ROCZNIK POLSKIEGO TOWARZYSTWA GEOLOGICZNEGO
ANNALES DE LA SOCIÉTÉ GÉOLOGIQUE DE POLOGNE
Vol. XLVII — 3: 355—370 Kraków 1977

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ANCIENT DEEP-SEA TRACTION CURRENTS DEPOSITS IN THE LGOTA BEDS (ALBIAN) OF THE CARPATHIAN FLYSCH

(Pl. I—IV and 5 Figs.)

Osady głębokowodnych prądów trakcyjnych w warstwach lgockich fliszu karpackiego

(Tabl. I—IV i 5 fig.)

Abstract: The Lgota beds (Albian) of the Carpathian Flysch contain thin lenticular beds of fine-grained sandstone, siltstone and spongiolite with cross-lamination, concentrations of heavy minerals in individual laminae and good sorting. These beds are intercalated in clayey shales alternating with turbidite sandstones. The lenticular beds are regarded as deposits of deep-sea traction currents. The relation of the ancient traction currents deposits to recent contourites is discussed. A general term „tractionite" is suggested for ancient traction currents deposits alternating with turbidites.

INTRODUCTORY REMARKS

Small-scale cross-lamination is common in some lithostratigraphic units of the Carpathian Flysch, and an early paper dealing with this type of sedimentary structures was published by Książkiewicz (1974). With the advent of the turbidity currents theory it has been recognized that small-scale cross-lamination can be produced by turbidity currents. Since the paper by Kuenen and Carozzi (1953) small-scale cross-lamination in Flysch rocks was usually attributed to the action of turbidity currents.

Research on recent sediments brought evidence of other important mechanisms of transport and sedimentation in deep-sea basins (the term deep-sea is used here for basins with bottom lying below the neritic depth range). The importance of geostrophic thermohaline contour currents for transport and deposition of fine-grained detrital sediments has been recognized (Heezen et al. 1966, Schneider et al. 1967). Earlier fine sand layers with cross lamination accentuated by heavy minerals concentrations were described in Recent sediments of the North Atlantic Ocean (Heezen and Hollister, 1964). These sediments were regarded at first as turbidite deposits, but later their origin due to currents of thermohaline circulation has been recognized. Hollister and Heezen (1972) introduced the term „contourite" for fine sand and silt layers deposited by thermohaline geostrophic currents deflected by the Corolis force againts the sides of the basin and flowing parallel to the contour lines across the bottom slope.

Detailed characteristics of modern contourites and criteria for their distinction from turbidites were given by Bouma (1972a) and Bouma and Hollister (1973).

Since some years students of flysch rocks discussed generally the importance of bottom currents for sediment transport and deposition in ancient deep-sea basins (Walton 1967, with references to earlier papers, Wezel 1970, Mutti and Ricci Lucchi 1972, Bouma 1972 a,b). A well documented description of traction current deposits alternating with turbidite beds was given by Ballance (1964), while Bouma (1972a) published an account of possible ancient contourites.

This paper presents a description of rocks, which, in the opinion of the writer, can be regarded with high probability as ancient sediments of bottom traction currents. The possibility of their deposition by ancient geostrophic contour currents is discussed.

TURBIDITES AND TRACTION CURRENTS DEPOSITS IN THE LGOTA BEDS

Turbidites

The Lgota beds of Albian age (Bieda et. al. 1963), form a widespread lithostratigraphic unit in the Silesian Series of the Carpathian Flysch. The sedimentological characters indicate, that the Lgota beds consist predominantly of turbidites (Unrug 1959). Lithologically the Lgota beds are composed of alternating sandstones and shales. The sandstones are coarse- to fine-grained, thick-bedded to thin-bedded, graded, laminated, and cross laminated. The stratification structures follow the ordered pattern typical for turbidite beds, and full sequences of Bouma's (1962) divisions, as well as base-truncated and top-truncated sequences are present in the sandstone beds. The sandstones contain calcareous and clay matrix, the latter being concentrated in dark laminae. Some coarse-grained lenticular beds with graded bedding and erosional base contacts were interpreted as channelized deposits of turbidity currents. (Unrug 1959).

In the upper division of the profile of the Lgota beds — called the Mikuszowice Cherts — the sandstones contain much biogenic silica in the form of opal and chalcedony cement and spongiolite chert bands within the sandstone beds.

The sandstones of the Lgota beds are alternating with dark grey and greenish clayey shales, containing foraminiferal assemblages indicating an upper bathyal depth range of the sea floor (K s i ą ż k i e w i c z 1975). The general character of facial development falls into the category of facies C — sandstones with shale interbeds, and facies D — shales with sandstone interbeds of M u t t i and R i c c i L u c c h i (1972). The association of these facies is indicative of outer fan environment.

Traction currents deposits

Already in 1959 the present author noted in the Lgota beds the presence of very thin-bedded sandstones with small-scale cross-lamination as the only sedimentary structure. These beds were then interpreted (U n r u g 1959), in terms of rate of deposition from diluted tails of turbidity currents. A recent re-examination of exposures of the Lgota beds in quarries at Kozy, Kaczyna and Lanckorona (Fig. 1) in the west-

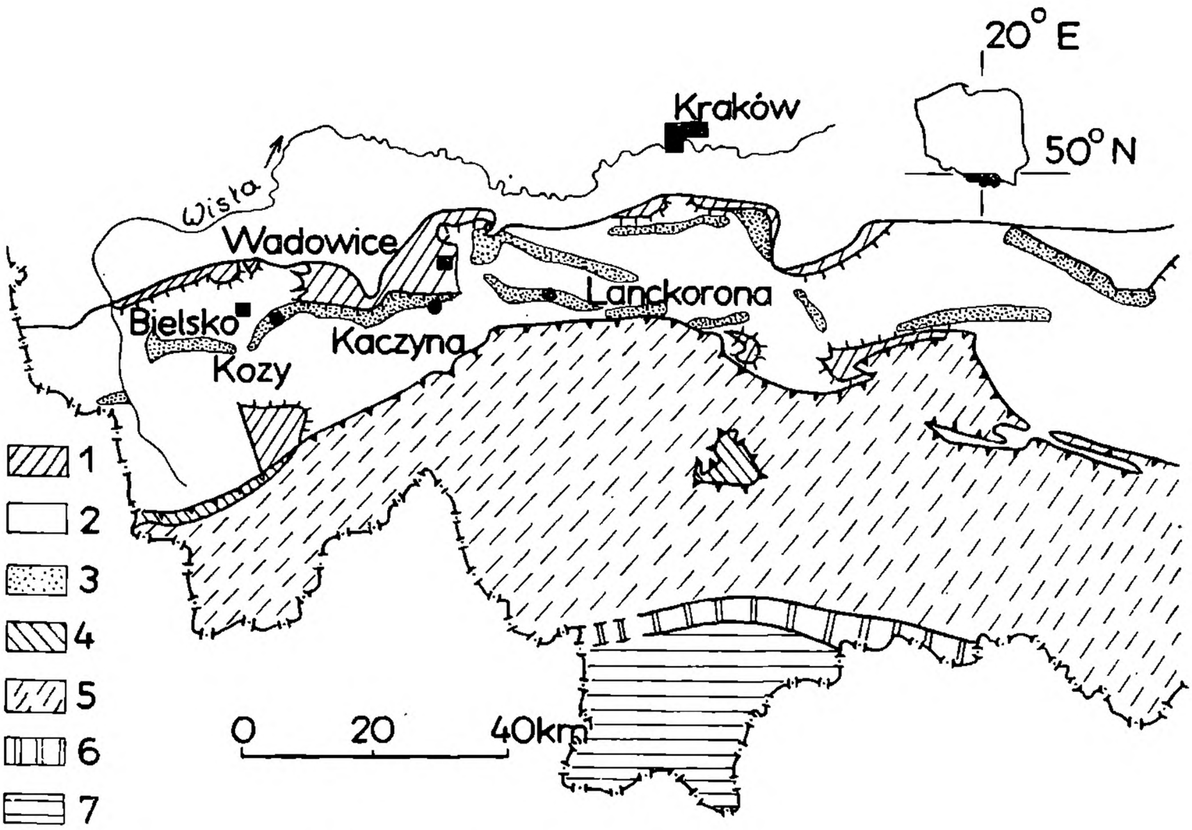

Fig. 1. General map of occurrences of the Lgota beds in the western Polish Carpathians. 1 — Sub-Silesian nappe; 2 — Silesian nappe; 3 — generalized areas of outcrops of the Lgota beds, 4 — Fore-Magura nappe; 5 — Magura nappe; 6 — Pieniny Klippes Belt; 7 — Inner Carpathians

Fig. 1. Mapa występowania warstw lgockich w zachodniej części polskich Karpat fliszowych. 1 — Płaszczowina podśląska; 2 — płaszczowina śląska; 3 — zgeneralizowane obszary występowania warstw lgockich; 4 — łuska przedmagurska i jednostka okienna; 5 — płaszczowina magurska; 6 — pieniński pas skałkowy; — 7 Karpaty wewnętrzne

ern part of the Polish Carpathians provided evidence of the occurrence of beds with textural and structural features considered typical for deep-sea traction currents deposits.

Bedding

The sandstone and siltstone beds regarded as traction currents deposits form lenticular beds in the shales alternating with turbidite sandstones. The lenticular beds have maximum thicknesses in the range of a few milimetres up to 5 cm, and are from 20 cm up to 2 m long. Lenses c. 50 cm long are most frequent. As a rule several lenses in the same horizon can be seen in large exposures in quarry faces (Plate I Fig. 1). Both the base and the top contacts of these beds are sharp, and only in rare cases gradational contacts with overlying siltstone are present (Plate II, Fig. 1, Fig. 2, Plate III, Fig. 1).

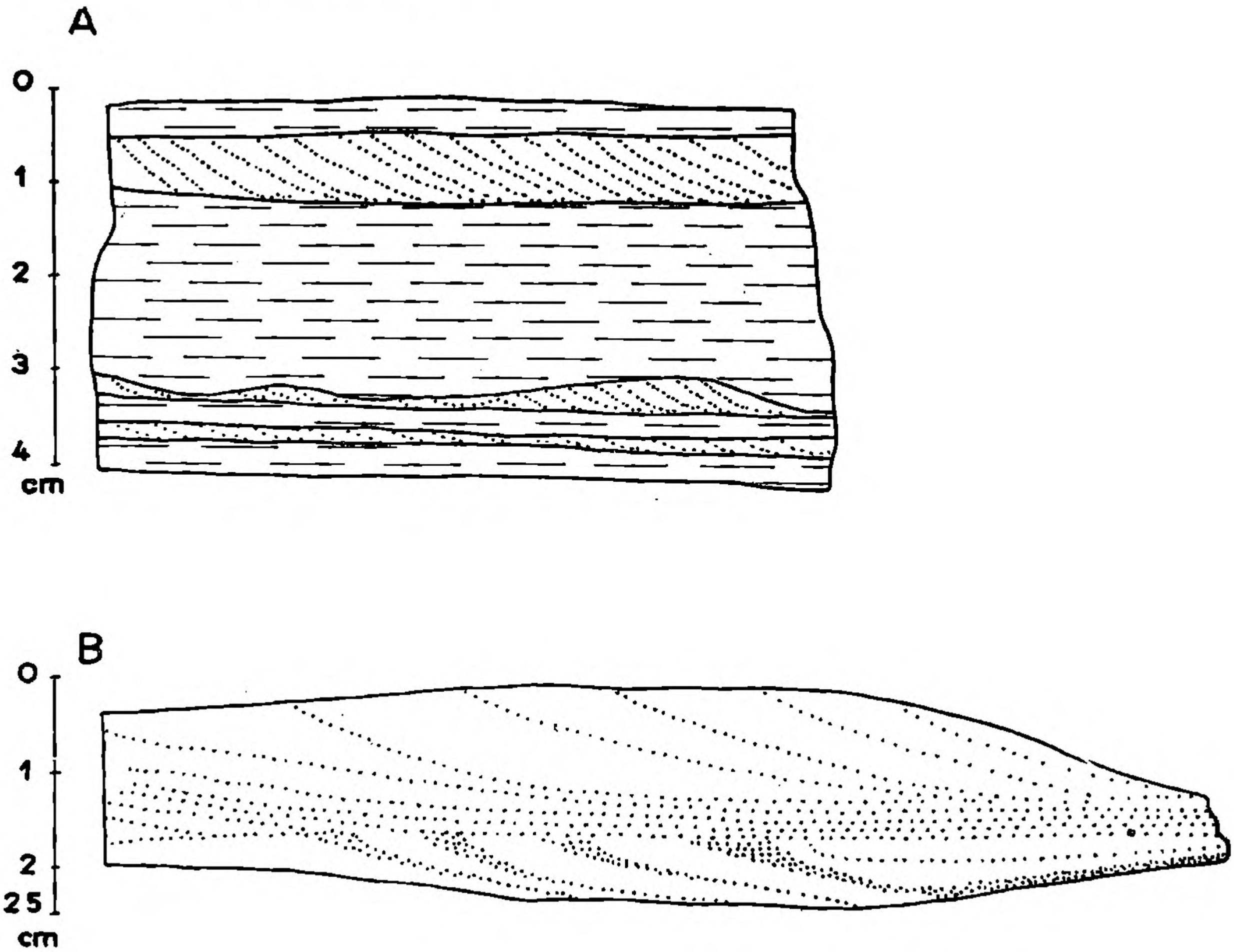

Fig. 2A. Small-scale cross-lamination in lenticular beds of fine grained sandstone and siltstone. Lgota beds, quarry at Kozy. B. Small-scale cross-lamination and horizontal lamination in lenticular bed of spongiolite. Upper part of Lgota beds (Mikuszowice Cherts), quarry at Lanckorona

Fig. 2A. Laminacja przekątna małej skali w soczewkowych warstwach piaskowca drobnoziarnistego i mułowca. Warstwy lgockie, kamieniołom w Kozach. B. Laminacja przekątna małej skali i laminacja pozioma w soczewkowej warstwie spongiolitu. Rogowce mikuszowickie, kamieniołom w Lanckoronie

Stratification structures

Small-scale cross-lamination is present in all lenticular beds. In some cases it is associated with horizontal lamination (Fig. 2). The cross-laminae are often marked by concentrations of heavy minerals, in most cases one grain thick (Plate IV Fig. 1) and more rarely dispersed within the whole thickness of a lamina. In siltstone lenses mica flakes are arranged parallel on the surfaces of cross-laminae.

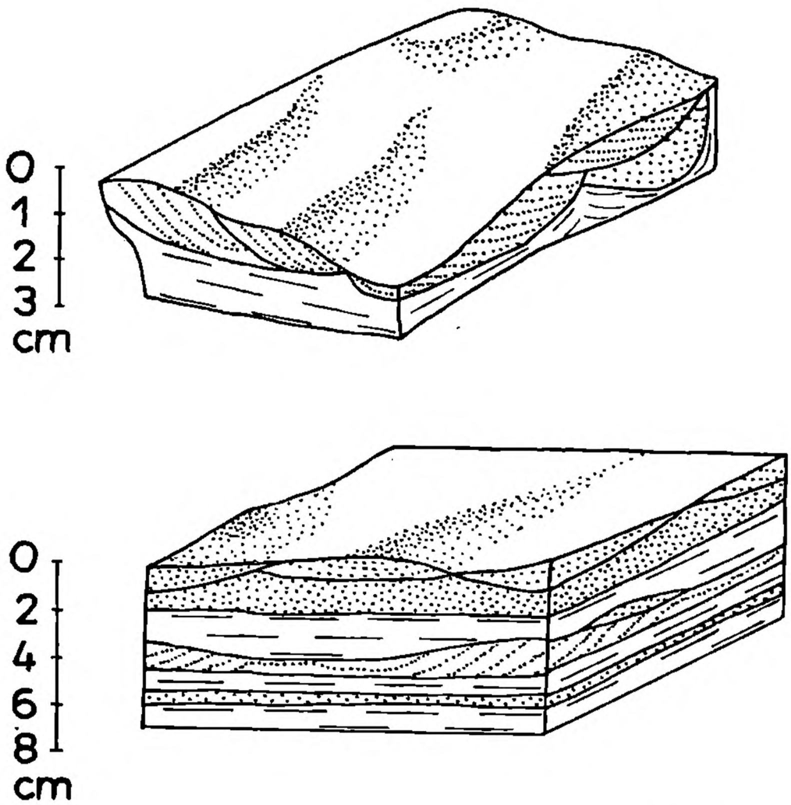

Fig. 3. Superposed ripples in lenticular beds of fine-grained sandstone. Lgota bed, quarry at Kaczyna

Fig. 3. Nakładające się riplemarki w soczewkowych warstwach drobnoziarnistego piaskowca. Warstwy lgockie, kamieniołom w Kaczynie

The lenticular beds consist of single sets or of cosets of cross-laminae (Fig. 2). The one-set beds form often single ripples. In some cases the ripples are superposed and imbricated, smoothing the irregularities of the depositional surface (Fig. 3). In such cases the cross-lamination in the lower ripples is usually load deformed.

Another type of deformations of the cross-laminated lenticular beds consists in disruption of continuity of the beds, and formation of short lenses not exceeding 10 cm in length. The lenses are load deformed and imbricated, while the sets of cross-laminae are deformed into more or less complicated recumbent folds (Fig. 4). This type of deformations is attributed to the action of current drag upon sand fluidized or liquefied

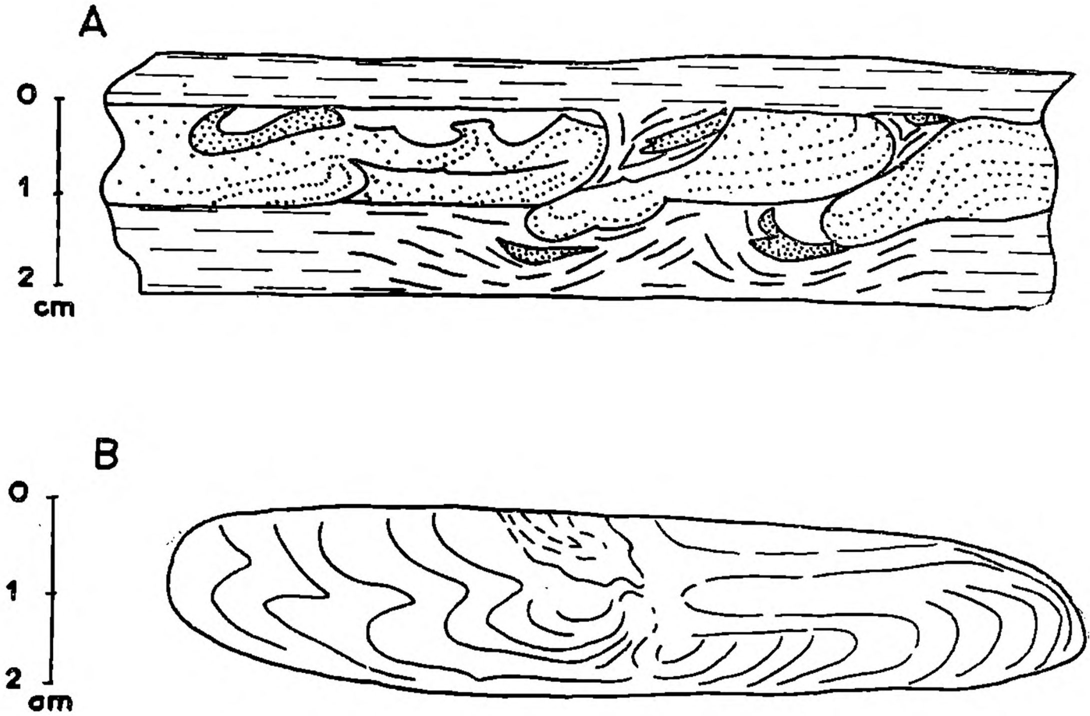

Fig. 4. A. Lenticular bed disrupted into short imbricated lenses with deformed lamination. Lgota beds, quarry at Kozy. B. Lamination deformed into recumbent folds in short lens of spongiolite. Upper Lgota beds (Mikuszowice Cherts) quarry at Lanckorona.

Fig. 4. A. Soczewkowa warstwa mułowca rozerwana na krótkie soczewki łuskowo ułożone, ze zdeformowaną laminacją. Warstwy lgockie, kamieniołom w Kozach. B. Laminacja przekątna małej skali zdeformowana w fałdy leżące, w krótkiej soczewce spongiolitu. Rogowce mikuszowickie, kamieniołom w Lanckoronie

by earthquake shock (Allen and Banks 1972). All three types of deformations of cross-laminae described by these authors occur in the deformed sandstone lenses of the Lgota beds.

Sedimentary material

In the lower and middle division of the profile of the Lgota beds the lenticular beds are composed of fine-grained sandstone and coarse siltstone. The maximum grain size present in the individual beds range from 0,2 mm to 0,01 mm. Sorting of the detrital framework grains is good to very good, the ratio of the largest and smallest grain diameter in individual beds ranging from 4 to 2. The sandstones contain very little muddy matrix. The cement is calcareous, and in some laminae rhomboedric crystals of ferrous dolomite (ankerite) are numerous.

The sandstones and siltstones are composed of quartz, rare glauconite (present only in sandstones), heavy minerals and foraminiferal chambers and whole tests filled with pyrite.

Within the upper division of the Lgota beds i.e. in the Mikuszowice Cherts — the petrographic character of the lenticular beds is different.

They are composed of sponge spicules, foraminiferal single chambers and whole tests, and contain very little if any terrigenous material. The sponge spicules display a strongly marked preferred orientation, differing in individual cross-laminae.

The terrigenous material, if present, is concentrated in separate laminae rich in heavy minerals and containing also some quartz. Sometimes the purely biogenic laminae contain concentrations of foraminiferal chambers and whole tests filled with pyrite. These chambers and tests probably were already filled with pyrite at the time of deposition and behaved hydraulically like heavy minerals.

Directions of traction currents

In one of the examined quarries — at Kozy — exposure conditions permitted to take 10 measurements of directions of cross-laminae in the lenticular beds. Six out of ten measured directions of dip of cross-laminae are roughly perpendicular to the regional palaeocurrent direction of turbidity currents which is very constant in this exposure and has an azimuth of 110° (Fig. 5).

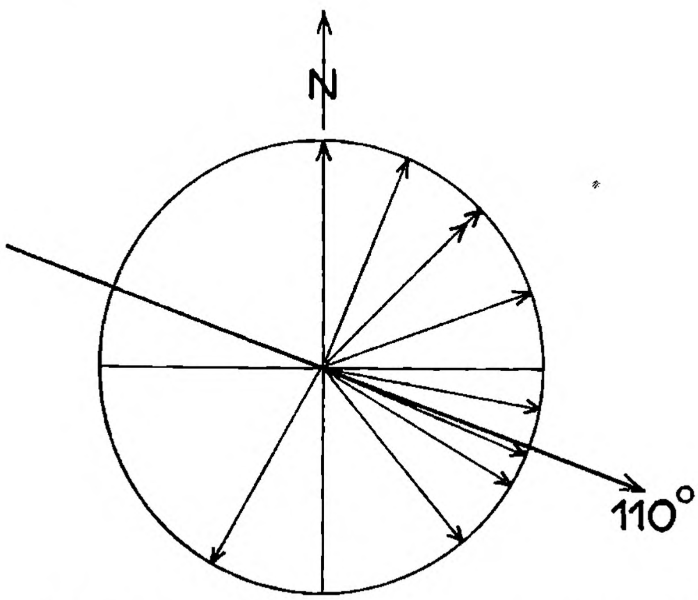

Fig. 5. Directions of bottom traction palaeocurrents as indicated by azimuths of dip of cross-laminae. Direction of turbidity palaeocurrents — 110° indicated by sole markings of turbidite beds. Lgota beds, quarry at Kozy.

Fig. 5. Kierunki dennych prądów trakcyjnych wskazywane przez azymut nachylenia lamin przekątnych. Kierunek prądów zawiesinowych — 110° na podstawie azymutu jamek wirowych i śladów wleczenia na spągowych powierzchniach ławic turbidi-towych. Warstwy lgockie, kamieniołom w Kozach.

Features diagnostic for traction currents deposits

To summarize, the described lenticular beds display the following features regarded as diagnostic for traction currents deposits (compare B o u m a 1972 a, B o u m a and H o l l i s t e r 1973):

— accumulation of detrital and biogenic (sponge spicules, foraminifers) material in the form of lenses and ripples,
— sharp base and top contacts of the lenticular beds (for rare cases of gradational top contacts see discussion in the following paragraph),
— small thickness of beds, rarely exceeding 5 cm, and often inferior to 1 cm,
— grain size in the very fine sand and silt grades,
— well developed grain orientation, visible especially in the case of sponge spicules,
— good sorting of the terrigenous and biogenic material,
— absence of clay matrix; mica flakes associated with silt grades only,
— concentrations of heavy minerals and heavy, pyrite-filled foraminiferal tests and chambers in individual laminae,
— stratification structures restricted to cross-lamination and horizontal lamination,
— no fixed vertical order of stratification structures,
— purely biogenic material (sponge spicules, foraminiferal chambers and tests) in some beds, showing grain orientation, cross-lamination and accumulation in the form of lenses and ripples.

It is concluded therefore, that the discussed beds, forming intercalations in clayey shales alternating with turbidite sandstones were deposited by bottom traction currents and not by turbidity currents.

SPECIAL CASES: SEDIMENTATION FROM NEPHELOID LAYER, REWORKING OF TURBIDITE SAND LAYERS BY BOTTOM TRACTION CURRENTS

Some of the beds, usually less than 1 cm thick, are consisting of alternating dark and light laminae. The light laminae are composed of well sorted very fine-grained sandstone and often contain concentrations of heavy minerals. The dark laminae contain abundant clay matrix. Horizontal lamination is common in such beds and the top contacts are sharp, or often gradational.

It is suggested that in such beds the clay-rich laminae (Plate IV Fig. 2) and gradational top contacts do not indicate deposition by turbidity currents, but rather were formed by settling of clay from a bottom nepheloid layer containing clay-sized particles in suspension, as described by Ewing and Thorndike (1965), and moved by a traction current. It is supposed that the clay suspension of the nepheloid layer in recent oceans is formed by injection by turbidity currents (Eittreim, Ewing and Thorndike 1969). Thus is logical to assume the presence of a nepheloid bottom layer in the sedimentary basin of the Lgota beds, where the action of turbidity currents was constantly repeated.

It is also possible that clay floccules and pellets formed by the action of benthic animals were transported by traction currents together with the very fine sand grains.

Many beds of turbidite sandstone of the Lgota beds contain the division of small-scale cross-lamination (division C in the scheme of Bouma 1962). These beds contain more clay matrix and have coarser grain and poorer sorting than the lenticular beds of traction currents deposits. However, in some beds the division of small-scale cross-lamination consist of well sorted, fine grained sandstone or coarse-grained siltstone, with no clay matrix and concentrations of heavy minerals in individual laminae.

Sets of cross-laminae with these textural characters are occurring in beds with two types of patterns of sedimentary structures:

— in thin and medium beds consisting of sets of cross-laminae and sets of horizontal laminae, alternating with no fixed order,

— in thin and medium beds always at the top of the bed above the graded and/or horizontally laminated division (Plate III, Fig. 2).

In the first case the whole, or most of the bed is probably a deposit of traction current, possibly formed by interaction of traction currents and diluted tails of turbidite currents, or dense nepheloid layers.

In the second case, the cross laminated division is interpreted as the result of reworking of turbidite sand layer by bottom traction current.

COMPARISON OF ANCIENT TRACTION CURRENTS DEPOSITS AND RECENT CONTOURITES

In recent literature deep-sea traction currents deposits associated with turbidites are attributed to the action of geostrophic contour currents (Bouma 1972 a, b, Bouma and Hollister 1973). Certainly these two types of sediments were deposited in Quarternary times in the North Atlantic. However the problem of actualistic approach to ancient traction currents deposits deserves a critical discussion.

The recent contour currents of the Atlantic and other oceans are the result of thermohaline circulation controlled by climatic and morphologic factors. In the Atlantic Ocean they are due directly to the dense and cold masses of Artic Bottom Water in the Western Boundary Undercurrent and of the Antarctic Bottom Water in the Antarctic Bottom Current (for good reviews of deep-sea currents see Neumann and Pierson 1966, Hollister and Heezen 1971).

In the case of the described traction currents deposits in the Lgota beds, the problem of palaemorphologic and palaeoclimatic conditions influencing the bottom palaeocurrents system in the Thetys Ocean remains an open question. According to B o u m a and, H o l l i s t e r (1973) bottom circulation of contour currents should be expected in any large basin (at least 300 x 500 miles = c. 500 x 900 km), whose waters are not topographically contained and which has a source of heavy water. In spite of the crustal shortening of the geosynclines of the Alpine belt it seems certain that the Thetys Ocean was elongated East-West, and therefore it is unlikely that polar regions could supply heavy water in Early Cretaceous times. Although the Atlantic Ocean was already opened and connected with the Thetys Ocean, it is not sure whether its dimensions and climatic contrasts of high latitude and low latitude regions were sufficient to create strong bottom currents circulation. However it is possible that a source of heavy water due to evaporation and increased salt concentration existed in the low latitude region of the Thetys Ocean. The northern part of the Early Cretaceous Thetys Ocean formed probably one major basin with relatively uniform sedimentary environment, as indicated by remarkable similarities in lithological development of Lower Cretaceous Flysch sequences throughout the Carpathians and in the Caucasus (K s i ą ż k i e w i c z 1962, 1973). This leads to the idea that thermohaline circulation currents could flow over very large distances in this basin.

It should be also taken into consideration that recent currents are flowing at depth of 3000 m to 5000 m (H e e z e n et al. 1966), while the latest estimates of the depth of deposition of the Flysch rocks of the Carpathians indicate smaller depth — in the range of the upper bathyal zone (K s i ą ż k i e w i c z 1975). If this depth range is assumed, the direct action of large surface currents on the bottom of deep-sea basins should also be considered. The recent Gulf Stream is transporting detrital material in depth exceeding 500 m on the Blake Plateau (H e e z e n et al. 1966, Fig. 1).

In the Lgota beds the traction currents deposits occur between and at the top of turbidite beds. A support for the hypothesis of contourite nature of the traction currents deposits in the Lgota beds seems to be provided by the contrast in palaeocurrents directions in the turbidite beds and a major part of the lenticular beds (Fig. 5). If it is assumed that turbidity currents flowed downslope to the East-South-East, it would follow that the traction currents flowing to the North-East were moving across the slope. However some traction currents flowed in the same direction as the turbidity currents. As the present amount of data is small, it would be unwise to rely too heavily on this line of evidence until more observations are collected.

On the other hand, in recent oceans turbidites are deposited on gently sloping submarine fans and flat submarine plains, while contourites are deposited on the relatively steeper sloping continental rise and are absent on the flat abyssal plains (H e e z e n et al. 1966), because of the dynamics of the geostrophic contour currents. The structure and origin of the continental rise is a debatable matter and some authors consider it as deposited principally by contour currents (Heezen et. 1966), while others stressed upon the importance of slump deposits (Emery et al. 1970). Although there are probably important differences between ancient Flysch basins and Recent oceans — it can be said that deposition of turbidites tends to produce gently sloping or flat accumulation surfaces which are not the site of deposition of sediments by contour currents. The described Lgota beds were deposited in the outer fan environment. It is not known whether the slope of the fan surface was comparable to that of the recent continental rise.

In the opinion of the writer, the presented data indicate that the deposition of lenticular fine-grained and cross-laminated thin beds, intercalated in the shales alternating with turbidite sandstones in the Lgota beds, can be attributed to the action of deep-sea traction currents. These currents could also rework the top surfaces of layers of turbidite sands. It is not certain whether these currents could be compared directly to recent geostrophic contour currents. However it seems probable that some kind of thermohaline circulation was involved in the generation of these traction currents.

For these reasons the use of the term „contourite" would be inapropriate in the case of the described deposits of the Lgota beds. The more general term „traction currents deposits" is preferred. If a one-word term is really needed, the writer would suggest the name „tractionite" [1] for deposits of traction currents, as opposed to „turbidite" — deposits of sediment-laden turbidity currents. The contourites should be considered then as a special case of tractionites. At present there are no clear cut criteria for distinguishing ancient contourites within tractionite deposits. Criteria permitting such a distinction will be probably based upon palaeogeographical consideration rather than upon textural and structural characters of the ancient sediments, which are likely to be similar in all types of tractionite deposites.

Coordinated research on traction currents deposits and on the relation of traction palaeocurrents systems to turbidity palaeocurrents systems in various parts of the Thetys domain are urgently needed. More data on traction palaeocurrents systems would certainly provide a better understanding of the complex palaeogeography of ancient Flysch basins in the Alpine fold belt.

Specimens pertaining to this study are housed in the Geological Mu-

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[1] Note added in print: After this paper has been submitted for publication Dr Franco Ricci Lucchi (University of Bologna) pointed out to the author that the term „tractionite" is inappropriate for determination of deep-sea traction currents deposits, as it has been used earlier in another meaning by M.L. Natland.

seum, Institute of Geological Sciences, Jagellonian University: UJ 12 — thin sections, UJ 13M — rock samples.

The author expresses his thanks to Professor M. Książkiewicz for discussion of the problem of traction currents deposits.

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September 1976

Manuscript received X 1976, accepted XI 1976

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STRESZCZENIE

Warstwy lgockie składają się z naprzemianległych ławic piaskowców osadzonych przez prądy zawiesinowe i łupków. W łupkach występują ponadto nieciągłe, soczewkowate, cienkie i bardzo cienkie ławice bardzo drobnoziarnistych piaskowców i mułowców, różniące się pod względem teksturalnym i strukturalnym od ławic piaskowców osadzonych przez prądy zawiesinowe.

Maksymalna grubość ławic soczewkowatych wynosi od kilku mm do 5 cm. Długość soczewek zmienia się w granicach od kilkunastu cm do 2 m, najczęściej wynosi około 50 cm. Powierzchnie spągowe i stropowe są ostre. Soczewki są laminowane i zawierają jeden lub więcej zestawów lamin przekątnych małej skali (Fig. 2). Niekiedy soczewki takie zachodzą łuskowo na siebie (Fig. 3). Niżej leżące soczewki mają wówczas laminy zdeformowane przez obciążenie. Występują też deformacje polegające na rozerwaniu ciągłości soczewek i pofałdowaniu lamin przekątnych (Fig. 4). Deformacje tego typu są przypisywane oddziaływaniu prądu trakcyjnego na osad upłynniony np. wskutek wstrząsu sejsmicznego.

Ławice soczewkowate zbudowane są z materiału bardzo drobnoziarnistego, dobrze wysortowanego. Iłowa masa wypełniająca (matrix) występuje w bardzo niewielkiej ilości lub jest całkowicie nieobecna. Spoiwo jest wapniste, niezbyt obfite. Laminacja przekątna podkreślona jest koncentracjami minerałów ciężkich, często o grubości jednego ziarna. Skład mineralny cienkoławicowych piaskowców i mułowców obejmuje: kwarc, minerały ciężkie, glaukonit. Występują też skorupki otwornic i ich pojedyncze komory, często wypełnione pirytem.

W rogowcach mikuszowskich stanowiących górny oddział warstw lgockich ławice soczewkowate zbudowane są ze spikul gąbek wykazujących wyraźną orientację, różniącą się w poszczególnych laminach. Materiał terygeniczny jest najczęściej całkowicie nieobecny, a jeśli występuje, to skoncentrowany jest w pojedynczych laminach zawierających kwarc i wzbogaconych w minerały ciężkie. Laminy czysto biogenicznego materiału zawierają niekiedy koncentracje skorupek i pojedynczych komór otwornic wypełnionych pirytem. Te skorupki i komory były prawdopodobnie wypełnione pirytem już w chwili ich transportu i zachowywały się hydraulicznie podobnie jak ziarna minerałów ciężkich.

Wymienione obserwacje cech teksturalnych i strukturalnych wskazują, że opisywane soczewkowate ławice nie były osadzone przez prądy zawiesinowe, lecz przez prądy trakcyjne.

W niektórych ławicach soczewkowatych występują dwa typy lamin: laminy wzbogacone w minerały ciężkie i laminy wzbogacone w iłową matrix. Jest możliwe, że matrix iłowa tych lamin osadzana była z przydennej warstwy nefeloidalnej.

Niektóre ławice piaskowców osadzone przez prądy zawiesinowe zawierają w swej stropowej części zestawy lamin przekątnych zbudowane z dobrze wysortowanego bardzo drobnoziarnistego piaskowca lub mułowca. Niektóre laminy wzbogacone są w minerały ciężkie. Te zestawy lamin prawdopodobnie zostały utworzone przez działanie dennego prądu trakcyjnego na materiał osadzony przez prąd zawiesinowy.

W literaturze istnieje tendencja do przypisywania genezy kopalnych głębokowodnych prądów trakcyjnych działalności geostroficznych prądów cyrkulacji termohalinowej płynących wzdłuż izobat, analogicznych do prądów płynących wzdłuż podniesienia przedkontynentalnego w Oceanie Atlantyckim. Zdaniem autora nie można porównywać ściśle dennych prądów trakcyjnych istniejących w basenie sedymentacyjnym warstw lgockich ze współczesnymi prądami geostroficznymi. Przeciwko takiemu bezpośredniemu porównaniu przemawiają argumenty paleogeograficzne, paleobatymetryczne i środowiskowe. Denne prądy trakcyjne w basenie sedymentacyjnym warstw lgockich związane były zapewne z cyrkulacją termohalinową, jednak odmiennego typu niż we współczesnych oceanach, gdzie w prądach geostroficznych przenoszone są masy zimnych i ciężkich wód z wysokich szerokości geograficznych. Nie można też wykluczyć oddziaływania wielkich prądów powierzchniowych na dno basenu sedymentacyjnego leżącego w zasięgu górnej części strefy batialnej.

Dlatego stosowanie terminu „konturyt" dla określenia kopalnych osadów głębokomorskich prądów trakcyjnych wydaje się nieuzasadnione, nie ma bowiem możliwości stwierdzenia, czy te prądy trakcyjne były geostroficznymi prądami „konturowymi" płynącymi wzdłuż izobat. Odpowiedniejszy wydaje się termin „osad głębokowodnego prądu trakcyjnego" lub dla krótkości: „trakcjonit" — przez analogię do określenia „turbidyt".

Materiały do niniejszej pracy przechowywane są w Muzeum Geologicznym Instytutu Nauk Geologicznych Uniwersytetu Jagiellońskiego, nr kolekcji: UJ12 (płytki cienkie), UJ13 M (okazy skał).

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EXPLANATION OF PLATES
OBJAŚNIENIA TABLIC

Plate I — Tablica I

Fig. 1. Alternating turbidite sandstones (A) and shales with thin lenticular beds of traction currents deposits (B and C, all scales in cm). Lgota beds, quarry at Kozy. Phot. R. U n r u g.

Fig. 1. Naprzemianległe ławice piaskowców osadzanych przez prądy zawiesinowe (A) i łupków zawierających cienkie soczewkowate wkładki osadów dennych prądów trakcyjnych (B i C, wszystkie podziałki w cm). Warstwy lgockie, kamieniołom w Kozach. Fot. R. U n r u g.

Plate II — Tablica II

Fig. 1. Very thin lenticular siltstone beds in shales. All scales in cm. Bed A consists of isolated ripples. Lgota beds, quarry at Kozy. Phot. R. U n r u g.

Fig. 1. Bardzo cienkie soczewki mułowca w łupku. Wszystkie podziałki w cm. Warstwa A składa się z izolowanych riplemarków mułowcowych. Warstwy lgockie, kamieniołom w Kozach. Fot. R. U n r u g.

Fig. 2. Lenticular bed of spongiolite (the diameter of the coin is 27 mm) between thicker turbidite cherty sandstones and shales. The series is overturned, basal contacts of beds at upper right. Upper Lgota beds (Mikuszowice Cherts). Quarry at Lanckorona. Phot. R. U n r u g.

Fig. 2. Soczewkowata ławica spongiolitu (średnica monety wynosi 27 mm) pomiędzy grubszymi ławicami piaskowców z rogowcami osadzonych przez prądy zawiesinowe i łupków. Seria jest odwrócona. Rogowce mikuszowickie, Kamieniołom w Lanckoronie. Fot. R. U n r u g.

Plate III — Tablica III

Fig. 1. Very thin lenticular beds of traction current deposits in shales between thicker turbidite sandstones (above and below rule — scale in cm). Lgota beds, quarry at Kozy. Phot. R. U n r u g.

Fig. 1. Bardzo cienkie soczewkowe ławiczki osadów dennych prądów trakcyjnych wśród łupków pomiędzy grubszymi ławicami piaskowców osadzonych przez prądy zawiesinowe. Warstwy lgockie, kamieniołom w Kozach. Fot. R. Unrug.

Fig. 2. Composite bed: turbidite (lower part, 19 cm thick) and traction current deposit (upper part 7 cm thick) with sharp basal and top contacts (arrows). Lgota beds, quarry at Kozy. UJ13M24. Phot. K. Fedorowicz.

Fig. 2. Ławica złożona: piaskowiec osadzony przez prąd zawiesinowy (dolna część miąższości 19 cm) i osad dennego prądu trakcyjnego (górna część miąższości 7 cm) z ostrymi powierzchniami granicznymi w spągu i stropie (strzałki). Warstwy lgockie, kamieniołom w Kozach. UJ13M24. Fot. K. Fedorowicz.

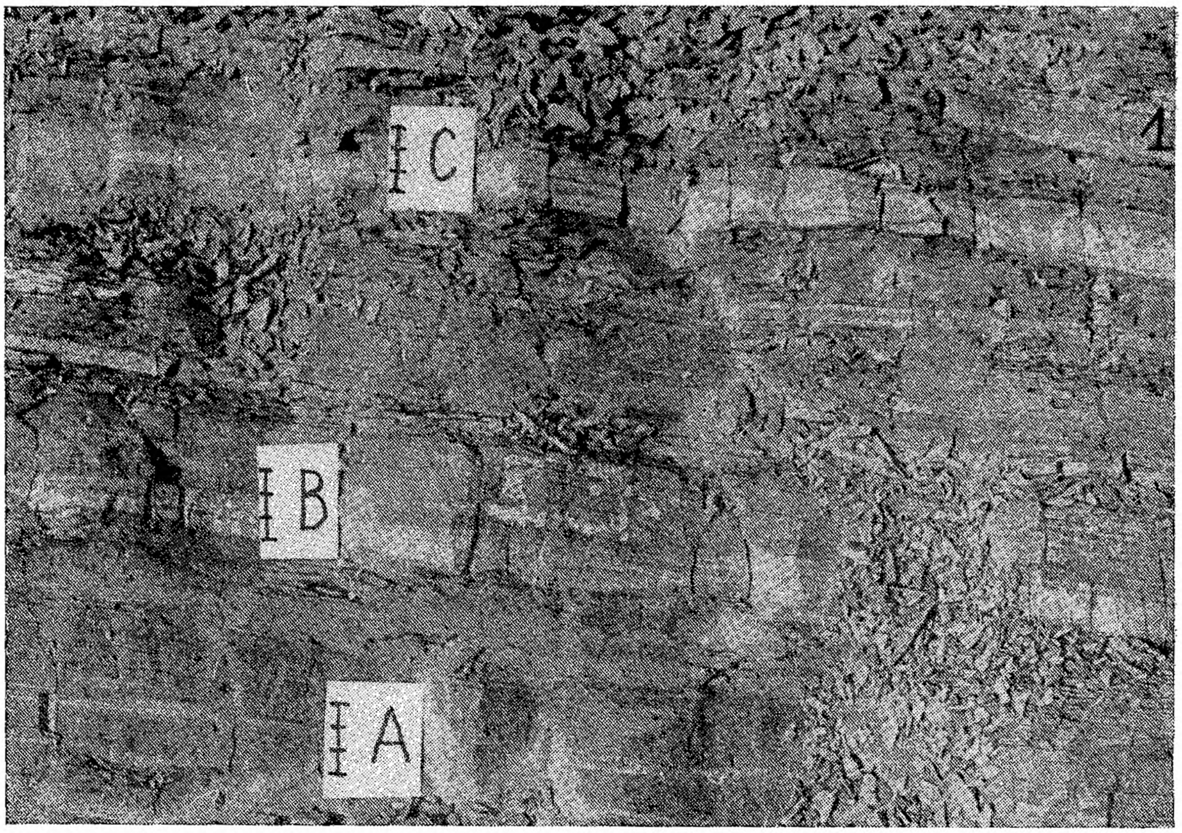
Plate IV — Tablica IV

Fig. 1. Lamina with concentration of heavy minerals in well sorted very fine-grained sandstone bed, 4 cm thick, with sharp base and top contacts. Thin section UJ 12/9b. Lgota beds, quarry at Kozy. Phot. R. Unrug.

Fig. 1. Lamina z koncentracją minerałów ciężkich w ławicy dobrze wysortowanego, bardzo drobnoziarnistego piaskowca o miąższości 4 cm. Płytka cienka UJ 12/9b. Warstwy lgockie, kamieniołom w Kozach. Fot. R. Unrug.

Fig. 2. Well sorted laminae (at base and top), with concentration of heavy minerals at base), separated by a lamina rich in clay (deposit of nepheloid layer?). Very fine-grained sandstone with sharp base and top contacts, 2,5 cm thick. Thin section UJ12/30. Lgota beds, quarry at Kozy. Phot. R. Unrug.

Fig. 2. Dobrze wysortowane laminy, dolna z koncentracją minerałów ciężkich, rozdzielone laminą wzbogaconą w platki substancji iłowej (osad warstwy nefeloidalnej?). Piaskowiec bardzo drobnoziarnisty z ostrą powierzchnią spągu i stropu, miąższości 2,5 cm. Płytka cienka UJ12/30. Warstwy lgockie, kamieniołom w Kozach. Fot. R. Unrug.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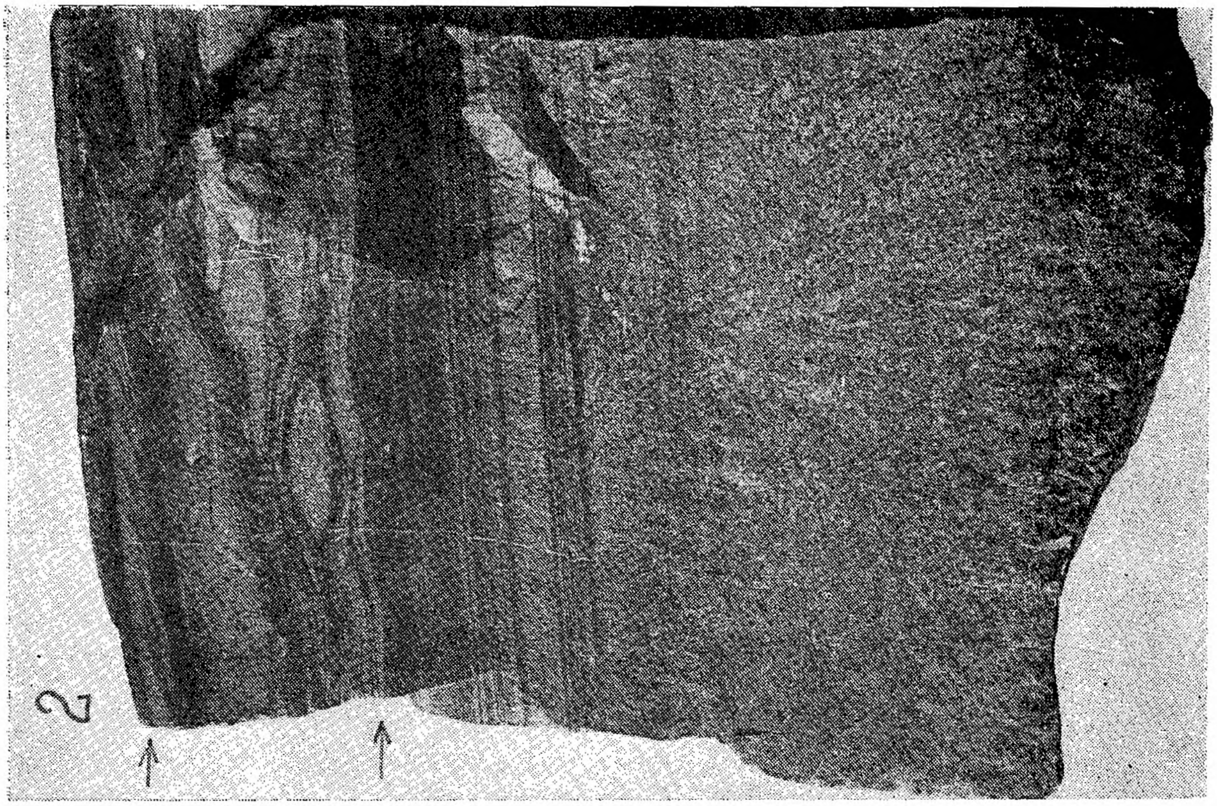

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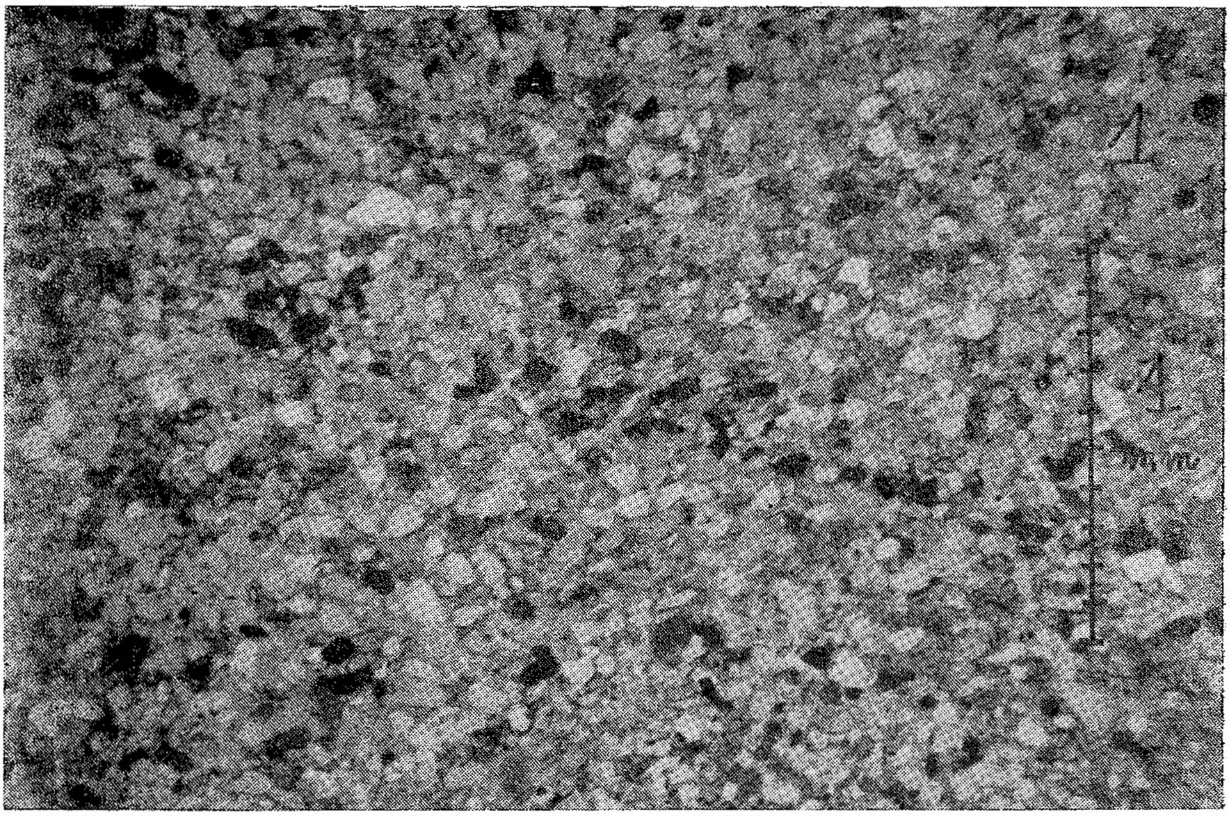
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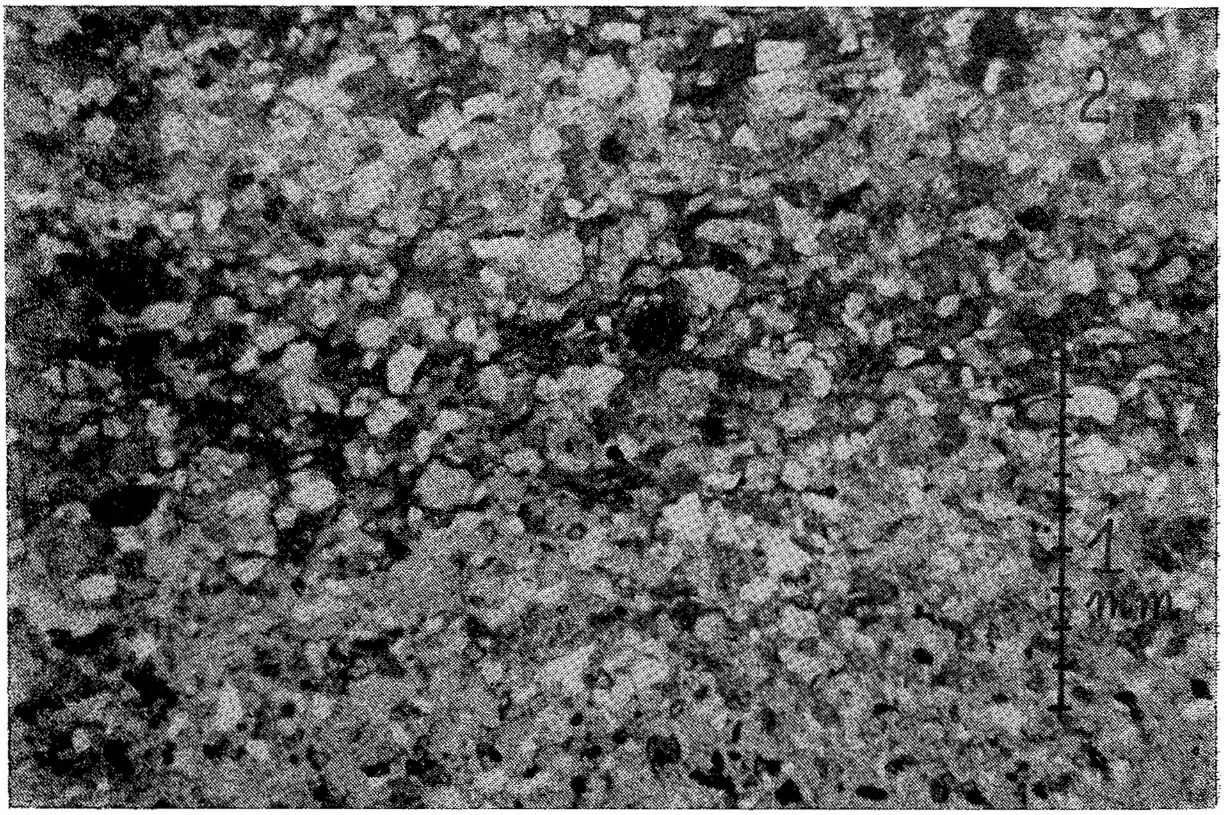
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