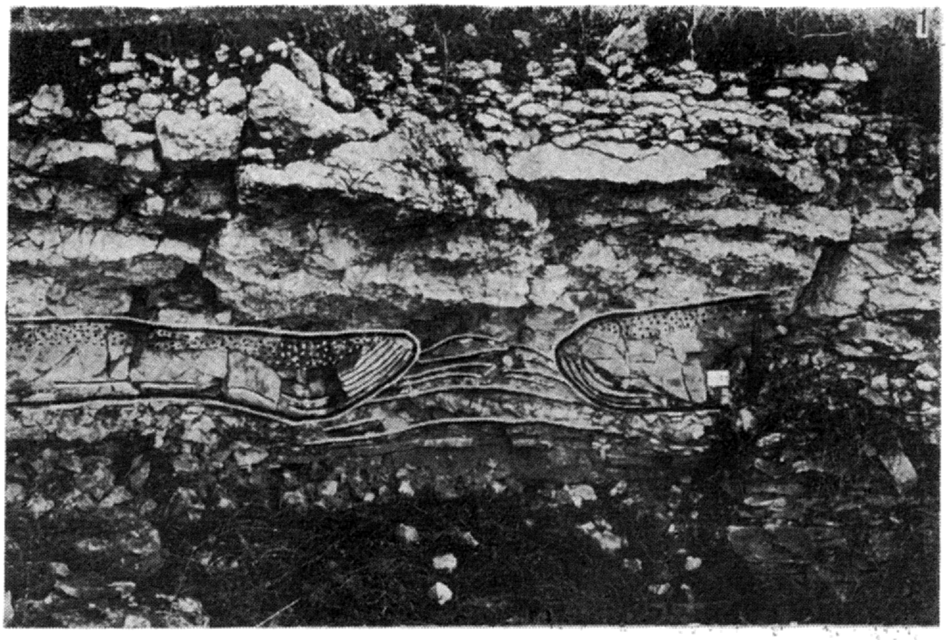
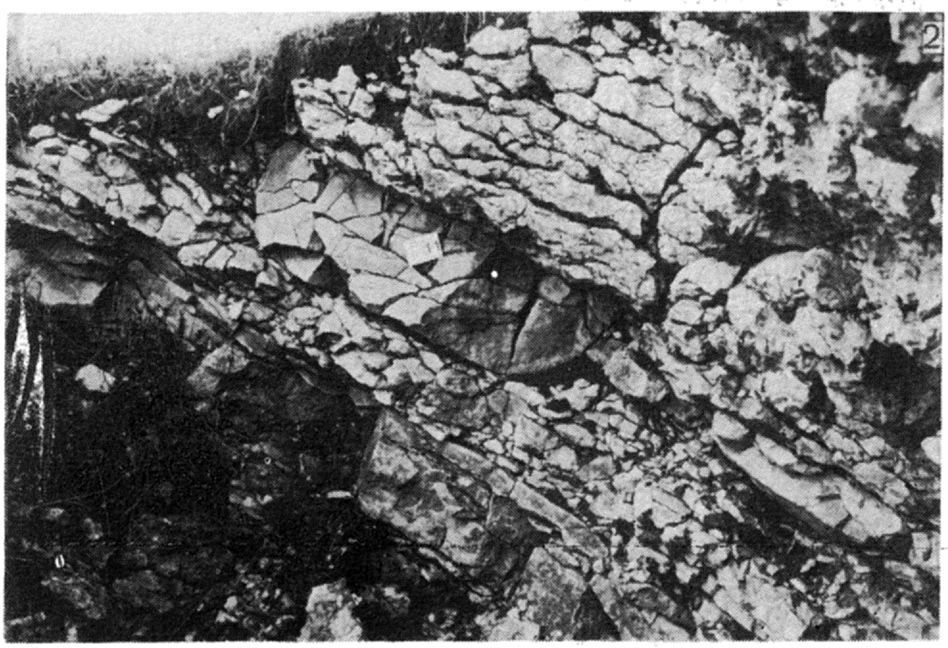
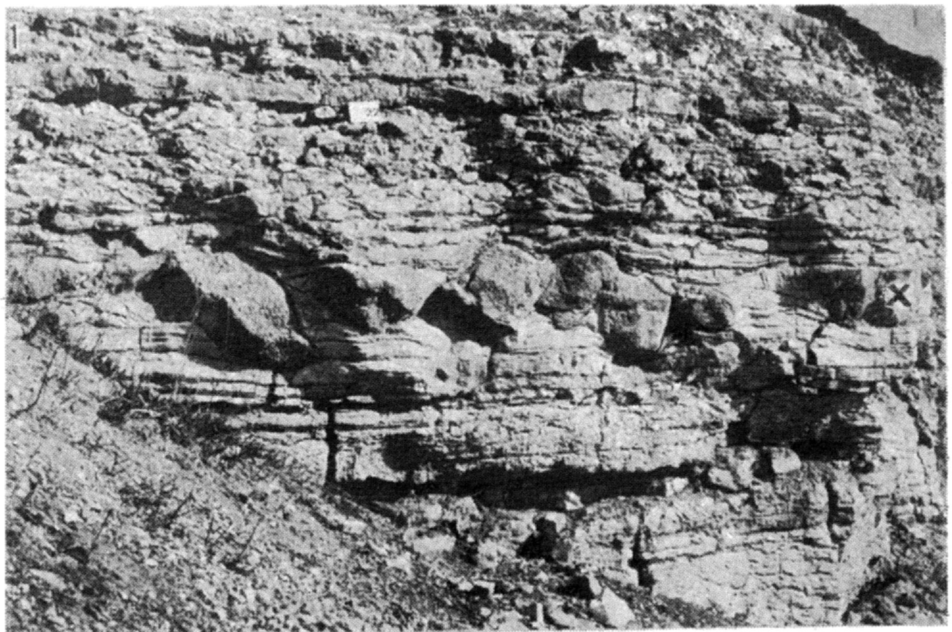
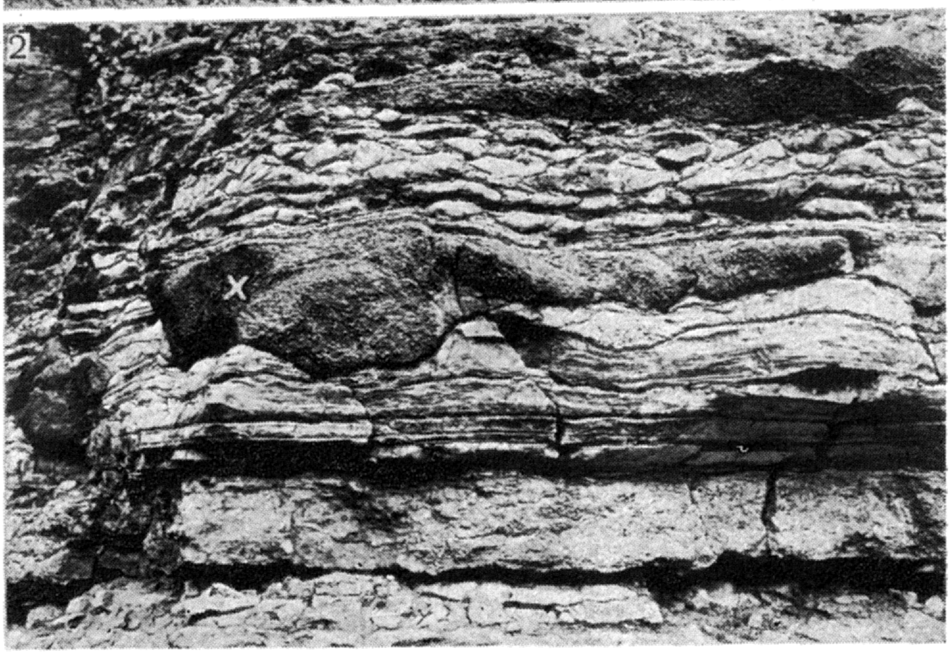




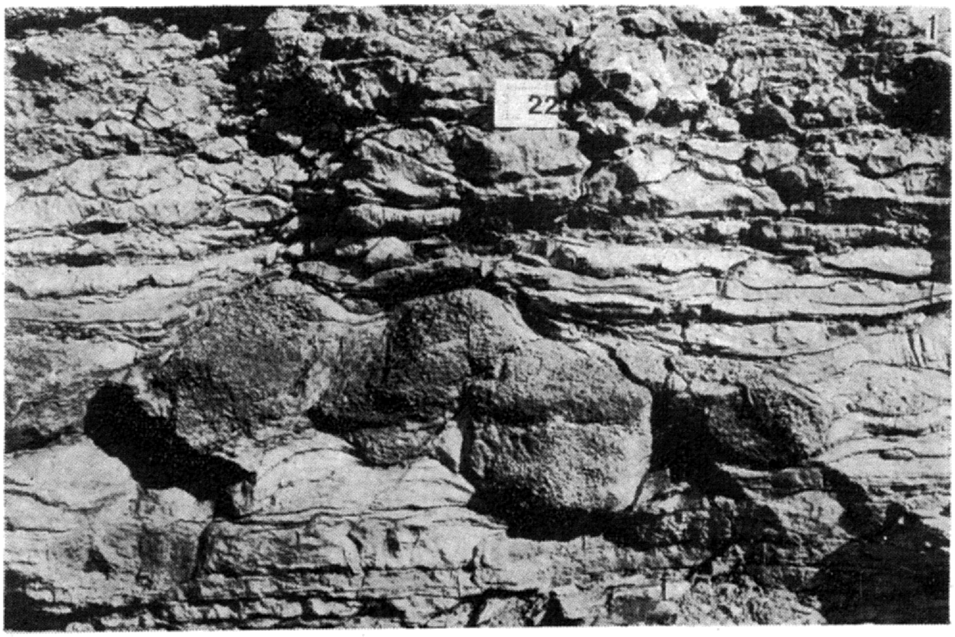
1 — Deformational structure in the Wellenkalk at Pierzchnica.
2 — Another part of the same structure at Pierzchnica (view perpendicular to that in preceding photo).

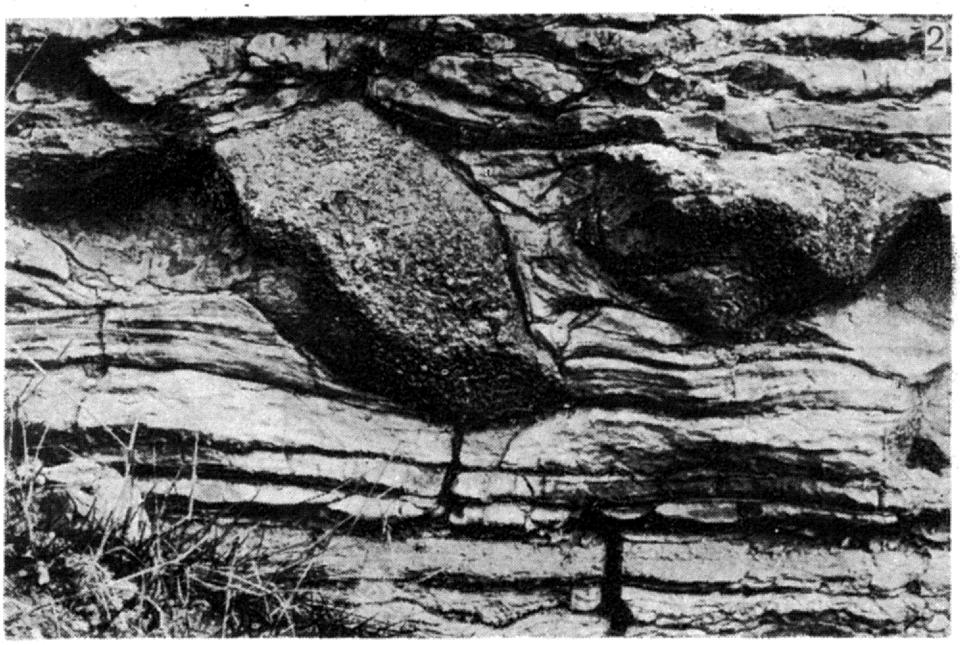




1 — General view of the deformational structures in the Wellenkalk at Wolica.

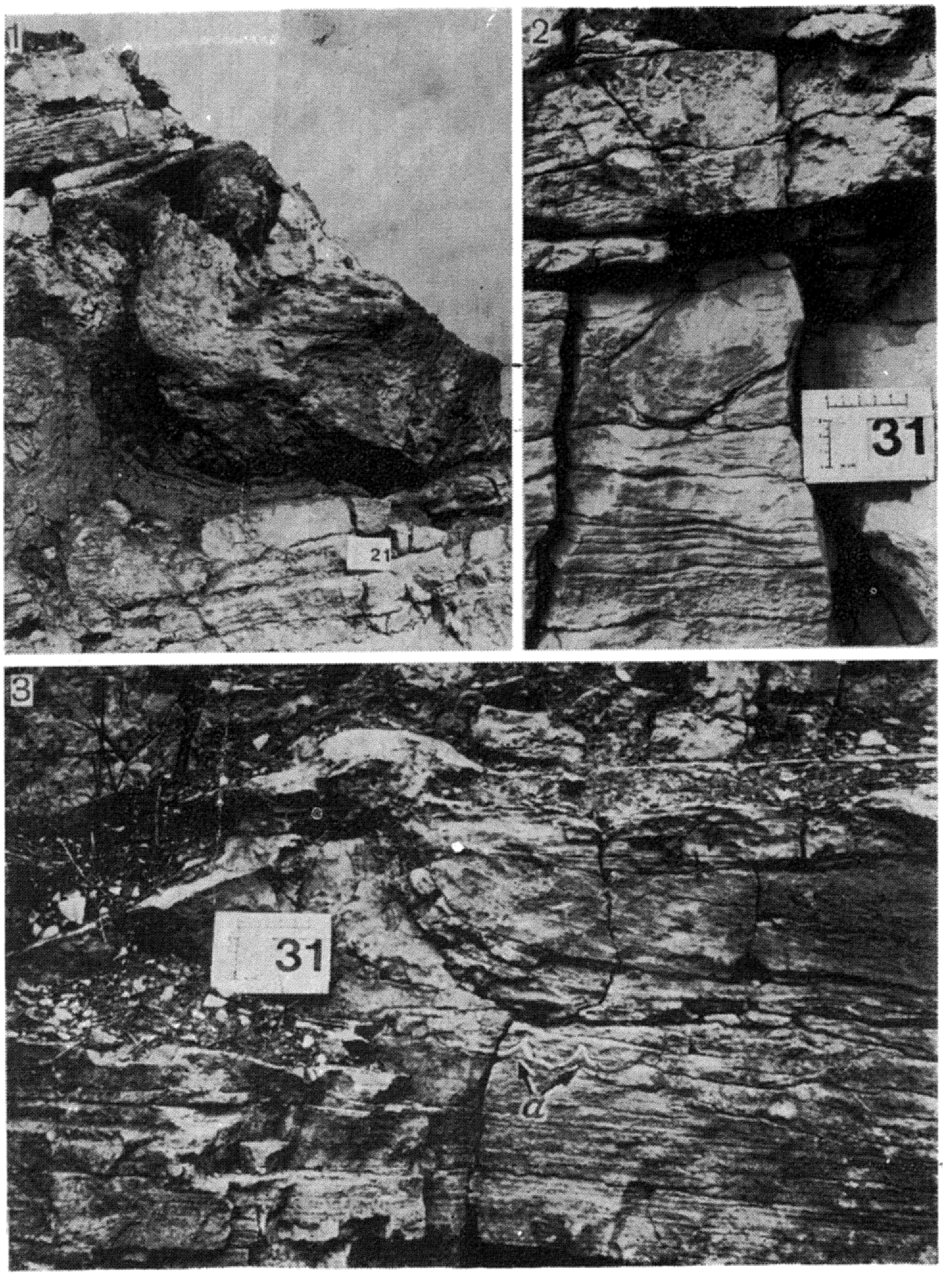
2 — The same structures visible in perpendicular section of the exposure (mark x the same as in preceding photo).





1 — Detailed view of the structures presented in Pl. 2, Fig. 1.

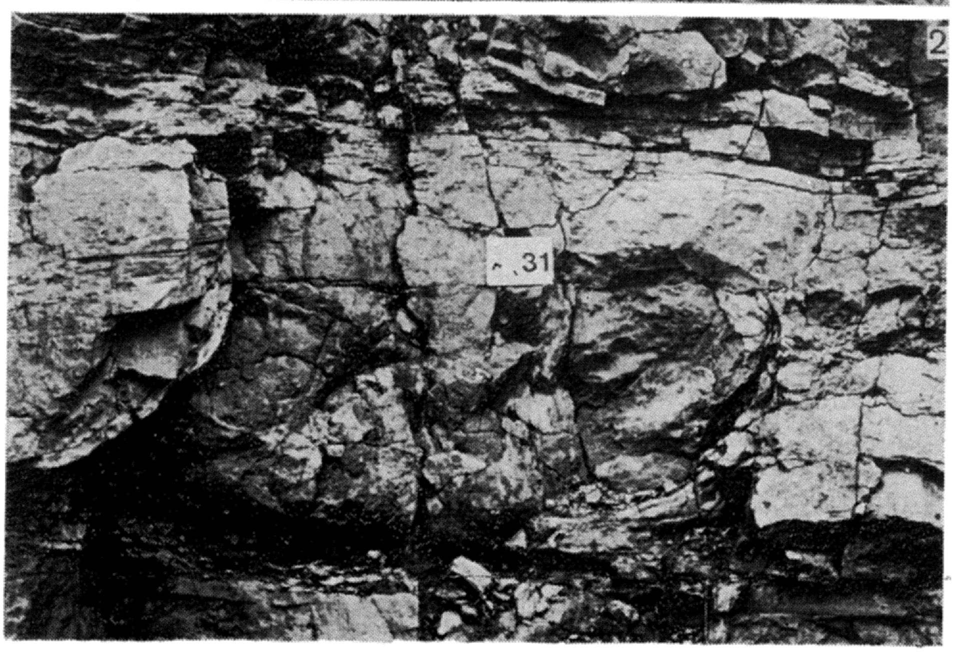
2 — Another detailed view of the same structures: between the torn-out fragments of the layer a diapiric squeeze is visible.



1 — Deformational structure in the Wellenkalk at Wolica (*cf.* Text-fig. 3).

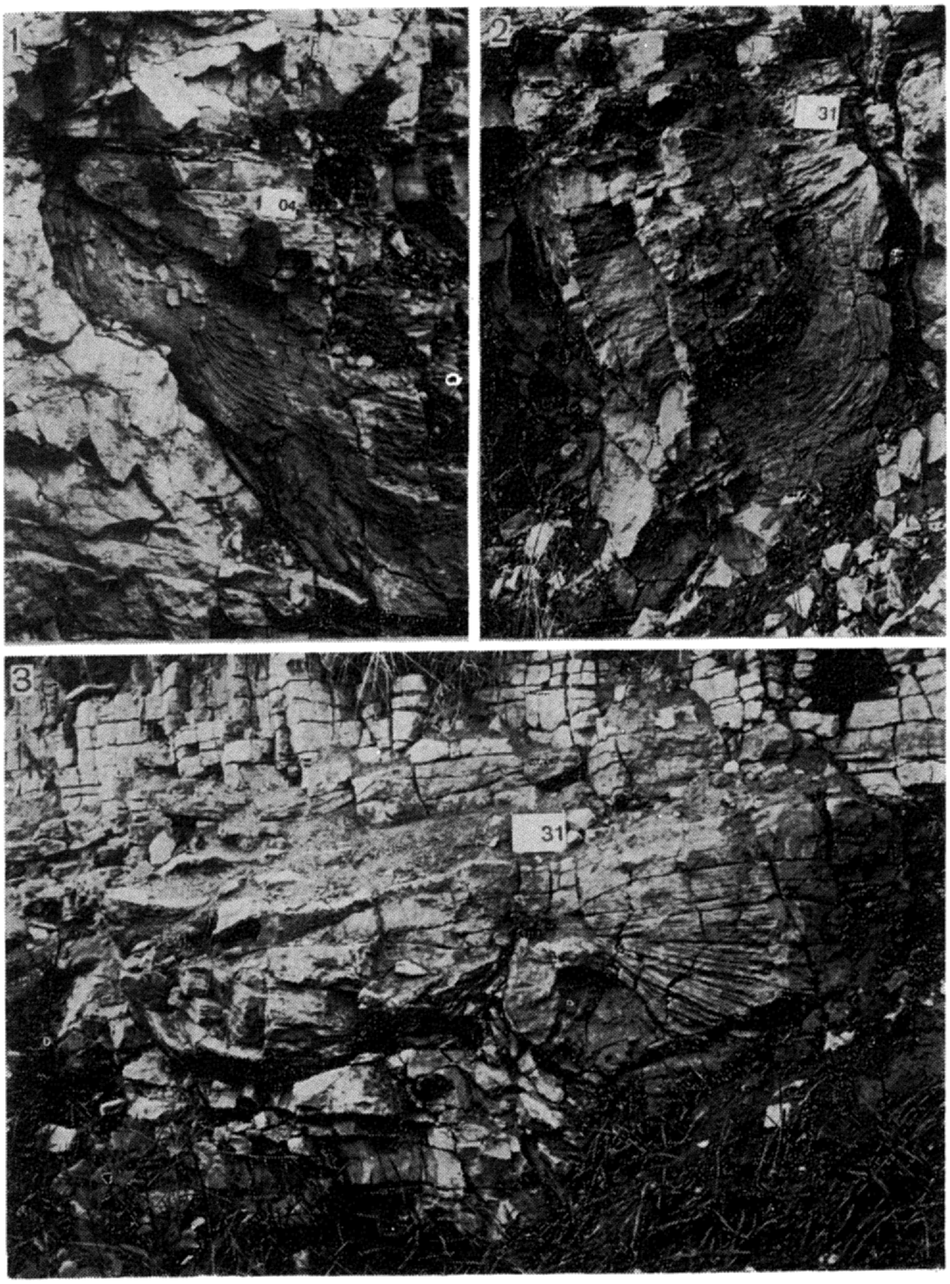
2 — Torn-out and translocated fragment of the layer from the upper disturbed complex at Drabów (Łukowa Beds); northern part of the exposure.

3 — Diapiric structure in the upper disturbed complex at Drabów: at the base of the bigger diapire smaller diapiric forms (*a*) are visible (*cf.* Text-fig. 6*A*).



1 — Detailed view of the deformational structure at Drabów: lower complex with a load-casted slab of layered, micritic limestone (*a*) and upper complex with a diapiric structure (*b*) are visible (*cf.* Text-fig. 6*B*).

2 — Disturbances in marly limestones of the lower complex at Drabów (*cf.* Text-fig. 6*B*).



1 and 2 — Load-casted slabs of layered limestones of the lower complex at Drabów (folding of the bedding in the slab presented in Fig. 1 is visible).

3 — Diapiric structures of the upper complex at Drabów (northern part of the exposure).