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METASOMATIC PROCESSES ALONG THE CONTACT OF THE ORE-BEARING DOLOMITE WITH LIMESTONES (OLKUSZ MINE, CRACOW-SILESIAN Zn-Pb ORE DISTRICT)

(Pl. I—IV and 2 Figs.)

Procesy metasomatyczne na kontakcie dolomitów kruszconośnych z wapieniami w złożu rud cynku i ołowiu kopalni Olkusz

(Pl. I—IV i 2 fig.)

Abstract: The paper presents the preliminary results of microscopic examinations of contact-relationships between the ore-bearing dolomite and limestones in the Triassic of the Cracow-Silesian region. The alterations observed include: dissolution, recrystallization of limestones and dedolomitization of the ore-bearing dolomite. Such alterations represent incipient stages of the main sulfide mineralization in karst cavities and are explained in terms of interference between hot mineralizing solutions and cold meteoric waters.

The ore-bearing dolomite is the host rock of the Cracow—Silesian Zn-Pb ores. This dolomite is of an epigenetic origin (neosome) and resulted from dolomitization of limestones and recrystallization of primary, i.e., early-diagenetic dolostones (Bogacz et al. 1975). The ore-bearing dolomite occurs in form of irregular bodies showing cross-cutting contacts with the surrounding, Middle Triassic carbonates (paleosome). The vertical extent of such bodies varies. In places, the ore-bearing dolomite includes the rock sequence from the upper Röth to the Middle Muschelkalk.

The ore-bearing dolomite may vary in character and composition, but its outstanding and ubiquitous feature is the presence of base metals such as, Fe, Zn and Pb. These metals are dispersed throughout the

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whole mass of the dolomite and, locally, are concentrated so as to produce economic ore bodies. Such ore bodies consist, of sulfides and are commonly associated with, or located in underground karst features. These mineralized karst features, which include solution caverns and collapse breccias, are thought to have originated through the action of hydrothermal solutions, concomittantly with deposition of ores.

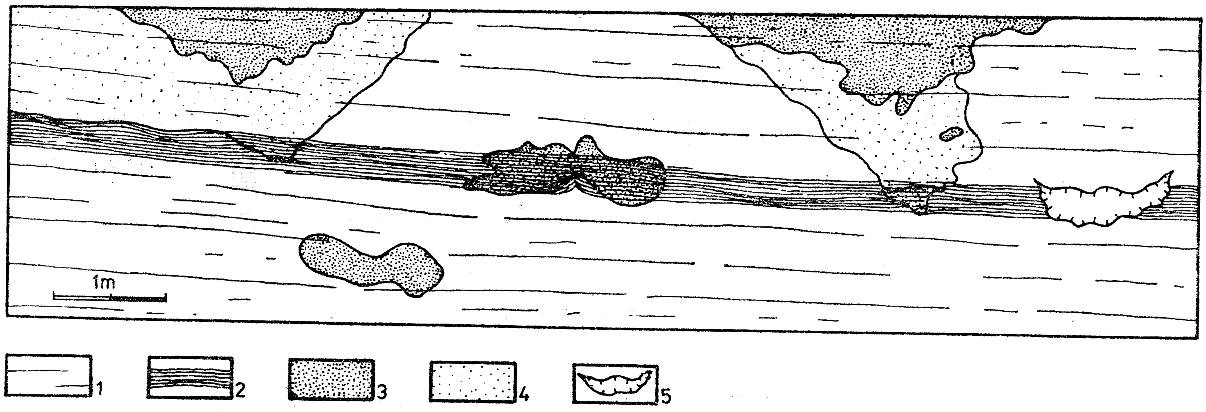

Fig. 1. Exposure showing contact between ore-bearing dolomite and limestone (compare Plate I and II)
1 — limestone; 2 — laminated limestone; 3 — ore-bearing dolomite; 4 — dedolomite; 5 — cavern

Fig. 1. Strefa kontaktu dolomitu kruszconośnego i wapnia (porównaj tablice I i II)
1 — wapień; 2 — wapień laminowany; 3 — dolomit kruszconośny; 4 — dedolomit; 5 — kawerna krasowa

The karst features in question are commonly developed along the lower, metasomatic boundaries of the ore-bearing dolomite. Accordingly, these boundaries may, and often do coincide with those of the ore bodies (Sass-Gustkiewicz, 1975).

On a macroscopic scale, the contacts of the ore-bearing dolomite with the unaltered paleosome have already been described (Bogacz et al., 1972). However, little consideration has been given to microscopic examinations of such contacts. Such examinations provide an insight into the complex processes operating along the metasomatic boundary of the ore-bearing dolomite. These processes are dealt with in the present note. The following considerations are based on the microscopic examinations of one representative section through the metasomatic boundary of the ore-bearing dolomite in the Olkusz Mine.

Within the contact zone depicted in fig. 1 and also Pl. I and II, the following types of carbonate rocks can be differentiated: 1. the ore-bearing dolomite (laminated and unlaminated), 2. unaltered, primary limestones (paleosome), 3. secondary or metasomatic limestones. The most essential properties of the above indicated types of carbonate rocks are summarized in Table I. At this place, only a few comments are necessary.

Table — Tabela I

UNALTERED LIMESTONE	ORE-BEARING DOLOMITE	METASOMATIC LIMESTONE
Laminated: light beige with darker laminae (1) or dark gray with lighter laminae (2). Composed of fine grained carbonate material. Carbonate organic remains, calcite grains and, occasionally quartz grains present. Chalcedony occurs as irregular accumulations. Scattered dolorhombs point to initial stages of dolomitization. Lamination accentuated by presence of fine crystalline laminae separated one from another by medium crystalline ones and by clay minerals and hydroxides. Micrite arranged parallel to lamination. Irregular voids partly filled with calcite. Coarse grained calcispar occurs in form of fracture fillings or irregular accumulations. Dark gray limestones show features indicative of recrystallization. Stylolites with iron-hydroxides present.	Laminated: laminae composed of xenotopic dolomite (4—15 μ) alternate with hipidiotopic laminae (15—30 μ). Porphyrotopic structures common. Large dolorhombs in matrix of smaller crystalls. Rare dolomicrite fragments, dolomitized organic remains chalcedony accumulations and quartz grains present. Rhombohedral pores partly filled with coarse calcite grains and chalcedony. Stylolites common.	Grill-work limestones: light-brown, grill-structure characterized by presence of 3 mm thin layers, separated one from another by solution cavities with calcitic incrustation. Coarsely crystalline, affected by recrystallization. Lamination is accentuated by presence of fine crystalline laminae, gradually passing to coarse crystalline calcitic incrustation. The stylolites are present.
Unlaminated: light beige, fine to medium crystalline, nearly equigranular. Composition similar to that of laminated limestone. Rhombohedral pores present.	Unlaminated: light beige, composition similar to that of laminated. Coarse grains of dolomite show features of recrystallization. ZnS I grains (40—60 μ) irregularly dissaminated. ZnS II in form of accumulations up to 500 μ.	Dedolomites: dark brown, crystalline „sugary" rocks, idiotopic texture. Rock consist of calcite replaces dolorhombs. Small amounts of dolomite and iron hydroxides present.

The ore-bearing dolomite here described consists of two generations of secondary dolomites. These generations will be henceforth referred to as dolomite I and II. Also among the sulfides resident in the dolomite two generations of sphalerite and pyrite have been discerned (ZnS I and ZnS II, FeS_2 I and FeS_2 II). The sphalerite occurs in form of dispersed and irregulary distributed grains. The pyrite appears as irregular concentrations and/or fracture-fillings. Close to its metasomatic boundary the ore-bearing dolomite is enriched in silica (see also Bogacz et al. 1972) which occurs in form of chalcedony.

The coarse-grained metasomatic limestones, interpreted here as produced by recrystallization of primary limestones and dedolomitization, are located at the metasomatic boundary of the ore-bearing dolomite. Another type of secondary limestone is that which shows cavernous „grill-work" structure. This type resulted from transformation of laminated limestones.

The secondary carbonates discussed bear a record of dolomitization, recrystallization nad dedolomitization processes. These processes were associated with dissolution and crystallization of newly formed carbonate minerals in fractures or voids.

The dolomitization processes which brought about the formation of the ore-bearing dolomite affected both the laminated and unlaminated limestones. The processes under consideration were also associated with crystallization of new dolomitic crystals in open voids.

The dedolomitization processes have been observed only in unlaminated dolomites. As it is seen in thin sections, the dedolomitization process is manifested by calcite pseudomorphoses after idiotopic dolomite crystals. The discernible contours of original dolomitic grains and the preserved zonation of such grains are accentuated by ironhydroxides (Pl. III, Fig. 1).

The recrystallization has been observed to affect the dolomite and calcite grains and is manifested by the apperance of saw-toothed margins of crystals and relics of fine crystals in neomorphic sparite (compare also Bathurst, 1975). The recrystallization processes (Pl. III, Fig. 2) play an important role in the formation of the previously mentioned grill-work structure (Pl. IV, Fig. 1 and 2).

The dissolution accounts for the apperance of rhombohedral voids after dissolved dolomite crystals and for the increased porosity of secondary carbonate rocks. It is however difficult to establish whether the rhombohedral pores resulted from dissolution of dolomite crystals or from calcite pseudomorphoses after the dolomite crystals (compare Evemy, 1967). The voids formed facilitated the transfer of liquids and promoted further dissolution and enlargement of cavities.

The successive alterations imposed upon the paleosome by the previously indicated processes are shown schematically in Fig. 2. Part „A"

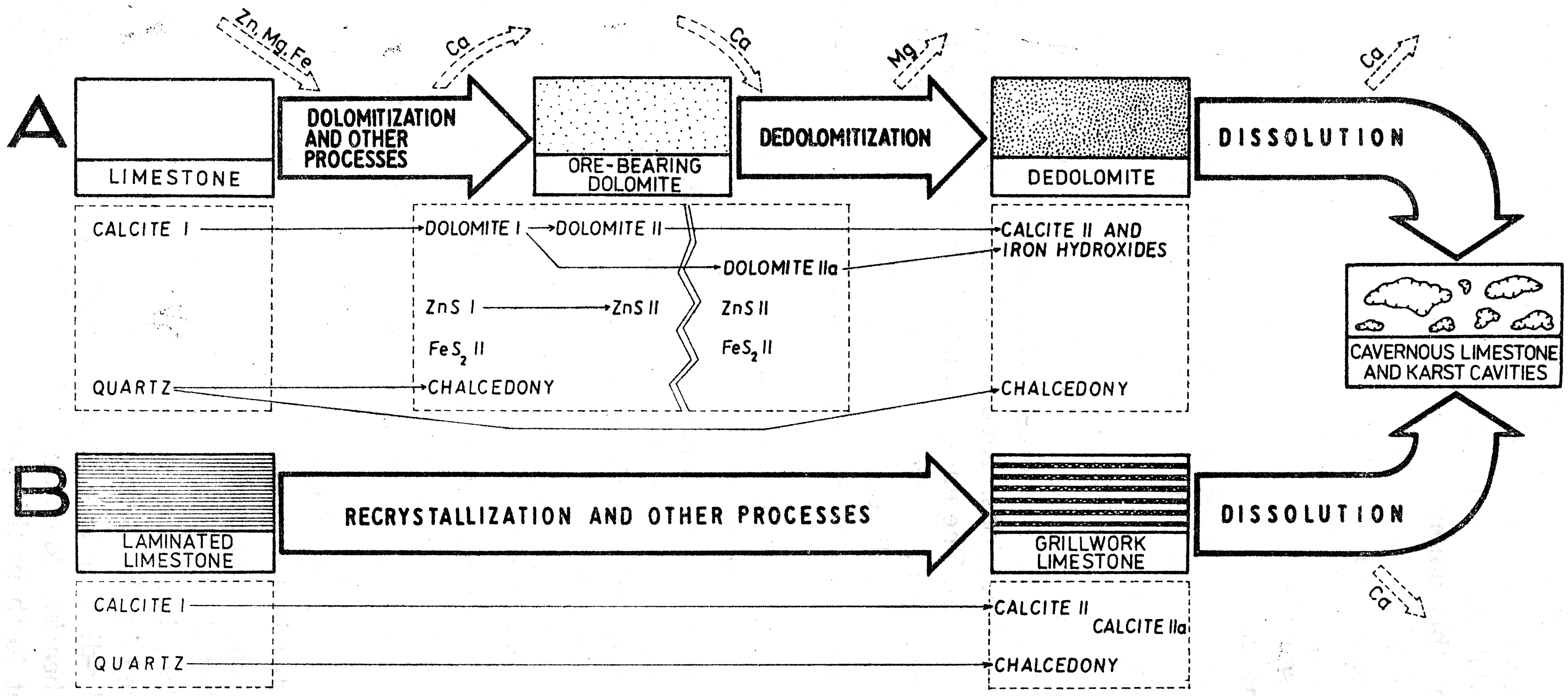

Fig. 2. Schematic presentation of processes in contact zone of orebearing dolomite with limestones (compare Fig. 1)

Fig. 2. Schemat procesów zachodzących w strefie kontaktu dolomitu kruszconośnego i wapienia (porównaj fig. 1)

of this figure shows alteration observed in unlaminated limestones. Here the following succession of events can be inferred. In the first stage of alternations the dolomite I was produced by replacement of limestones. The formation of this dolomite was accompanied by deposition of the first generation of sphalerite (ZnS I).

Subsequent processes led to further alterations. Thus, the dolomite I was subject to recrystallization and has been transformed into the dolomite II. At the same time, or slightly later, a part of the dolomite I was dissolved and reprecipitated as dolomite IIa. Similarly, the sphalerite I was subject to dissolution and, presumably, has reappeared in form of the sphalerite II. The clastic quartz grains were transformed into the chalcedony aggregates. The transformations discussed have been accomplished by the appearance of iron sulfides (FeS_2 I and FeS_2 II).

The previously mentioned processes brought about the formation of the ore-bearing dolomite. The ore-bearing dolomite thus produced was subject to further alterations. Among such alterations there were dedolomitization processes. The end-product of these processes is a crystalline limestone made up of coarse calcite crystals. Such orystals are here indicated as calcite II to differentiate them from those belonging to the paragenetic sequence of the sulfide mineralization (Sass-Gustkiewicz, 1975).

Part „B" of Fig. 2 illustrates alterations imposed upon the laminated limestone, as it is observed in the exposure discussed. In metasomatic limestones showing grill-work structures the calcite I recrystallized into calcite II. A further alteration was selective dissolution. Such dissolution proceeded along lamination surfaces and was followed by crystallization of the calcite IIa in voids.

At this place some comments are needed concerning the problem of dedolomitization. Three different hypotheses, complementary rather than antagonistic, have been advanced to explain the origin of dedolomites: 1. dedolomitization is regarded as a surface phenomenon and part of wheathering processes, 2. it is considered as a diagenetic process, and 3. it is thought to result from post-diagenetic reactions between the dolomite and sulfate-bearing solutions.

The dedolomites in the ore-bearing dolomite of the Cracow-Silesian district have already been mentioned by Śliwiński (1969), who came to the conclusion that they are best explained in terms of weathering processes. This explanation is not followed by the present authors, because the rocks involved in the dedolomitization here described are not weathered. The early-diagenetic origin of dedolomitization is also unlikely because the ore-bearing dolomite itself is of an epigenetic origin.

The thesis set forth in this paper is that the dedolomites under consideration resulted from post-diagenetic processes and were brought about by the action of low temperature solutions enriched in sulfates. According to Groot (1967), the dedolomitization processes take place in temperatures not higher than 40°C and at partial pressure of CO_2 not exeeding 0,5 atm. The presence of sulfate ions is also regarded as essential for dedolomitization by Tatarski (1949). In the case here discussed the sulfate ions might have been derived from transformation of the first generations of sulfides.

The dedolomitization processes were associated with and followed by intensive dissolution. On a microscopic scale the dissolution is evidenced by rhombohedral voids. On a slightly larger scale it is evidenced by abundant small solution cavities. The small solution voids may represent incipient passage ways of aggressive karst solutions which brought the appearence of large mineralized underground karst structures in the Triassic of the Cracow—Silesian region.

From microscopic examinations it appears that the processes of dedolomitization, recrystallization of limestones and dissolution occurred after the formation of the ore-bearing dolomite. The question that arises is whether the above mentioned processes occurred chiefly before, or after the main sulfide mineralization in karst structures (due allowance is here made to possible overlap). The second alternative which implies no genetic relationship between the processes under consideration and the main sulfide mineralization is rendered less likely by the apparent scarsity of such processes. In the authors opinion the first alternative is more plausible. The processes in question represent the incipient stage of the ore-forming karst processes. These latter are attributed to the action of hydrothermal solutions and the Cracow—Silesian sulfide ores are, at present, interpreted in terms of hydrothermal karst phenomena (Bogacz et al. 1970). However, such phenomena must have occurred close to an ancient erosian surface (see Bogacz et al., 1975). Consequently, there is a good reason to suppose that the rising hydrothermal solutions were mixing with cold surficial waters. Indeed, the intimate interrelationship between the visibly synchroneous, mineralized and unmineralized breccias in the Triassic of the Cracow—Silesian region has already been indicated as an argument in favor of such interpretation (Sass-Gustkiewicz, 1975). Accordingly, the dedolomitization and recrystallization processes discussed in this paper are regarded as products of interference between hot mineralizing and cold surficial waters.

Acknowledgement

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STRESZCZENIE

W pracy przedstawiono wyniki wstępnych badań nad strefami kontaktu wapieni i dolomitów kruszconośnych w kopalni Olkusz. Skałami występującymi w badanym profilu są wapienie laminowane i nie laminowane, dolomity kruszconośne laminowane i nie laminowane oraz wapienie metasomatyczne (dedolomity i wapienie o teksturze żeberkowej). Skrócony opis skał zawiera tabela I. Figura 1 przedstawia rozmieszczenie wspomnianych typów skał na ociosie chodnika kopalnianego. Dedolomity i wapienie o strukturze żeberkowej występują na bezpośrednim kontakcie dolomitu kruszconośnego z wapieniami lub w najbliższym jego sąsiedztwie. Na podstawie badań mikroskopowych stwierdzono szereg następujących po sobie procesów, które uogólniając są procesami zastępowania minerałów, rozpuszczania i tworzenia inkrustacji (fig. 2).

Opisywane procesy zachodziły po utworzeniu się siarczków pierwszych generacji a przed główną fazą mineralizacji kruszczowej. Przekształcenia te traktowane są jako wstępne stadium mineralizacji kruszcowej w kawernach krasowych i jest rozważane jako rezultat mieszania się gorących roztworów kruszconośnych z zimnymi wodami meteorycznymi.

EXPLANATION OF PLATES
OBJAŚNIENIA PLANSZ

PLATE — PLANSZA I

Contact between limestone (l) and ore-bearing dolomite (od). ddl — dedolomite; square insets — localization of samples; MgO/CaO — ratio indicated (analysed by M. Buczek-Pułka). Compare also Fig. 1

Kontakt wapienia (l) i dolomitu kruszconośnego (od). Widoczna strefa dedolomitu (ddl). Kwadraty oznaczają miejsca pobrania prób. Liczby obok nich — zawartość MgO i CaO (analizy wykonała M. Buczek-Pułka). Porównaj z fig. 1

PLATE — PLANSZA II

Contact between limestone (l) and ore-bearing dolomite (od). Square insets — localization of samples; MgO/CaO — ratio indicated (analysed by M. Buczek-Pułka. Compare also Fig. 1, centre)

Kontakt wapienia (l) i dolomitu kruszconośnego (od). Kwadraty oznaczają miejsca pobrania prób. Liczby obok nich zawartość MgO i CaO (analizy wykonała M. Buczek-Pułka. Porównaj ze środkową częścią fig. 1)

PLATE — PLANSZA III

Fig. 1. Dedolomite. Note, pseudomorphoses of calcite after dolomite. Ironhydroxides accentuated outlines of rhombohedra. One nicol

Fig. 1. Dedolomit. Widoczne pseudomorfozy kalcytu po dolomicie. Skupienia wodorotlenków żelaza podkreślają zarysy rombów. Bez analizatora

Fig. 2. Limestone showing grill-work structure. Neomorphic calcite II showing distinct features of recrystallization. Crossed nicols

Fig. 2. Wapień o teksturze żeberkowej. Widoczny fragment skały zbudowanej z kalcytu II o wyraźnych cechach rekrystalizacji. Nikole skrzyżowane

PLATE — PLANSZA IV

Fig. 1. Limestone showing grill-work structure. Negative print of thin section. Center — empty void whose walls are lined with calcite IIa

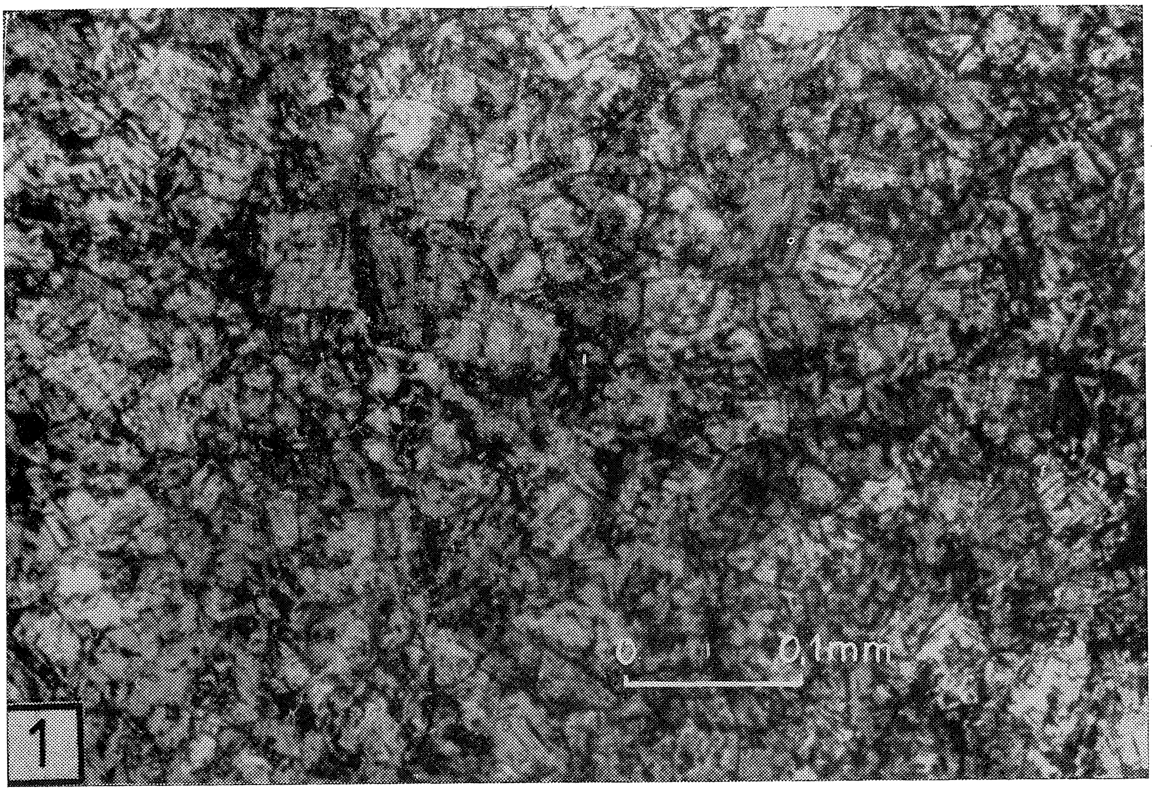
Fig. 1. Wapień o teksturze żeberkowej. W wolnej przestrzeni (czarna) widoczne są narastające od ścian kryształy kalcytu IIa. Negatywowe zdjęcie cienkiej płytki

Fig. 2. Limestone showing grill-work structure. Negative print of thin section. Note, lamination and alongated solution voids

Fig. 2. Wapień o teksturze żeberkowej. Widoczne podłużne, równoległe do siebie wolne przestrzenie, utworzone w wyniku rozpuszczania. Negatywowe zdjęcie cienkiej płytki


MgO
CaO
od
ddl
l
0
0,5m


MgO/CaO
1.09/50.96
3.51/49.59
12.23/36.42
15.40/33.06
2.87/47.06
17.46/29.41
od
0
0.25m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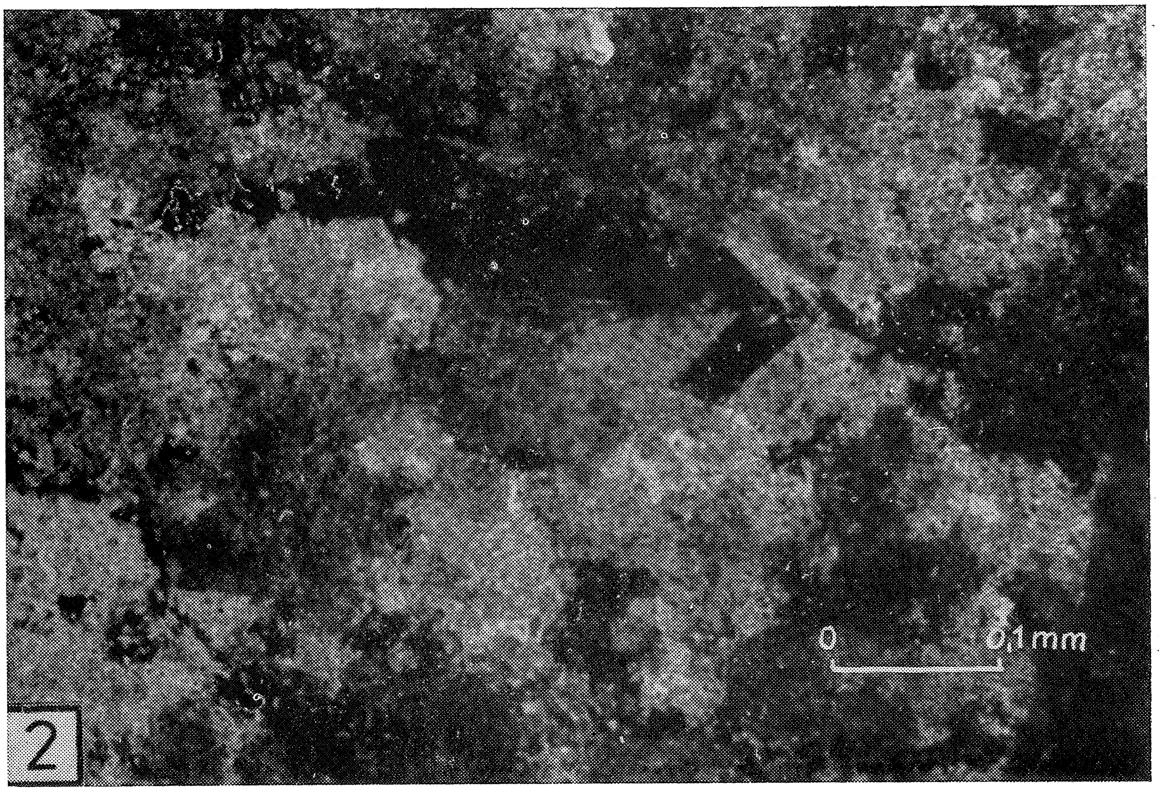
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