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CONTACT RELATIONS OF THE ORE-BEARING DOLOMITE IN THE TRIASSIC OF THE CRACOW-SILESIAN REGION

(Pl. XLIV—LI and 4 Figs.)

O kontaktach dolomitu kruszconośnego z otaczającymi skałami węglanowymi

(Tabl. XLIV—LI i 4 fig.)

Abstract: Evidence is presented for replacement of the Muschelkalk limestones and early-diagenetic dolomites by the „ore-bearing dolomite". It is suggested that the formation of the ore-bearing dolomite occurred after deposition of the Muschelkalk sequence but prior to its tectonization and jointing. The dolomitization is regarded as epigenetic and consequent upon the introduction of hydrothermal solutions at the close of Triassic time.

INTRODUCTION

The most distinctive rock-type in the Triassic of the Cracow-Silesian region is the so called "ore-bearing dolomite"; the host rock of zinc and lead ores. The term "ore-bearing dolomite" covers several varieties of dolomitic rocks that may present considerable diversity in appearance. Notwithstanding the diversity, the ore-bearing dolomite as a whole, is easily distinguishable from other Muschelkalk carbonates by its crystalline texture, darker color, frequent content of sulfide ores, and cross-cutting relations to the surrounding rocks.

COMMENTS ON PREVIOUS WORK AND SCOPE OF REPORT

Various opinions have been advanced about the nature and origin of the ore-bearing dolomite, syngenetic and epigenetic views being all expressed without reaching unanimity. Similar controversy exists over

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the origin of sulfide ores resident in the dolomite. In fact, the nature of the ore-bearing dolomite is a moot point in dispute over the origin of these ores. Opinions on this subject are so divided that syngenetic, i. e. syn--sedimentary origin of the ore-bearing dolomite is invoked by advocates of syngenetic hypotheses of the ores (e. g. Althans, 1891; Gürich, 1903; Keil, 1942; Gruszczyk, 1956; Smolarska, 1968). In contrast, the adherents of epigenetic and hydrothermal genesis of the Cracow-Silesian ores postulate an epigenetic origin for the dolomite, but no agreement has been reached as to the time and cause of the dolomitization (e.g. Michael, 1913; Duwensee, 1928, 1929; Kuźniar, 1929, 1932; Siedlecki, 1948, 1952; Ekiert, 1959; Śliwiński, 1969; Gałkiewicz, 1971).

This paper does not review the various hypotheses advanced to explain the origin of the ore-bearing dolomite. Instead, attention is focused on contact relations between the ore-bearing dolomite and the surrounding rocks. Such contact relations have been variously interpreted by proponents of rival hypotheses and used as arguments in favor or against each others' views. The supporters of epigenetic hypotheses have repeatedly pointed to cross-cutting contacts of the ore-bearing dolomite with the surrounding rocks, as to the strongest argument in favor of their interpretation (e. g. Bogdanowicz, 1909—10; Duwensee, 1928, 1929; Siedlecki, 1952; Ekiert, 1959; Śliwiński, 1968). Under the syngenetic hypotheses, however, such contacts have been interpreted in terms of sedimentary and early-diagenetic structures or as due to insignificant and local rearangements of sedimentary contacts of the original dolomitic sediment (Gruszczyk, 1956; Smolarska, 1968). In addition, Gruszczyk (1956) has introduced the concept of sedimentary "interfacial zone" between the ore-bearing dolomite and the Muschelkalk limestones. In his interpretation, the ore-bearing dolomite is a sedimentary facies of the Muschelkalk, i.e. a primary sediment that retains its original facies limitations and that interfingers along sedimentary contacts with the limy facies on the same stratigraphic level. The interfacial zone, under such an interpretation, is characterized by alternation of limestones and dolomites. These latter form sedimentary intercalations within the limy sediment, tapering towards the western parts of the Cracow-Silesian basin, where the limy facies predominates (compare Gruszczyk, 1956, fig. 3). The idea of sedimentary „interfacial zone" is in sharp antithesis to the opinions advanced by proponents of epigenetic origin of the ore-bearing dolomite.

The present paper aims to submit some additional evidence to support the epigenetic interpretation of the ore-bearing dolomite. It contains the description of dolomite-limestone contacts from two stratigraphic units of the Lower Muschelkalk exposed in Trzebionka, west of Cracow. The following discussion is a continuation of, and a supplement to the paper on „Hydrothermal karst features in the Triassic rocks of the Cracow-Silesian region" by Bogacz et al., 1970.

CLARIFICATION OF TERMS

The terms „syngenetic" or „primary" will be used synonymously for dolomites that: 1) are believed to have precipitated as such from the sea water and 2) are the products of early-diagenetic alterations that take place in soft bottom sediments at, or close to, the sediment-water interface. The formation of syngenetic dolomites is directly controlled by the depositional environment. The terms „epigenetic" or "secondary" will cover all other types of dolomites.

It is realized that there is no sharp distinction between these two types of dolomites, and that all gradations are possible. The use of the terms "syngenetic" and "epigenetic" as adopted in this report approximates closely to the practice of most geologists working on the Cracow-Silesian ores.

GEOLOGIC SETTING

Stratigraphic relations

The Triassic strata overlie the Paleozoic with major unconformity, and are overlain disconformably by the Jurassic sediments. Succeeding the Bunter sandstones and primary dolomites of the Röth, is the Muschelkalk sequence divided into lower, middle, and upper members. The Lower Muschelkalk comprises, in ascending order, the Gogolin, Górażdże, Terebratula, and Karchowice Beds. The Middle Muschelkalk consists of the primary "Diplopora Dolomite" and is followed by a sequence of limestones, primary dolomites, and argilaceous sediments of the Upper Muschelkalk (for details concerning stratigraphy and lithology of the Muschelkalk sequence in the Cracow-Silesian region see: Assmann, 1944 and Siedlecki, 1948).

The Lower Muschelkalk- the host rock of the ore-bearing dolomite attains a maximum thickness of about 60 m. Of the four lithostratigraphic units distinguished within the Lower Muschelkalk, only the Gogolin and the Górażdże Beds are briefly described as relevant to the following discussion.

The Gogolin Beds comprise fine-grained, thin-, to medium-bedded limestones intercalated with marls. The dominant sedimentary structures include: 1) horizontal laminations, 2) wavy bedding, characterized by frequent swelling and pinching of layers, 3) crumpled bedding made up of contorted, load deformed fragments of layers (for details concerning this structure see Bogacz et al., 1968).

The Górażdże Beds consist of clastic, medium- to thick-bedded limestones with chert nodules. Large cross-stratifications are locally common. In places, and subordinately, the Górażdże Beds contain intercalations of primary dolomites.

Depositional environment of the Lower Muschelkalk

The Lower Muschelkalk sequence was deposited over a broad platform--type environment in shallow and well aerated waters. Notable is the virtual absence of zinc and lead in limestones and primary dolomites. The high carbonate content of the Muschelkalk sequence is due to: 1) paleogeographic and climatic conditions favoring biochemical precipitation of carbonates, 2) ecologic conditions conducive to prolific productivity of lime--secreting organisms, and 3) lack of any significant dilution by terrigenous materials.

The depositional environment of the Muschelkalk alternated between high and low energy conditions. Following Muschelkalk time, the sea withdrew from the Cracow-Silesian region. The Muschelkalk carbonates were, in places, exposed to erosion and then covered in an overlapping manner with the Keuper and Rhaetian deposits of non-marine and marine derivation (for details and references see: Grodzicka-Szymanko, 1971, Grodzicka-Szymanko and Orłowska-Zwolińska, 1972). At that time, the Cracow-Silesian region was also affected by slight, and chiefly vertical, tectonic disturbances, collectively referred to as the Early-Cimmerian movements (see e. g. Tokarski, 1965; Moryc, 1971).

Upper time limits of dolomitization

The relative age of dolomitization is becoming a question of increasing importance, and before entering into the discussion of contact relations, it seems advisable to indicate the time limitations imposed by geologic evidence upon the formation of the ore-bearing dolomite. Investigations carried out by numerous authors have definitely proven that the bulk of the ore-bearing dolomite was formed prior to the Jurassic erosional and depositional cycle. The Middle Jurassic marine sediments rest upon a truncated surface of the ore-bearing dolomite, and the paleo-karst features developed within this dolomite are filled with the Liassic and/or late Triassic deposits. Of particular significance for the upper time limits of the ore-bearing dolomite are "pocket-coals" that tend to occur in some of such cavities. These coals contain fragments of Arthropods and an assemblage of Mesozoic pollen (Lipiarski, 1971). The facs brought out by Lipiarski's investigations lead to the conclusion that the coals filling the karst cavities in the ore-bearing dolomite are either of Keuper or Liassic age. Admittedly, however, different opinions on this subject are also being held (Krajewski et al., 1971).

According to Ekiert (1959), fragments of the ore-bearing dolomite occur as pebbles in the Keuper sediments. This statement, although not to be discarded, requires further confirmation. The available data point, however, to pre-Liassic age of the ore-bearing dolomite and render the hypotheses of post-Jurassic origin of this rock untenable (such hypotheses have been advanced by some authors: e. g. Assmann, 1926; Bobrowski, 1950; Seidl, 1960—62).

In discussing the upper limits of the ore-bearing dolomite due allowance should be made for some parts of the ore-bearing dolomite "sensu lato" that might have been formed later. There is a good reason to suppose that the Muschelkalk carbonates and the ore-bearing dolomite were affected in some way by passing solutions that resulted in localized and limited dolomitization and mineralization of the Upper Jurassic limestones adjacent to high-angle thrust faults (see Harańczyk et al., 1968). Such solutions might have also affected the unaltered Muschelkalk limestones as well as the already existing dolomitic rocks.

ORE-BEARING DOLOMITE

Stratigraphic position and distribution

In agreement with the opinion held by the majority of authors, the ore-bearing dolomite is here interpreted as an extensive neosome developed chiefly within the Górażdże Beds, and in the two succeeding units. The dolomite tends to occur in form of discordant but roughly tabular bodies (Bogdanowicz, 1909—10) whose horizontal dimensions greately exceed the vertical ones (for details and references see: e.g. Siedlecki, 1952; Śliwiński, 1969).

The ore-bearing dolomite is chiefly confined to the eastern and north--eastern parts of the Silesian Basin. It is conspicuously absent in the neighboring Sandomierz Basin, where a lithologically very similar Muschelkalk sequence is known to occur (Moryc, 1971). During the Lower Muschelkalk these two basins were separated by a land barrier or by a chain of islands (see e. g. Śliwiński, 1969; Alexandrowicz, 1971). The importance of this structure for the genesis of the ore-bearing dolomite and ores should not be overlooked.

General characteristics

The ore-bearing dolomite comprises: 1) replacement dolomites, 2) dolomites resulting from open space crystallization, i. e. "vein dolomites", 3) clastic dolomites confined to certain cavities within the ore-bearing dolomite. The last two types are insignificant in quantity, and both are excluded from the following considerations. The clastic dolomites occur as internal sediments filling the cavities. They are the products of solutional disaggregation of replacement dolomites ("recycled dolomites" in the meaning of Friedman and Sanders, 1967). These dolomites will be dealt with in a forthcoming paper.

The bulk of the ore-bearing dolomite is made up of replacement dolomites. There are several types of such dolomites that may differ in composition, color, coarseness, and structure (see Siedlecki, 1952; Görlich and Szwaja, 1963; Smolarska, 1968; Śliwiński 1969). All these types reveal, however, one common feature; the crystalline texture. Some of them represent presumably the varieties related to one single phase of dolomitization and may reflect the differences in the original composition of the paleosome. Other, however, may correspond to two or more different phases of dolomitization, superimposed one upon another. Until recently this fact has not been realized, and a satisfactory account of such dolomitic phases is not at hand. The following considerations are therefore fraught with uncertainties as to which phase of the ore-bearing dolomite is in contact with the unaltered carbonate rock.

Sedimentary structures inherited from unaltered sequence, the scale of which is large in comparison with that of the dolomite crystals, are preserved. Such structures are frequently replaced, impregnated, or lined with ore minerals. They also tend to be accentuated by voids that form concurrently with emplacement of ores.

It should be noted that the term "ore-bearing dolomite" is sometimes used in two meanings: 1) to indicate distinct and mapable dolomitic bodies within the Muschelkalk sequence that are characterized by the presence of sulfide ores, and 2) for dolomites containing sulfide ores and not limited to any particular stratigraphic unit. In the last meaning, the term "ore--bearing dolomite" has been applied to wall-rock alterations adjacent to ore-bodies in the Paleozoic and Upper Jurassic carbonates (Harańczyk, 1970).

Difference between the ore-bearing dolomite and syngenetic dolomites

The proponents of syngenetic hypotheses do not make any genetic distinction between the ore-bearing dolomite and the dolomites that show all diagnostic features of early-diagenetic origin. As emphasized by the advocates of epigenetic hypotheses (e. g. Siedlecki, 1948; Śliwiński, 1969, and others) these two types of rocks should be distinguished to avoid grave errors caused by confusing one with the other. A comparison of the ore-bearing dolomite with the syngenetic dolomite on the same stratigraphic level reveals conspicuous differences between these two rock-types. Such differences are shown in Table 1, see also Pl. LI, fig. 3, 4. Particularly noteworthy is the fact that the primary dolomites are nearly entirely devoid of zinc and lead sulfides. This indicates that they were formed in an environment in which there was no concentration of zinc and lead. It will be shown later (p. 360) that the syngenetic dolomites have metasomatic replacement-contacts with respect to the ore-bearing dolomite.

CONTACT RELATIONS

1. Undersurface of the ore-bearing dolomite

The lower boundary of the ore-bearing dolomite, as exposed in Trzebionka, is typically uneven and cross-cutting (Pl. XLIV, fig. 1). The black sulfide-rich dolomite replaces here the Gogolin Beds that are made up of fine-grained, stratified limestones with common wavy and crumpled bedding. The dolomite consists of a mosaic of fine equidimensional crystals with abundant sulfides (pyrite is the chief coloring matter).

The contact surface between the dolomite and limestones is sharp or gradational over very short distances (Pl. XLVI, fig. 1, 2). The gradation is due to the presence of relatively large dolomite rhombs in the adjacent limestone. These rhombs are distributed in such a way that their abundance increases towards the dolomite. In thin sections, however, one can observe a sharp boundary between the concentrations of large idiomorphic dolomite crystals and the fine-grained mosaic that makes up the ore-bearing dolomite (Pl. LI, fig. 4, Pl. XLIX, fig. 1).

A characteristic constituent of the outer limits of the ore-bearing dolomite are globular calcite clusters (Pl. XLVI, fig. 1, Pl. XLVII, fig. 1, compare also Smulikowski, 1946). It is tentatively suggested that the calcite clusters originated from calcium carbonate dissolved during dolomitization.

Contact configurations

The dolomite-limestone relations are expressed in a variety of geometrical configurations or contact structures that represent a "frozen" penetration pattern of an advancing front of dolomitization. Although there are theoretically no limitations on the shape of the dolomite-limestone interface, certain configurations tend to occur repeatedly. Some typical examples of such configurations are briefly discussed in the following sections.

Table 1

Comparison of representative features of syngenetic dolomites and the ore-bearing dolomite

Syngenetic dolomite	Ore-bearing dolomite
1. Primary depositional texture preserved. Micrite present. Grain-size highly differentiated.	1. Primary depositional texture transformed into mosaic of roughly equidimensional crystals. Micrite absent.
2. Dolomites virtually devoid of zinc and lead.	2. Dolomites frequently contain zinc and lead sulfides.
3. Marly seams well preserved and sharply defined.	3. Marly seams obscured or absent.
4. Dolomites restricted to specific beds. Occur as ordinary sedimentary intercalations, i.e. display sedimentary contacts with other carbonates.	4. Dolomites showing cross-outting relations to the surrounding rocks and stratification planes.
5. Microfossils present	5. Microfossils small in relation to dolomite crystals obliterated.
6. Dolomites showing yellow-rouge U.V. luminiscence.	6. Dolomites devoid of U.V. luminiscence

Tabular configurations

Of common occurrence are tabular or sheet-like dolomitic bodies developed on both sides of bedding surfaces of the paleosome (Pl. XLV, fig. 1). The bedding surfaces served as routes for dolomitizing solutions that first moved along these primary discontinuities and then spread vertically through adjacent limestone (Pl. XLVI, fig. 2). With incomplete dolomitization, the inner parts of limestone layers are left unaltered, and only the outer parts immediately underlying and overlying the bedding surfaces are transformed into dolomite. The outer surfaces of such tabular dolomitic bodies reveal irregularities, and numerous dolomitic veins that extend into the adjacent limestone (Pl. XLVI, fig. 1, Pl. XLIX, fig. 1). Some of such veins terminate at short distance, but others cut across the intervening limestone and join the neighbouring dolomite (Pl. XLV, fig. 1). The location of veins is either fortuitous or controlled by primary discontinuities. Some of them appear to be organically controlled (Pl. XLVI, fig. 1).

All these dolomitic veins are highly irregular, and some may assume tubular shapes (Pl. XLVI, fig. 1). Isolated dark patches on the surfaces of intervening limestones frequently represent the cross-sections of such veins.

The tabular dolomites under consideration extend laterally from the main body of the ore-bearing dolomite. They may be traced over a distance of several tens of meters, tapering slowly towards the distal end. Some of them exhibit secondary alterations manifested in a progressive softening of the dolomite towards primary bedding surfaces. Such alteration, indicated by some authors as "shalification" of dolomites (Heyl et al., 1955), is commonly regarded as due to the action of dissolving solutions. The end-product of "shalification" is difficult to distinguish from primary marly intercalations.

Alternation of dolomitic and limestone bands

Alternation of dolomitic and limestone bands on a smaller scale, is yet another example of bedding-controlled incomplete dolomitization (Pl. L, fig. 1). It may be considered as a small-scale model of tabular dolomites previously described. The dolomitic banding may be horizontal or cross-stratified depending on the pattern of primary lamination of the paleosome (Pl. L, fig. 1). Where further developed, the dolomitic parts expand at the expense of the limy ones, and the laminated paleosome is transformed into a banded dolomite with preserved primary lamination (laminated dolomite, by Smolarska, 1968).

Mottled configurations

The term "mottling" is used to indicate a spotty color pattern on rock surfaces (e. g. Osmond, 1956). Such a pattern is frequently the surface expression of incomplete dolomitization. In its typical development, the mottled configurations described in this paper, consist of irregularly shaped small relics of light colored limestones, embedded in a mass of dark sulfide-rich dolomite ("spotty dolomite" in the meaning of Smolarska, 1968). The margins of these relics are either sharp or gradational (Pl. XLVII, fig. 1, 2).

The development of mottled patterns may be controlled by various primary and secondary structures (see e. g. Beales, 1956; Osmond, 1956; Lebauer, 1965). In the Gogolin Beds such patterns, frequently, though not exclusively, developed in limestones showing wavy and crumpled bedding. In such instances, the incipient stages of dolomitization are characterized by the appearance of dolomitic streaks that follow marly seams separating and enveloping limestone nodules. (Pl. XLVIII, fig. 1). Such marly seams, which represent load-deformed bedding planes, guided the dolomitizing solutions. In more advanced stages of dolomitization, however, the relations of limestone relics to the above mentioned marly seams are vague or no longer recognizable.

Coincidence of dolomite boundaries with sedimentary interfaces and early diagenetic structures

In the contacts hitherto described, no specific primary structures were seen to delineate the outer limits of the ore-bearing dolomite. Bedding surfaces, for instance, were seen to act as prefered routes rather than barriers for dolomitizing solutions. Such surfaces, however, are known to play a dual role in transfer of liquids. They promote the transfer parallel to the bedding, but may serve as temporary or permanent barriers for liquids moving in transverse direction. This accounts for a close correspondance of some of the dolomite-limestone contacts to sedimentary interfaces. Such instances merit particular attention, inasmuch as they may lead to erroneous interpretations. An example of such misleading configuration is shown in Pl. L, fig. 1 which illustrates a fragment of a "scour-and-fill" structure. The fill is largely made of laminated dolomite and an alternation of dolomitic and limestone bands. The scour surface coincides with that of the dolomite-limestone interface, and is lined with a dark dolomitic matter. Relations such as the last described may be mistaken for sedimentary contacts, were it not for their intimate and close association with contacts of undoubted replacement origin.

Of interest are also contact surfaces that follow stylolitic seams. One of such contacts is illustrated in Pl. L, fig. 2. It shows a fragment of the boundary between the ore-bearing dolomite and the limestone relic depicted in fig. 3.

LIMESTONE RELICS

A feature to which attention has been repeatedly directed by authors supporting the epigenetic origin of the ore-bearing dolomite are large limestone relics (e. g. Duwensee, 1929; Siedlecki, 1952; Ekiert, 1959). The existence of such relics, has been either ignored or contested by advocates of the sedimentary origin of the dolomite, chiefly on the ground of insufficient evidence (Gruszczyk, 1956).

The limestone relics in the ore-bearing dolomite are of common occurrence in exposures of Trzebionka. The relic shown in Fig. 1 and in Pl. XLIV, fig. 2 was selected for a more detailed examination. The Upper Gogolin Beds that make up the relic differ from those previously discussed in the absence of wavy and crumpled bedding. The chemical analyses shown in Tabl. 2 failed to reveal any significant amounts of zinc and lead sulfides.

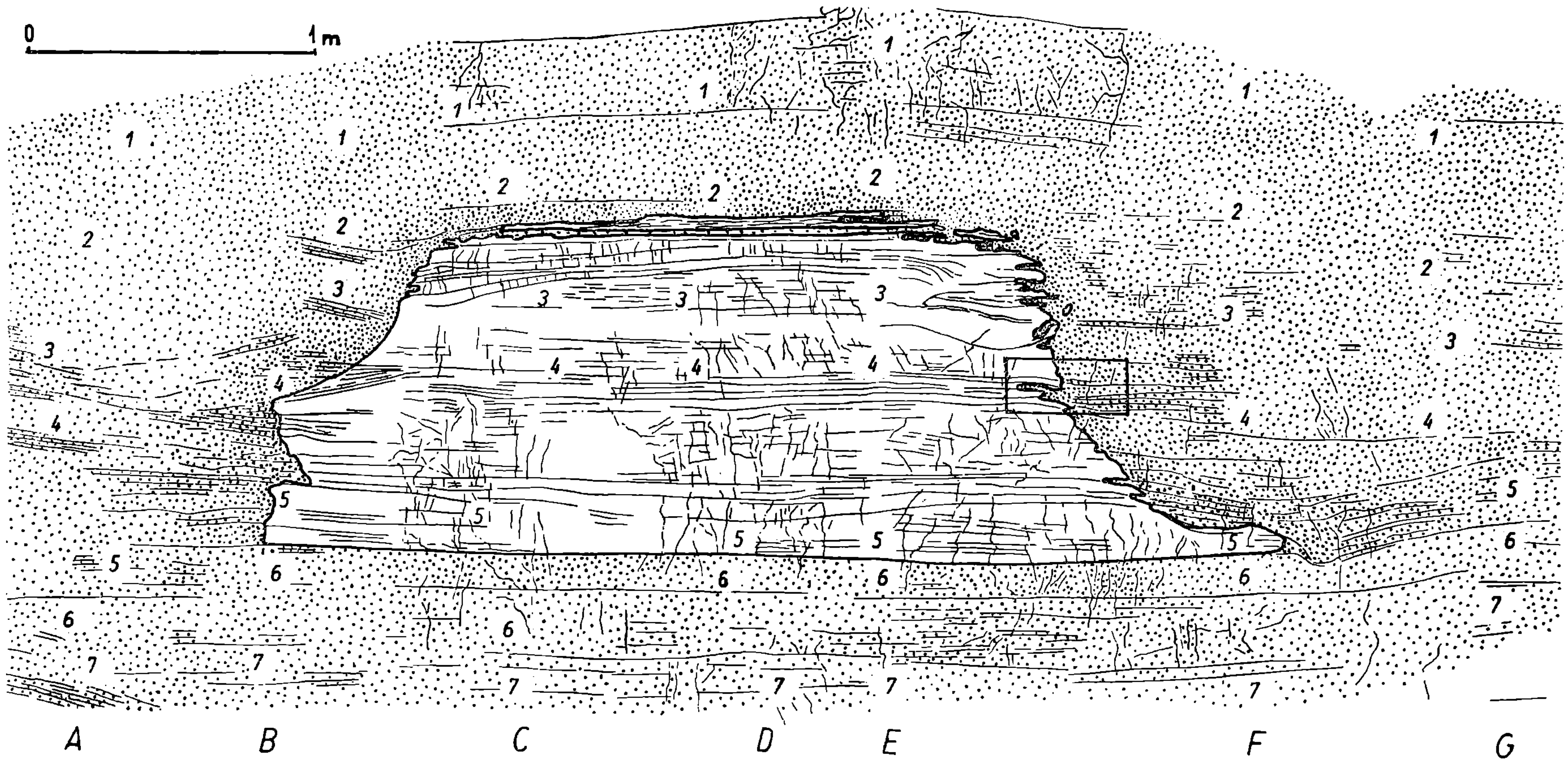

Fig. 1. Relic of Gogolin limestone in ore-bearing dolomite (dotted area). Numbers show location of analysed samples listed in Tabl. 2. Rectangular inset more fully shown in fig. 2 (compare Pl. XLV, fig. 2)

Fig. 1. Ostaniec wapienia gogolińskiego w dolomicie kruszconośnym (obszar zakropkowany). Liczby oznaczają miejsca pobranych próbek, których analizy zestawiono na tabl. 2. Obszar zakreślony prostokątem jest przedstawiony na fig. 2

Table 2

Sample	SiO_2	CaO	MgO	Sample	SiO_2	CaO	MgO	Sample	SiO_2	CaO	MgO
A-1	4.30	31.32	16.97	D-1	3.93	31.00	16.96	G-1	6.82	33.33	12.83
A-2	12.93	25.57	13.86	D-2	3.38	42.50	7.04	G-2	17.67	23.27	12.00
A-3	6.20	29.59	16.55	D-3	3.86	48.27	3.31	G-3	5.01	29.97	17.67
A-4	3.11	31.60	16.14	D-4	3.61	49.74	2.48	G-4	3.91	32.82	15.00
A-5	3.30	32.89	14.90	D-5	2.45	49.74	2.07	G-5	17.23	23.12	14.18
A-6	13.28	25.86	15.11	D-6	17.16	24.42	10.76	G-6	17.68	23.40	13.56
A-7	25.06	19.25	11.38	D-7	14.94	23.56	12.83	G-7	27.87	17.41	7.39
B-1	6.27	29.30	15.73	E-1	4.46	31.60	15.52				
B-2	16.23	23.56	13.86	E-2	4.49	31.89	14.90				
B-3	7.58	28.44	14.48	E-3	4.65	45.40	3.52				
B-4	3.77	31.03	16.14	E-4	6.24	31.00	12.83				
B-5	2.97	31.60	16.14	E-5	1.03	54.30	0.22				
B-6	15.49	24.42	13.24	E-6	20.04	22.99	10.76				
B-7	15.01	23.56	14.07	E-7	15.42	23.85	11.59				
C-1	4.69	30.17	16.55	F-1	5.79	29.31	14.90				
C-2	13.52	24.42	14.90	F-2	3.91	32.18	15.52				
C-3	4.78	46.26	4.97	F-3	6.15	31.32	12.83				
C-4	5.60	47.12	3.31	F-4	4.24	47.98	3.52				
C-5	2.60	51-43	2.27	F-5	1.09	51.43	2.89				
C-6	11.82	26.72	12.62	F-6	16.07	22.70	13.04				
C-7	16.37	24.14	11.80	F-7	17.52	24.14	12.42				

Chemical analyses of ore-bearing dolomite and Gogolin limestone from exposure shown in text-figure 1. Analyses made by A. Stachańczyk

Analizy chemiczne dolomitu kruszconośnego i wapienia warstw gogolińskich z odsłonięcia przedstawionego na Fig. 1. Analizy wykonała A. Stachańczyk

The rock enclosing the relic is a dark-grayish dolomite. It differs from that described in connection with the undersurface configuration not only in color but also in lesser amounts of dispersed ores. The analyses show irregularities in magnesium content (Tabl. 2), but all the samples analysed fall into the category of dolomites. Of particular interest is the concentration of silica in the ore-bearing dolomite close to its contact with limestones. The chemical analyses of samples collected from tow layers, passing uninterruptedly from limestone to dolomite (fig. 2), show an abrupt and marked increase in silica at the boundary between the ore-bearing dolomite and the limestone (Tabl. 3).

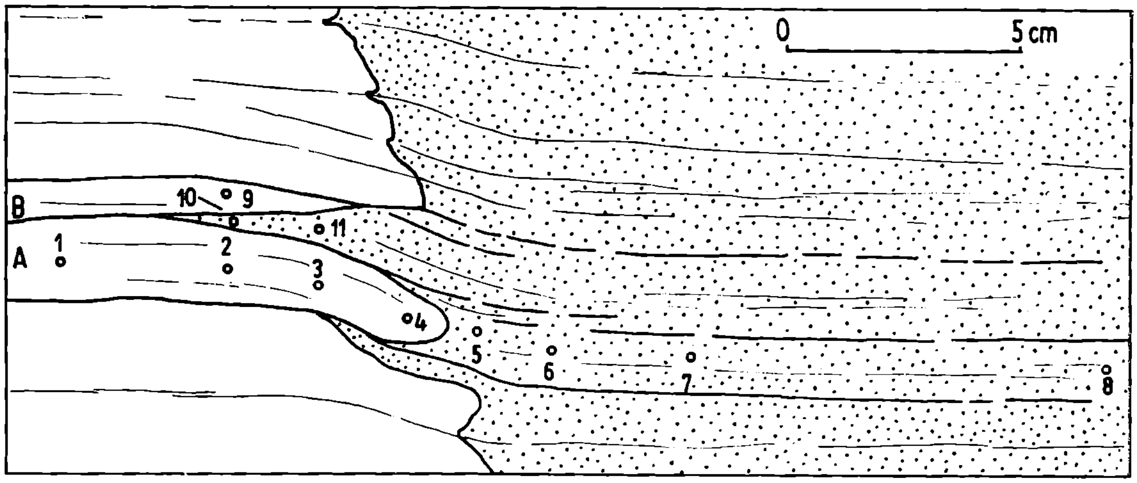

Fig. 2. Detail of contact between ore-bearing dolomite (dotted area) and Gogolin limestone shown in rectangular inset delineated in fig. 1. Numbers indicate location of analysed samples listed in Tabl. 3. A — layer of fine-grained limestone; B — layer of marly limestone, both A and B passing from unaltered relic to ore-bearing dolomite. Marly layer is slightly blurred in dolomite. Analyses of samples (Tabl. 3) indicate concentration of silica in dolomite close to contact with limestone

Fig. 2. Wycinek powierzchni granicznej między dolomitem kruszconośnym (obszar zakropkowany) a ostańcem wapieni gogolińskich. Wycinek objęty prostokątem zaznaczonym na fig. 1. Liczby oznaczają miejsca pobrania próbek do analiz zestawionych na tabl. 3. A — ławica wapienna; B — wkładka wapienno-marglista, obydwie przechodzą z nie zmienionego ostańca do dolomitu. Granice wkładki marglistej są w dolomicie częściowo zatarte. Wyniki analiz (tabl. 3) wskazują na koncentrację krzemionki w dolomicie kruszconośnym przy granicy z wapieniami

Sedimentary structures, the scale of which is large in comparison with that of the dolomite crystals are relatively well preserved. The beds are seen to pass uninterruptedly from limestone to dolomite without any marked change in volume (Pl. XLIV, fig. 2). In dolomitized areas, however, the bedding surfaces are closely welded, and their recognition is not as easy as in limestones (Pl. XLV, Fig. 2).

The dolomite is seen to replace irregularly the limestone. Under the microscope the actual boundary surface is very sharp (Pl. L, fig. 1, 2). It is marked by an abrupt change from a typically limestone texture to a mosaic of interlocked anhedral and hypidiomorphic crystals of dolomite.

In the dark-grayish dolomite that encloses the relic, there are also inclusions of a much darker dolomite that is somewhat similar to that described in the previous section. This dark sulfide-rich dolomite may form intercalations that roughly follow the bedding or may cut across the bedding surfaces as dark dolomitic veins. Such dolomitic veins are also seen to cut across limestone relics.

Table 3

	Sample	SiO_2	CaO	MgO
	1.	2.97	51.48	2.13
	2.	3.05	39.55	8.47
	3.	2.40	48.10	4.06
A	4.	8.29	27.43	11.32
	5.	5.61	29.22	15.01
	6.	6.37	28.96	12.45
	7.	6.43	28.68	13.73
	8.	4.14	30.07	15.68
	9.	3.63	42.39	6.84
B	10.	12.70	26.24	10.35
	11.	9.24	26.20	10.62

Chemical data on contact between ore-bearing dolomite and Gogolin limestone. For location of samples see text-figure 2. Analyses by A. Stachańczyk

Dane chemiczne dotyczące kontaktu dolomitu kruszconośnego z wapieniami gogolińskimi. Umiejscowienie próbek podano na fig. 2. Analizowała A. Stachańczyk

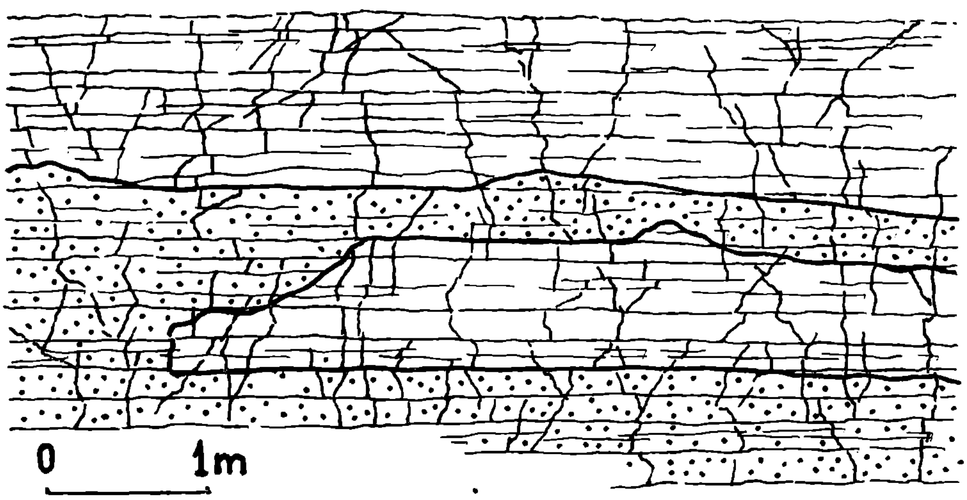

Fig. 3. Contact between ore-bearing dolomite (dotted area) and Górażdże limestone. Fragment of large limestone relic in ore-bearing dolomite. Compare Pl. L, fig. 2

Fig. 3. Kontakt dolomitu kruszconośnego (obszar zakropkowany) z wapieniem górażdżańskim. Fragment dużego ostańca wapiennego w dolomicie kruszconośnym

In the higher levels of the ore-bearing dolomite, numerous relics of the Gorażdże Beds occur. Such relics show all the properties that are characteristic and diagnostic of these beds. The contact surfaces are similar to those previously discussed (Fig. 3).

CONTACT RELATIONS WITH SYNGENETIC DOLOMITES

The syngenetic dolomites recently exposed in Trzebionka occur as regular sedimentary intercalations in the upper part of the Gorażdże Beds, about 10 m, above their base. These dolomites correspond presumably to those that are exposed in the nearby region of Płaza. The dolomites from Płaza were described by Siedlecki (1952) as suspected of being primary. The dolomites here described are light colored with a yellowish tint. They contain numerous chert nodules. Partial analyses failed to reveal any significant amounts of sulfide minerals and one complete analysis has shown only insignificant quantity of zinc and lead (Tabl. 4). Differential thermal and thermal gravimetrical analyses (fig. 4),

Table 4

Chemical data on primary /syngenetic/ dolomite from Gorażdże Beds near contact with ore-bearing dolomite. Analysis made by A. Stachańczyk

Analiza chemiczna syngenetycznego dolomitu z warstw gorażdżańskich z pobliża kontaktu z dolomitem kruszconośnym. Analizę wykonała A. Stachańczyk

SiO_2	0,77
Al_2O_3	0,52
Fe_2O_3	0,45
FeO	3,46
MnO	0,22
MgO	16,29
CaO	31,96
Zn_{total}	0,27
Pb_{total}	0,06
S_{total}	0,13
Ignition loss /1000°C/	45,56
	99,69
CO_2	42,86
SO_3	0,03
Zn/ZnO	0,20
Pb/PbO	0,06
FeS_2	0,17

point to a typical dolomitic composition of the rock under consideration. In thin sections, the dolomites show structures that are known to occur in the Muschelkalk limestones and in other primary dolomites. The original depositional texture is still preserved and contains micrite (Pl. LI, fig. 3).

The dolomites under consideration show, in places, secondary alterations that are very similar to those described from contact configurations along the base of the ore-bearing dolomite (p. 354). The alterations take a shape of dark bands that tend to develop on both sides of bedding surfaces (Pl. XLIX, fig. 2). Such bands are made up of crystalline dolomite with certain amounts of sulfides. They represent presumably the off-shoots that project away from the main body of the ore-bearing dolomite. This is indicated by the fact that the tabular bodies of these epigenetic dolomites thicken towards the area occupied by the ore-bearing dolomite.

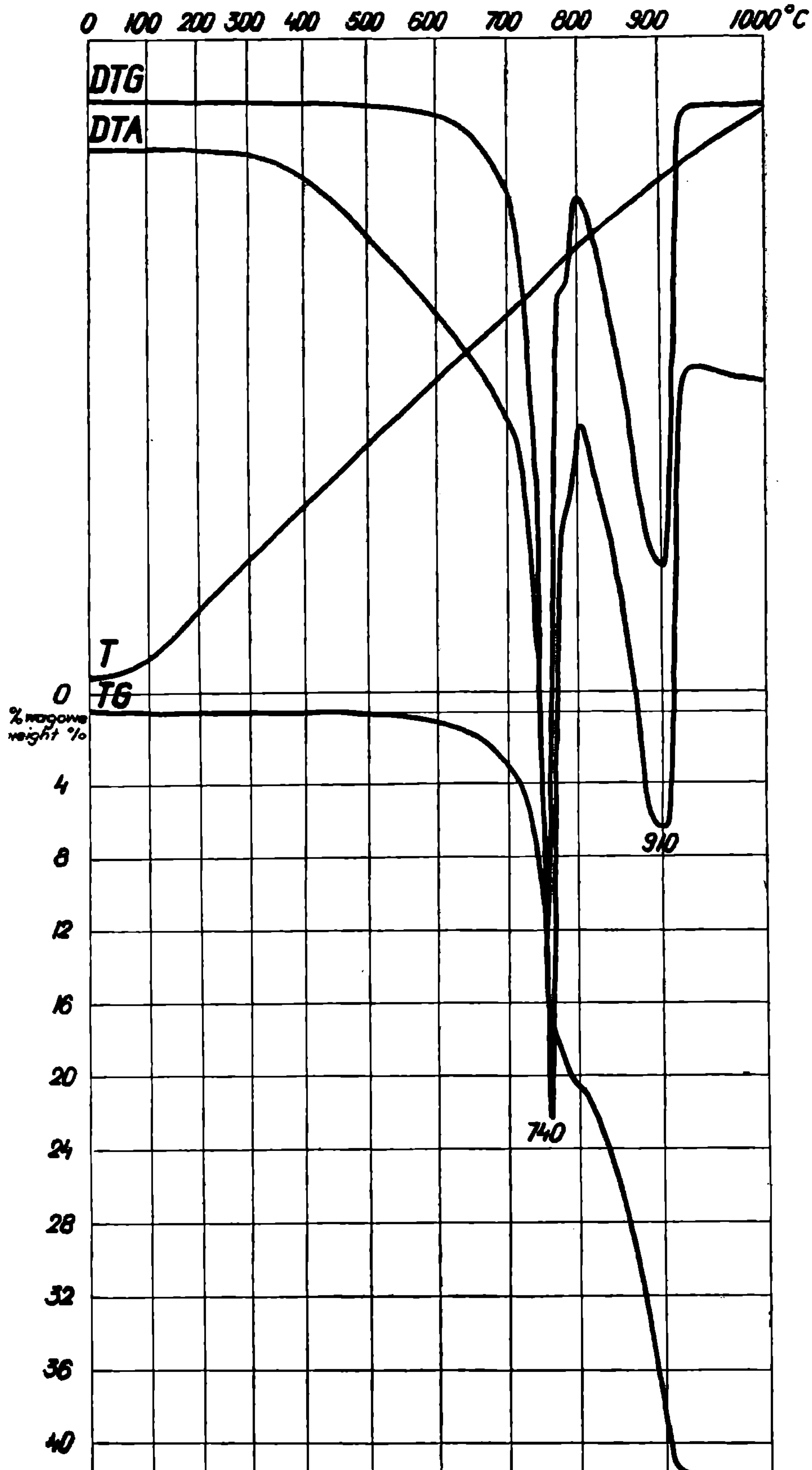

Fig. 4. Differential thermal and thermo-gravimetric analysis curves (DTA, DTG and TG) of primary Górażdże dolomite (0.5 g sample). Heating up to 1000°C in air atmosphere. Heating rate (T), 10°C/min. Derivatograph by F. Paulik, J. Paulik and L. Erdey, produced by MOM, Budapest

Fig. 4. Krzywa termiczna różnicowa (DTA), krzywa termograwimetryczna różnicowa (DTG) i krzywa termograwimetryczna (TG) próbki (0,5 g) syngenetycznego (pierwotnego) dolomitu z warstw górażdżańskich. Przyrost temperatury (T), 10°C/min. Derywatograf produkcji węgierskiej. F. Paulik, J. Paulik i L. Erdey, MON — Budapest

In the section exposed, the ore-bearing dolomite underlies the syngenetic one. The contact between these two types of rock is gradational or semi-gradational over a distance of about 1 m. The change is accomplished in three or more steps that appear as distinct zones showing succesively ligther colors and lesser degrees of crystallization. The boundaries of these zones are relatively sharply defined, and their appearance is not related to recognizable sedimentary structures. Therefore, they should be regarded as replacement contacts between the paleosome developed as a syngenetic dolomite and the neosome that is the ore-bearing dolomite.

The transformation of one type of a dolomite into another may be considered as simple recrystallization if the magnesium ions are derived from within the transforming rock. However, in the case discussed, much of the magnesium ions were introduced from outside.

DISCUSSION OF CONTACT RELATIONS

Contact configurations

Distinction should be made between the contact configurations as understood in this paper and structures resulting from incomplete dolomitization in general. The former are also products of incomplete dolomitization but, in addition, they are directly associated with a specific neosome of regional extent. The structures resulting from incomplete dolomitization may or may not be the contact configurations in this meaning. For instance, mottling as a structure may develop from a multitude of centers scattered randomly through a specific layer or set of layers, without being related to any specific neosome. Such mottling is believed to be a product of incomplete dolomitization accomplished during or shortly after deposition (e. g. Osmond, 1956; Carozzi, 1960). However, it cannot be directly identified with the mottled contact configurations.

The contact configurations described here are exclusively confined to a relatively narrow contact zone around the ore-bearing dolomite. They extend from the main body of the ore-bearing dolomite as variously shaped protuberances and never occur independently. It is to be noted that no concentrations of clay minerals have been found along the contact surfaces hitherto discussed.

Replacement nature of the ore-bearing dolomite

The contact configurations discussed testify so definitely to the replacement origin of the main body of the ore-bearing dolomite as to occasion no controversy. The pictures included are in this respect self-explanatory. The contacts of this type render untenable the concept of a sedimentary "interfacial zone" (Gruszczyk, 1956) between the ore-bearing dolomite and the remaining Muschelkalk carbonates.

The dolomitization, which comprised large parts of the Muschelkalk sequence, was effected without visible change of volume (see also Görlich and Szwaja, 1963). If such a change has ever occurred, it must have been lesser than that suggested by some authors, since the sedimentary structures of the paleosome are not disconnected at the contact with the ore-bearing dolomite. They can be traced into this rock without any significant alteration and retain their identity and integrity. Such inherited structures comprise all the types that may occur in the unaltered sequence of the Muschelkalk, e. g. horizontal lamination, cross-stratification, and wavy bedding. Emphasis is here laid on the fact that the structures under consideration are inherited from the paleosome. Such structures can no longer be discussed separately from the ore-structures, since they are usually replaced, impregnated, and/or lined with sulfide minerals. This subject is beyond the scope of the present article and will be dealt with in a forthcoming paper.

Structures controlling the spread of dolomitization

Summation of evidences derived from the study of contact configurations leads to the conclusion that the following discontinuities guided the spread of dolomitization in the Muschelkalk sequence: 1) primary sedimentary interfaces, 2) pore space, and 3) early diagenetic structures.

Notable is the absence of any apparent relation between the contact configurations described and numerous joints and fractures that cut across the Muschelkalk sequence.

The bedding surfaces were first utilized by dolomitizing solutions. The question now arises as to how far the marly seams, inherent to bedding planes of the Muschelkalk limestones, affected the flow of dolomitizing solutions.

The preferential development of dolomites along marly and shaly intercalations has been variously interpreted. Marls and shales are frequently more permeable than dense compact limestones, and "it is believed that they were the dominant channels through which the magnesian solutions migrated" (C a r o z z i, 1960 p. 275). It has been also suggested that marls or, more properly, the clay minerals, may assume an active role in dolomitization by serving as centres of nucleation or by entering into chemical reactions which involve dolomite as one of the products (K a h l e, 1965, p. 448). Whatever may be the role of marls, it should be borne in mind that the mere presence of discontinuities between marly intercalations and limestones is an important factor in promoting the lateral transfer of dolomitizing solutions.

While the first access to the paleosome was provided by sedimentary interfaces, further spread of dolomitization occurred chiefly through the pore-space, as evidenced by irregular outlines of contact configurations (Pl. XLVI, fig. 2). This porosity however, was the primary one, and it cannot be identified with the present porosity of the Muschelkalk rocks. The remarkable ease with which the dolomitizing solutions moved through the paleosome, as evidenced by the extent of dolomitization, is explained by the presence of primary porosity.

Lateral spread of dolomitization

The contact configurations discussed give evidence of the lateral spread of dolomitizing solutions. This is in agreement with the distribution of the ore-bearing dolomite that reveals a tendency to occur in form of strata-bound bodies, situated chiefly over the less permeable Gogolin Beds. It is also in keeping with what is known of the propagation of ore-bearing solutions (B o g a c z et al., 1970).

There is also abundant evidence for localized vertical transfer of dolomitizing solutions. However, the crucial problem of "feeding channels" and the question of the predominance of descending vs. ascending motions cannot be solved on the basis of the configurations discussed in this paper.

Time of dolomitization

The general time limitations for the ore-bearing dolomite have been already given (p. 350). The question now arises whether the ore-bearing dolomite; (a) is a product of early diagenetic alterations as suggested by Smolarska (1968) or (b) is due to later processes as postulated by the majority of authors.

The following observations are difficult to reconcile with the early-diagenetic origin of the ore-bearing dolomite: 1) the dolomite-limestone boundary cuts across a great number of strata which comprise a considerable time interval (see also Siedlecki; 1952, Śliwiński, 1969), 2) there are no breaks in the continuous vertical extension of the dolomite that would point to a temporary emergence and exposure of the ore-bearing dolomite to marine erosion, 3) replacement contacts with early-diagenetic dolomites indicate that the formation of the ore-bearing dolomite post-dated the formation of the early diagenetic dolomites, and 4) the presence of stylolitic seams as one of the factors controlling the spread of dolomitization (Pl. L, fig. 2).

In addition, it should be noted that the ore-bearing dolomite is known to extend vertically up to the primary Diplopora Dolomite of Middle Muschelkalk age. Between these two types of rocks there are also replacement contacts.

These observations, as well as those provided by other authors (e.g. Duwensee, 1928; 1929; Siedlecki, 1948) compel the view that the dolomitization was not an early diagenetic replacement as suggested by Smolarska (1968), but occurred after the deposition of much, if not all, of the Muschelkalk sequence.

Yet there are also features that lead to the conclusion that the formation of the ore-bearing dolomite discussed in this paper was accomplished prior to any considerable tectonization of the paleosome and prior to the formation of joints. The evidence for this is threefold: 1) the absence of any apparent relation between the contact configurations and joints; 2) the highly irregular shape of contact configurations, and 3) the predominance of primary structures in controlling the progress of dolomitization.

In the context of the above, it is suggested that the dolomitization here discussed was later than early-diagenetic alterations. It preceded, however, the formation of joints and fractures that cut across the Muschelkalk sequence.

One may be tempted to refer to the ore-bearing dolomite as to a product of "late-diagenetic" alterations. However, any attempt to discuss the problem of the ore-bearing dolomite in terms of diagenetic processes encounters significant difficulties, since no agreement has been reached as to when and where such processes end. In addition, the term diagenesis should be used to "include all those processes that turn a fresh sediment into a stable rock of some hardness, under conditions of pressure and *temperature* not widely removed from those existing on the earth surface" (Sujkowski, 1958, p. 2693 — italics by the present writers). However, upon the question of temperature at which the ore-bearing dolomite might have been formed there is a diversity of opinions. There is at least a presumptive evidence that the ore-bearing dolomite might have been formed under conditions of increased temperatures consequent upon the introduction of hydrothermal solutions (see later p. 365). Therefore it serves little purpose to discuss the origin of the ore-bearing dolomite in terms of diagenetic processes.

CONCLUDING REMARKS

The present work has further strengthened the opinion held by several authors that the ore-bearing dolomite is of epigenetic origin. The summation of all the contact configurations shows that the concept of a sedimentary origin of this dolomite lacks any foundations. Nor is the early-diagenetic origin tenable, although the ore- bearing dolomite, within the exposures investigated, shows no relations to joints and fractures that cut across the Muschelkalk sequence. The conclusion is reached that the formation of the ore-bearing dolomite, as a distinct neosome within the Muschelkalk sequence, occurred relatively soon after the deposition of this sequence. Such a conclusion is consistent with known geological evidence that points to pre-Liassic age of the ore-bearing dolomite. Evidence to date more precisely the dolomitization has not yet been recognized.

If the assumption is admitted that dolomitization that resulted in the formation of the bulk of the ore-bearing dolomite took place relatively shortly after the deposition of the Muschelkalk sequence, then the stratabound character of the dolomite is easy to understand. The Muschelkalk sequence, at that time, was presumably not yet sufficiently tectonized and jointed so as to impede an extensive lateral transfer of dolomitizing solutions. It seems also reasonable to suppose that this sequence still possesed much of its primary porosity that might have facilitated the spread of solutions.

On the basis of the contact configuration alone, a cause of the dolomitization cannot be offered. In this respect, the origin of the ore-bearing dolomite is still elusive and remains in the realm of speculation. There is, however, a good reason to suppose that the formation of the ore-bearing dolomite was, in some way, genetically related to the emplacement of ores; an idea already advanced by many authors, irrespectively of their standpoint on the subject of the origin of the ores. The point is, that a considerable part of the ores (though not all of them!) were emplaced penecontemporaneously with, or shortly after, dolomitization of the Muschelkalk sequence. Although such an approximate correspondence in time and space does not necessarily mean a common source for magnesium and sulfides, it may point to a common formative process with brought about the appearance of the dolomite and the ores. The origin of magnesium ions is an open question. Two possibilities, which are mutually not exclusive, arise as plausible explanations: 1) the magnesium was introduced by ascending hot solutions or 2) it was, at least partly, derived from connate waters resident in the Muschelkalk sequence and/or from the primary dolomites. The second possibility was suggested by Dżułyński and Kubicz (1971) who attributed the origin of the ore-bearing dolomite to the action of connate brines mobilized and heated by the introduction of hot solutions. Without committing ourselves to any of the above possibilities we may conclude that the ore-bearing dolomite in the Muschelkalk of the Cracow-Silesian region is some sort of a "wall-rock alteration" on a gigantic scale consequent upon the introduction of hot ore-bearing solutions.

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Streszczenie

Badania kontaktów dolomitu kruszconośnego z otaczającymi go skałami węglanowymi, przeprowadzone w Trzebionce, wskazują niedwuznacznie na metasomatyczne i epigenetyczne pochodzenie tego dolomitu.

Za metasomatycznym pochodzeniem dolomitu kruszconośnego przemawiają, między innymi, następujące spostrzeżenia: 1) Powierzchnia graniczna dolomitu kruszconośnego, na ogół bardzo ostro zarysowana, biegnie skośnie do uwarstwienia, przecinając struktury sedymentacyjne, które w sposób ciągły i bez widocznych zmian przechodzą od skał otaczających do dolomitu. 2) W miejscach, w których widoczne są boczne granice dolomitu kruszconośnego, odchodzą od nich liczne, często rozwidlające się odgałęzienia, które pod postacią metasomatycznych apofiz wnikają w skały otaczające. Struktury powstałe w wyniku takiego przenikania zostały objęte mianem struktur kontaktowych, gdyż wiążą się bezpośrednio z granicą dolomitu i poza jego najbliższym otoczeniem nie występują w nie zmienionych utworach wapienia muszlowego. 3) W obrębie dolomitu kruszconośnego zachowały się liczne ostańce nie zmienionych warstw gogolińskich i górażdżańskich.

Za epigenetycznym pochodzeniem dolomitu kruszconośnego przemawiają, między innymi, następujące dane: 1) Rozpiętość pionowa metasomatycznej granicy dolomitu kruszconośnego obejmuje swoim zakresem większą część utworów wapienia muszlowego. 2) W pionowym przekroju dolomitu kruszconośnego nie dostrzega się nieciągłości, które by wskazywały na jego syn-depozycyjną erozję. Wszystkie struktury erozyjne występujące w dolomicie kruszconośnym są odziedziczone po pierwotnym osadzie. 3) Dolomit kruszconośny jest późniejszy od przemian wczesnodiagenetycznych. Wskazuje na to metasomatyczny kontakt tego dolomitu z wczesnodiagenetycznymi dolomitami z warstw górażdżańskich. Dolomity te różnią się barwą, strukturą i składem od dolomitu kruszconośnego i podobnie jak wapienie są pozbawione cynku i ołowiu lub zawierają śladowe ilości tych pierwiastków.

Dolomit kruszconośny powstał zatem w wyniku metasomatycznego przeobrażenia pierwotnych osadów węglanowych pod wpływem roztworów dolomityzujących. Roztwory te wniknęły do utworów wapienia muszlowego wówczas, gdy były one w całości lub w znacznej mierze osadzone. Środowisko sedymentacyjne, w którym gromadziły się osady wapienia muszlowego, nie mogło mieć zatem bezpośredniego wpływu na przebieg dolomityzacji, której następstwem jest dolomit kruszconośny. Proces przenikania

roztworów w nie zmienione jeszcze osady węglanowe został utrwalony pod postacią obecnej granicy dolomitu kruszconośnego. Nastąpiło to z chwilą przerwania dopływu roztworów. Struktury kontaktowe wskazują na to, że roztwory dolomityzujące wykorzystywały istniejące w osadzie nieciągłości sedymentacyjne i jego pierwotną porowatość. Nie dostrzega się natomiast związku między strukturami kontaktowymi a spękaniami ciosowymi, które przenikają utwory wapienia muszlowego. Wypływa stąd wniosek, iż powstanie dolomitu kruszconośnego nastąpiło jeszcze przed utworzeniem się spękań, a zatem stosunkowo niedługo po osadzeniu się utworów wapienia muszlowego.

Przyczyny dolomityzacji nie są znane. Dane, jakimi rozporządzamy, wskazują na istnienie co najmniej lokalnego przepływu bocznego, nie dają jednak odpowiedzi na pytanie, skąd nadeszły roztwory dolomityzujące. Magnez mógł być doprowadzony z głębiej położonych źródeł. Mógł być również uruchomiony z miejscowych zasobów, to znaczy z dolomitów pierwotnych i z wód reliktowych, przychwyconych w czasie sedymentacji wapienia muszlowego. Obydwie możliwości nie wykluczają się wzajemnie.

Dolomityzacja, która doprowadziła do utworzenia się dolomitu kruszconośnego, była zdaniem autorów, genetycznie związana z pierwszą fazą mineralizacji. W takim ujęciu dolomit kruszconośny można by uważać za rozległą aureolę zmian w osadach węglanowych, które nastąpiły w wyniku doprowadzenia hydrotermalnych roztworów mineralizujących.

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EXPLANATION OF PLATES
OBJAŚNIENIE TABLIC

Plate — Tablica XLIV

Fig. 1. Undersurface of ore-bearing dolomite (d_o) with mottled contact configurations (center) in limestone (1). Detail of replacement contact between ore-bearing dolomite and Gogolin limestone

Fig. 1. Nierówna dolna powierzchnia dolomitu kruszconośnego (d_o). Przykład kontaktu metasomatycznego z nieregularnymi wypustkami dolomitu, które wnikają do wapieni gogolińskich wzdłuż przemazów marglistych

Fig. 2. Sharp replacement contact between ore-bearing dolomite (d_o) and Gogolin limestone (l). Detail of limestone relic shown in text-figure 1. Note uninterrupted passage of bedding surfaces and sedimentary structures from limestone to dolomite

Fig. 2. Ostra granica kontaktu metasomatycznego wapieni gogolińskich (l) z dolomitem (d_o). Szczegół powierzchni granicznej ostańca wapiennego. (Porównaj fig. 1 w tekście)

Plate — Tablica XLV

Fig. 1. Contact configurations. Tabular and sheet-like dolomitic projections (d_o) extending from main body of ore-bearing dolomite. Tabular projections developed along bedding surfaces of Gogolin limestones (l). Note transverse dolomitic veinlet of ore-bearing dolomite (center) rising from upper margin of lowermost horizontal dolomitic body. Veinlet contains globular aggregates of calcite (C)

Fig. 1. Struktury kontaktowe dolomitu kruszconośnego. Poziome odgałęzienia dolomitu kruszconośnego (d_o) odchodzące od jego głównej masy wzdłuż powierzchni uwarstwienia wapieni gogolińskich (l). W środku zdjęcia drobna metasomatyczna żyła dolomitowa z kulistymi skupieniami grubokrystalicznego kalcytu (C)

Fig. 2. Sharp replacement contact between ore-bearing dolomite (right) and Gogolin limestone (left), showing wavy-bedding. Note dark streaks of dolomite developed along marly seams. The vertical fracture line (center) is an accidental artifact, not a natural structure. Detail of limestone-dolomite boundary shown in text-figure 1 and Pl. XLIV, fig. 2.

Fig. 2. Ostra granica kontaktu metasomatycznego między dolomitem kruszconośnym (prawa strona) a wapieniem Gogolińskim (lewa strona). Smugi dolomitu wchodzą do wapienia wzdłuż przemazów marglistych. Ciemna szczelinka w środku okazu to przypadkowe uszkodzenie. Szczegół powierzchni granicznej między wapieniami a dolomitem kruszconośnym z fig. 1 w tekście i z fig. 2, Tabl. XLIV. Fot. S. Michta.

Plate — Tablica XLVI

Fig. 1. Polished slab showing contacts of tabular (bottom) and sheet-like bodies (center) of ore-bearing dolomite (d_o) with Gogolin limestone (l). Note sharp (lower right) and sligthly gradational (lower left) contacts and transverse dolomitic vein with globular aggregates of calcite (C). Tubular dolomitic bodies (top) developed presumably along burrows

Fig. 1. Wygładzona płyta z kontaktem pokładowo rozwiniętego dolomitu kruszconośnego (d_o) z wapieniem gogolińskim (l). Ostry kontakt (w dolnej części zdjęcia po prawej stronie) i kontakt z przejściem (po lewej). W środku skośna żyłka dolomitowa z kulistymi skupieniami kalcytu (C). Rurkowate żyłki dolomitowe (góra) rozwinięte przypuszczalnie wzdłuż śladów żerowania

Fig. 2. Magnified section showing gradational contact between ore-bearing dolomite (d_o) and limestone (l) from fig. 1 (Compare also (Pl. LI, fig. 4); S — concentration of sulfides

Fig. 2. Powiększony fragment kontaktu z przejściem od dolomitu kruszconośnego (d_o) do wapienia (l), przedstawionego na fig. 1. Porównaj również Pl. LI, fig. 4; S — skupienia siarczków

Plate — Tablica XLVII

Fig. 1. Photograph of polished slab showing mottled contact configurations. White patches are relics of Gogolin limestones suspended in dark sulfide-rich ore-bearing dolomite (d_o). Note gradational contacts, upper part, and globular aggregate of calcite crystals (C), center

Fig. 1. Zdjęcie wygładzonej płyty ze strukturami plamistymi. Jasne obszary są ostańcami wapienia gogolińskiego. Zwrócić uwagę na kontakty z przejściem w górnej części zdjęcia i kuliste skupienia kalcytu (c) w części środkowej

Fig. 2. Photograph of polished slab, perpendicular to bedding showing variously shaped limestone relics (l)

Fig. 2. Zdjęcie wygładzonej powierzchni częściowo zdolomityzowanego wapienia gogolińskiego zachowanego w formie małych reliktów (l). Cięcie wygładu prostopadle do warstwowania

Plate — Tablica XLVIII

Fig. 1. Streaks of ore-bearing dolomite (d_o) developed along marly seams which envelope crumpled limestone nodules. Incipient stage of development of mottled contact configurations shown in fig. 1, Pl. XLIV (center)

Fig. 1. Smugi dolomitu kruszconośnego (d_o) rozwinięte wzdłuż przemazów marglistych w wapieniu gruzłowym (falistym). Szczegół struktur kontaktowych przedstawionych w środkowej części fig. 1, tabl. XLIV

Fig. 2. Negative print of thin section. Enlarged mottled contact configurations. Light colored areas, sulfide-rich, semi-transparent ore-bearing dolomite (d_o). Gray colored areas, small limestone relics with sphalerite crystals (S). Notice development of small cavities (black patches), inherent to emplacement of ores

Fig. 2. Zdjęcie negatywowe. Powiększony fragment struktury plamistej. Jasne tło jest półprzeźroczystym dolomitem kruszconośnym (d_o). Obszary o szarej barwie są drobnymi reliktami wapiennymi z wykrystalizowanym sfalerytem (S). Zwrócić uwagę na pustki (czarne plamy) powstałe w wyniku rozpuszczania węglanów, które towarzyszy okruszcowaniu

Plate — Tablica XLIX

Fig. 1. Negative print of thin section. Enlarged contact between tabular body of ore-bearing dolomite and Gogolin limestone: d_{o1} — black sulfide-rich ore-bearing dolomite (compare Pl. L, Fig. 4 bottom), d_{o2} — zone of large dolomite crystals replacing limestone (compare Pl. LI, fig. 4 center); S — concentration of sulfides, 1 — limestone (note small relics of limestone above d_{o1})

Fig. 1. Zdjęcia negatywowe. Powiększony wycinek kontaktu pokładowej żyły dolomitu kruszconośnego z wapieniem gogolińskim. d_{o1} — drobnokrystaliczny dolomit kruszconośny z siarczkami (porównaj Pl. LI, fig. 4, dolna część zdjęcia),

d_{o2} — nagromadzenia dużych idiomorficznych kryształów dolomitu (porównaj Pl. LI, fig. 4, środek). 1 — wapień (zwróć uwagę na drobne relikty wapienne nad d_{o1}); S — nagromadzenia siarczków

Fig. 2. Contact between ore-bearing dolomite (d_2) and syngenetic dolomite (d_s). Note etched upper contact of ore-bearing dolomite which forms a vein developed along bedding plane. Detail of contact between primary dolomite of Gorażdże Beds and ore-bearing dolomite

Fig. 2. Kontakt między pierwotnym dolomitem z warstw gorażdżańskich (d_s) a dolomitem kruszconośnym (d_o) rozwiniętym w formie żyły pokładowej wzdłuż powierzchni uwarstwienia. Zwrócić uwagę na nadżerki w górnej powierzchni dolomitu kruszconośnego. Przykład kontaktu metasomatycznego między dolomitem kruszconośnym a syngenetycznym

Plate — Tablica L

Fig. 1. Contact between Gogolin limestone (l) and ore-bearing dolomite (d_o) along scour surface. Detail of scour-fill structure. Fill consists of laminated dolomite and alternating dolomite and limestone bands. Note cross-stratification in limestone. Example of misleading contact configuration that may be confused with sedimentary contact.

Fig. 1. Kontakt między dolomitem kruszconośnym (d_o) a wapieniem gogolińskim (l). Powierzchnia kontaktu metasomatycznego pokrywa się z powierzchnią struktury erozyjnej podmorskiego rozmycia w skośnie uwarstwionym wapieniu. Przykład kontaktu metasomatycznego, który może być pomylony z kontaktem sedymentacyjnym

Fig. 2. Contact between Gorażdże limestone (l) and ore-bearing dolomite (d_o) along stylolitic seam trending obliquely to bedding. Detail of contact surface from text-figure 3.

Fig. 2. Kontakt dolomitu kruszconośnego (d_o) z wapieniem gorażdżańskim wzdłuż powierzchni szwu stylolitowego. Szczegół powierzchni kontaktowej z fig. 3 w tekście

Plate — Tablica LI

Fig. 1. Mosaic of subhedral dolomite crystals replacing fine-grained limestone. Detail of sharp contact between ore-bearing dolomite and Gogolin limestone. 60×

Fig. 1. Ostra granica między dolomitem kruszconośnym a drobnoziarnistym wapieniem gogolińskim.

Fig. 2. Sharp contact between interlocked mosaic of dolomite crystals (right) and limestone made up chiefly of sparry calcite (left). Detail of sharp contact between ore-bearing dolomite and Gogolin limestone.

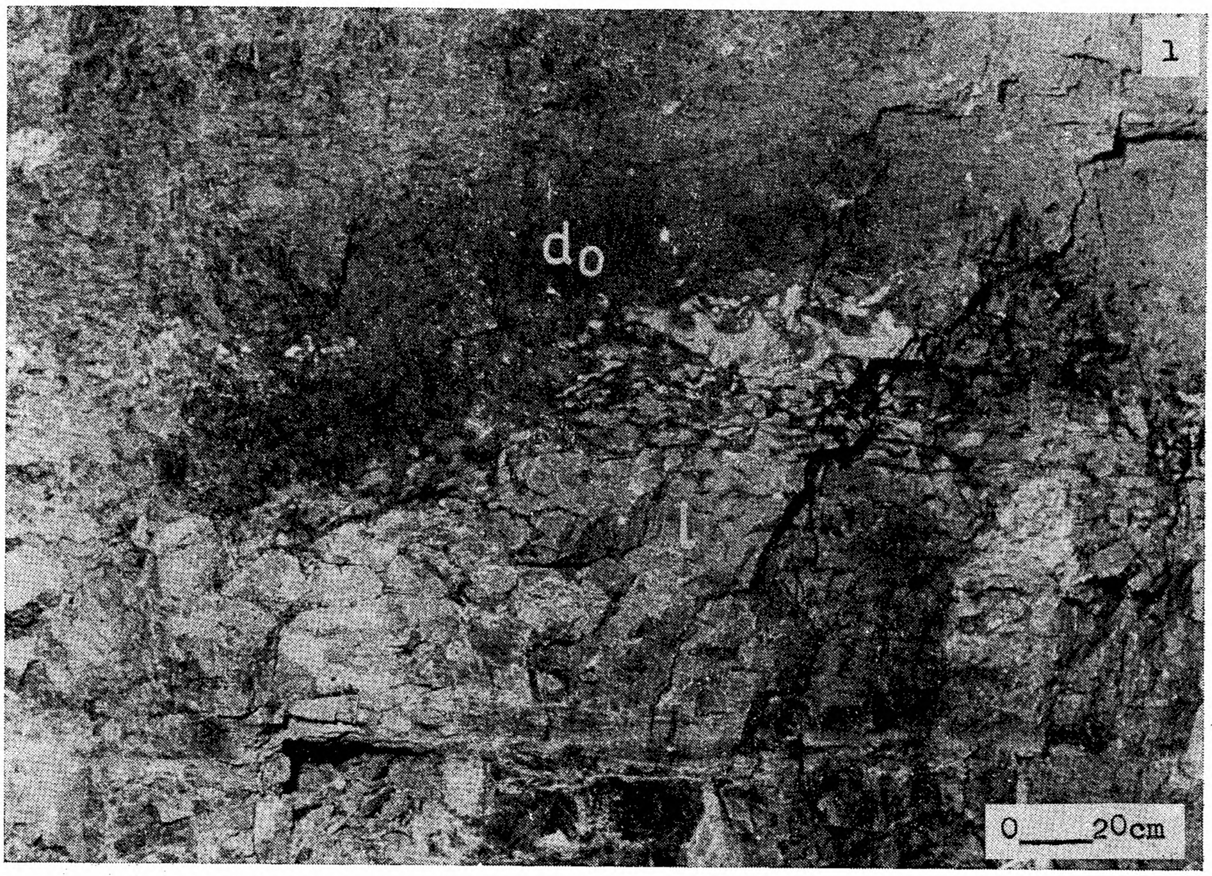
Fig. 2. Ostra granica między dolomitem kruszconośnym (prawa strona) a wapieniem zbudowanym głównie ze sparytu (lewa strona).

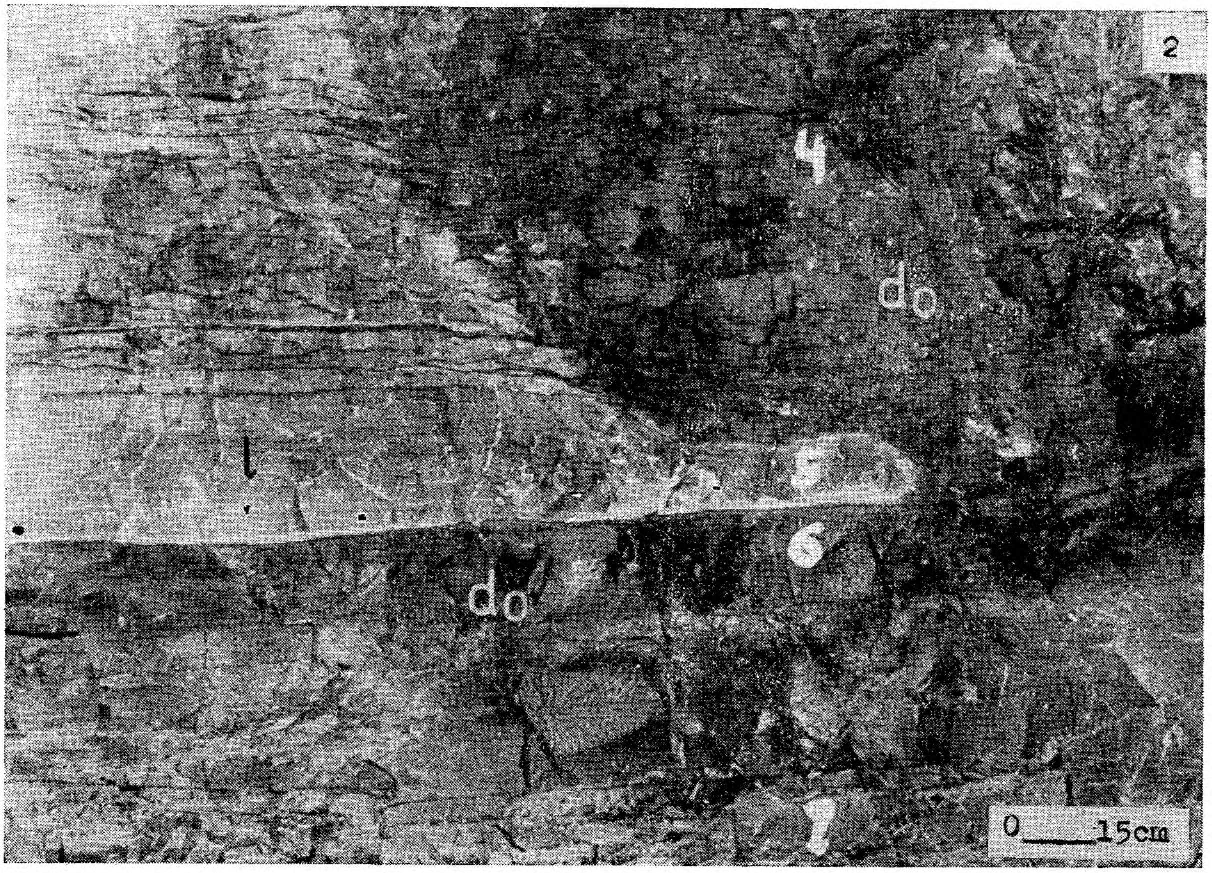
Fig. 3. Photomicrograph of thin section of primary Gorażdże dolomite showing micrite (dark areas) in microspar (light gray areas).

Fig. 3. Zdjęcie płytki cienkiej pierwotnego dolomitu z warstw gorażdżańskich z mikrytem w mikrosparycie.

Fig. 4. Photomicrograph of thin section showing gradational contact between ore-bearing dolomite and Gogolin limestone. Lower part — interlocking mosaic of anhedral, fine-grained and sulfide-rich dolomite. Center — large subhedral and euhedral dolomite crystals replacing fine-grained limestone. Upper part — fine-grained limestones with isolated rhombs of dolomite.

Fig. 4. Kontakt z przejściem między dolomitem kruszconośnym a wapieniem gogolińskim. Dolna część zdjęcia — mozaika drobnych kryształów dolomitu z siarczkami. Środek — duże kryształy dolomitu w drobnokrystalicznym wapieniu. Górna część zdjęcia — wapień z odosobnionymi kryształami dolomitu.





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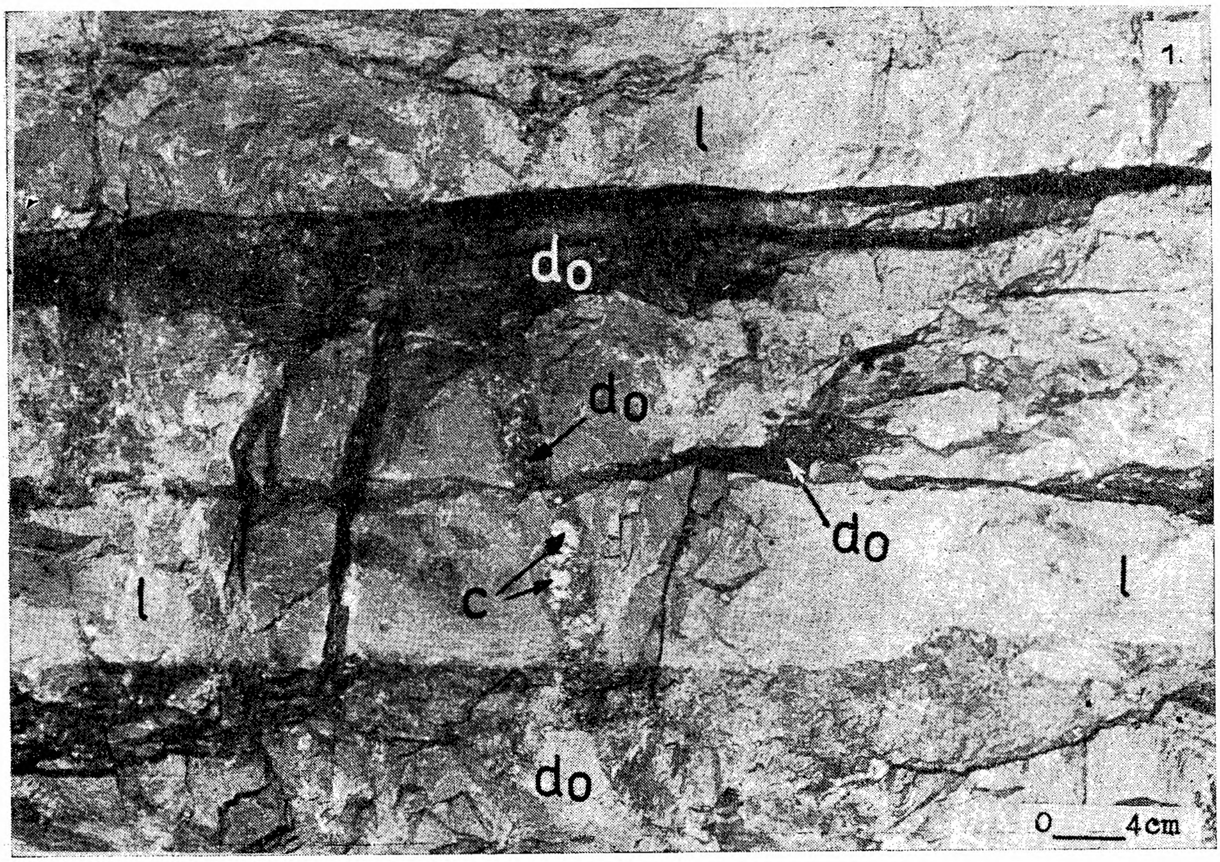

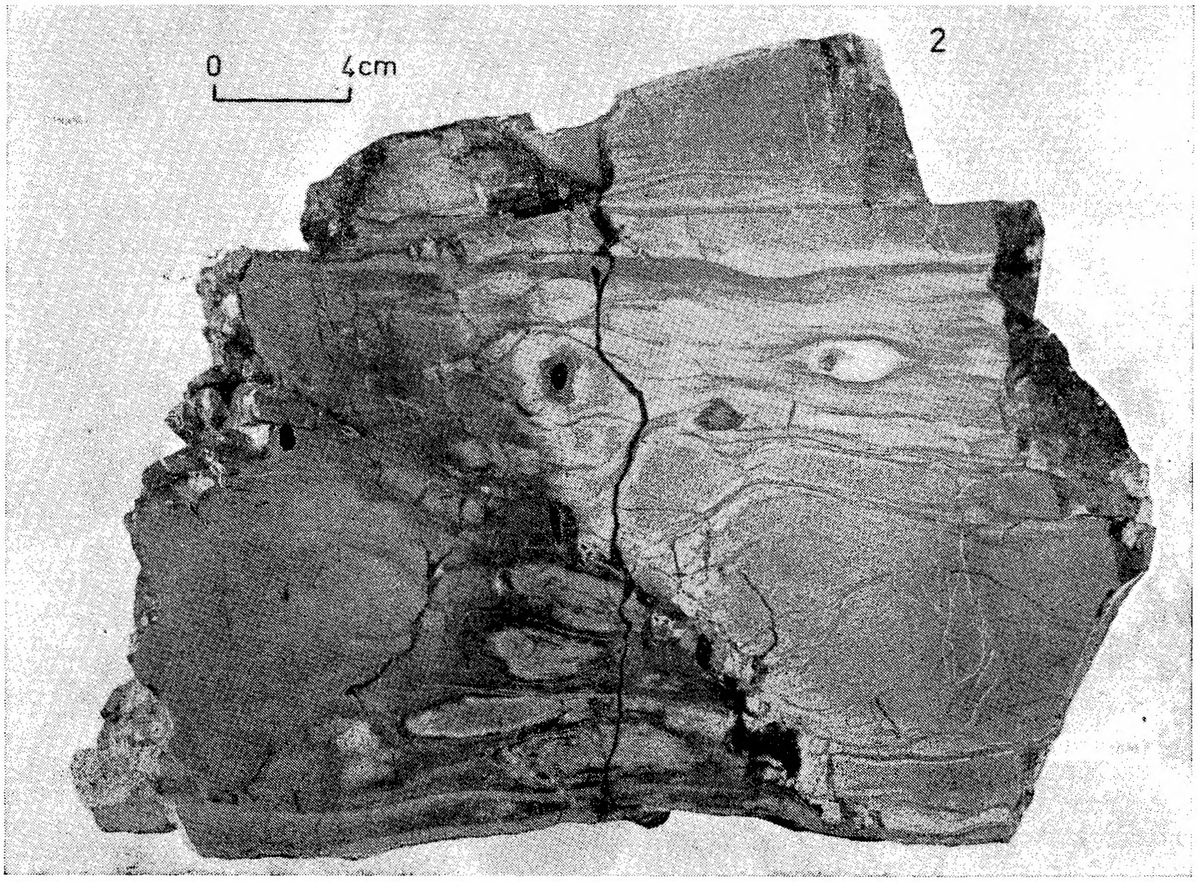

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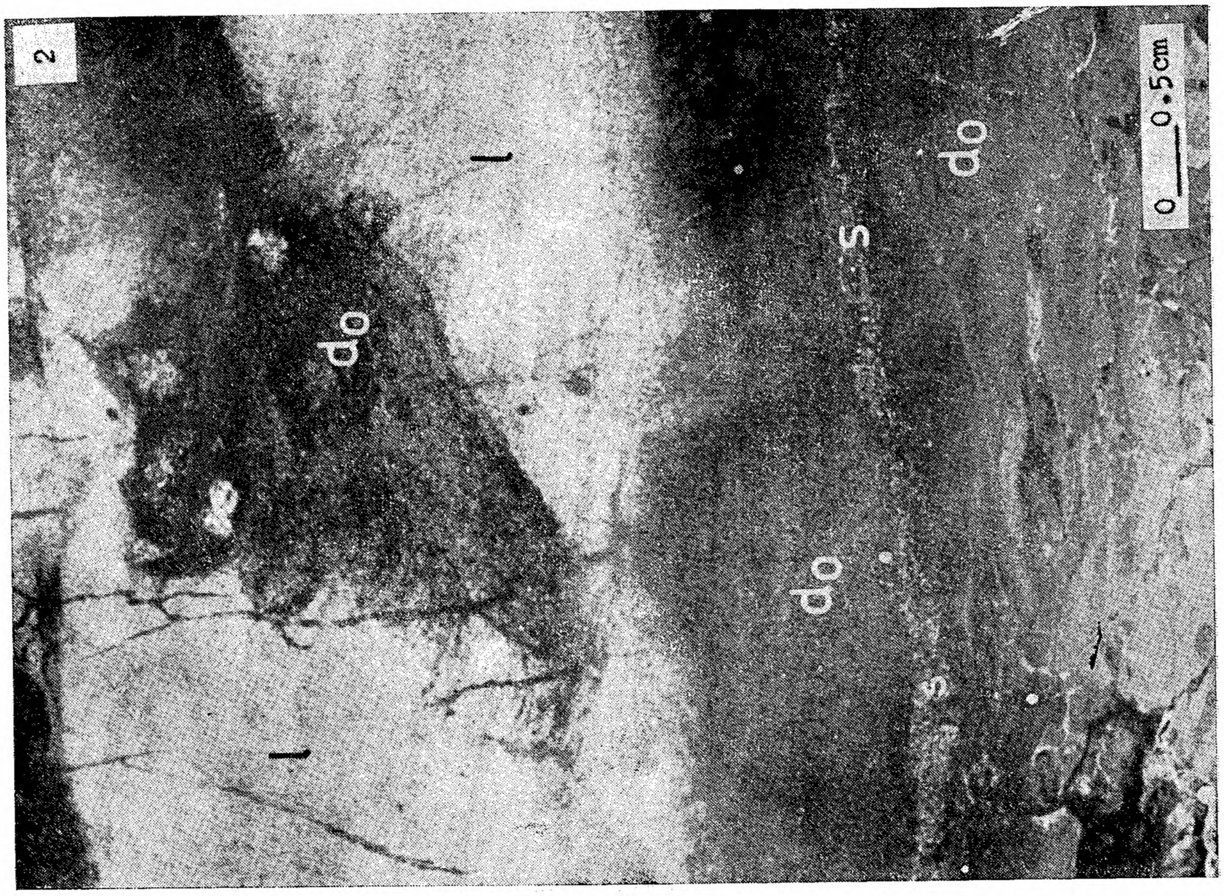

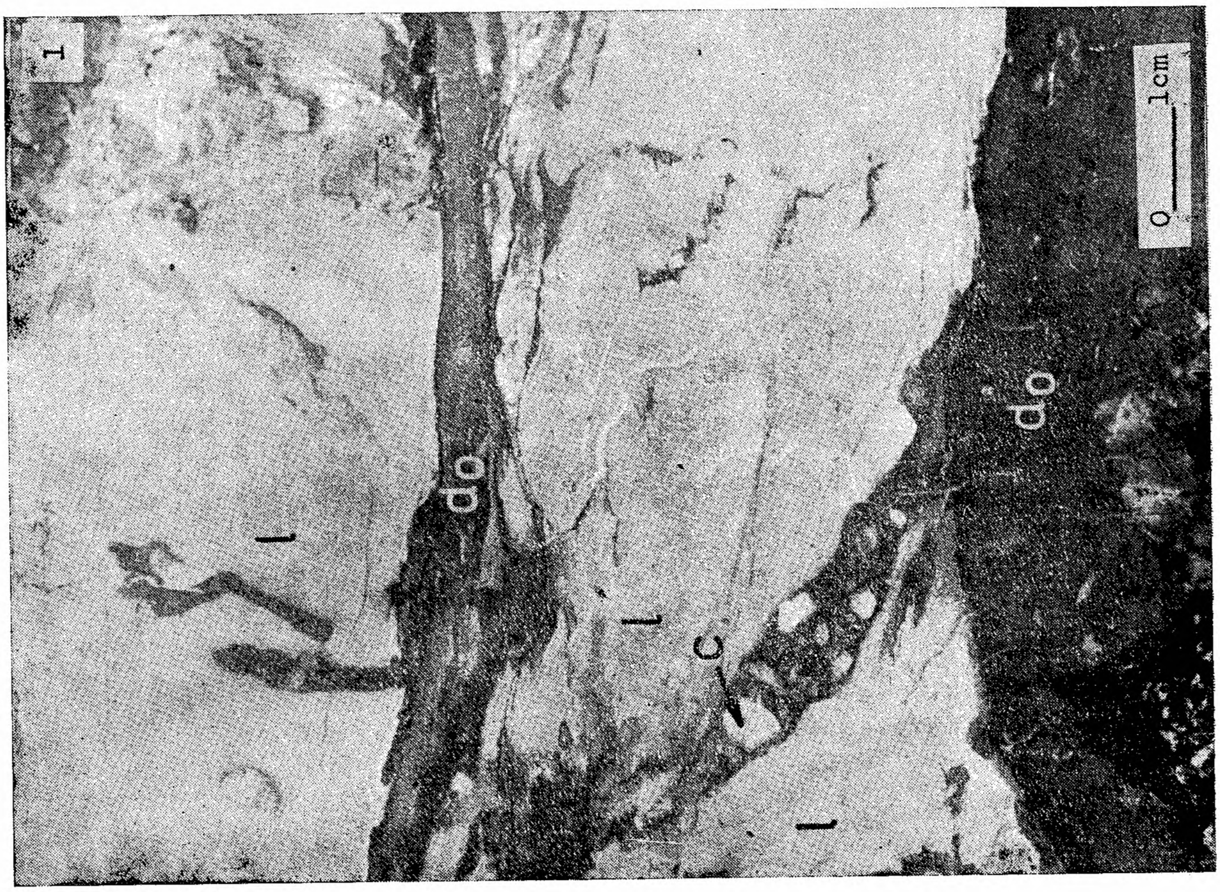

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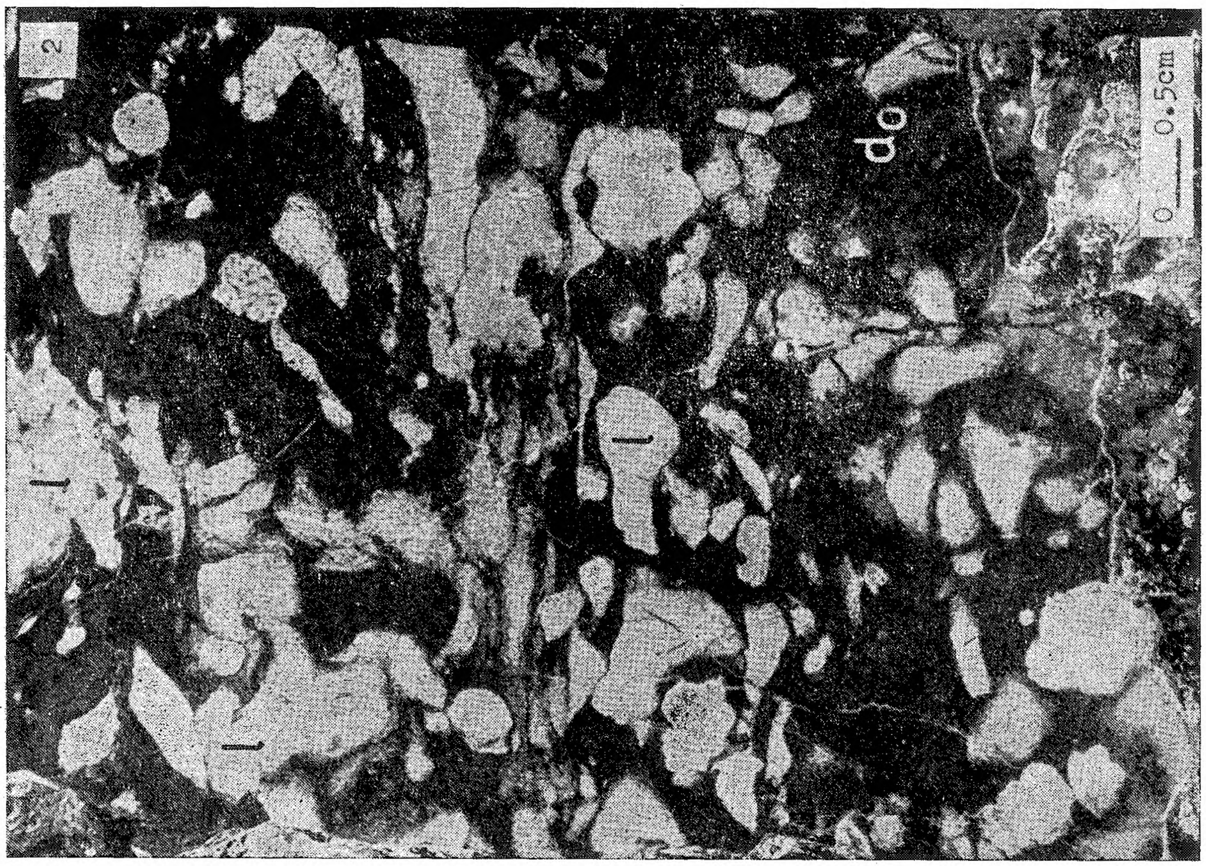

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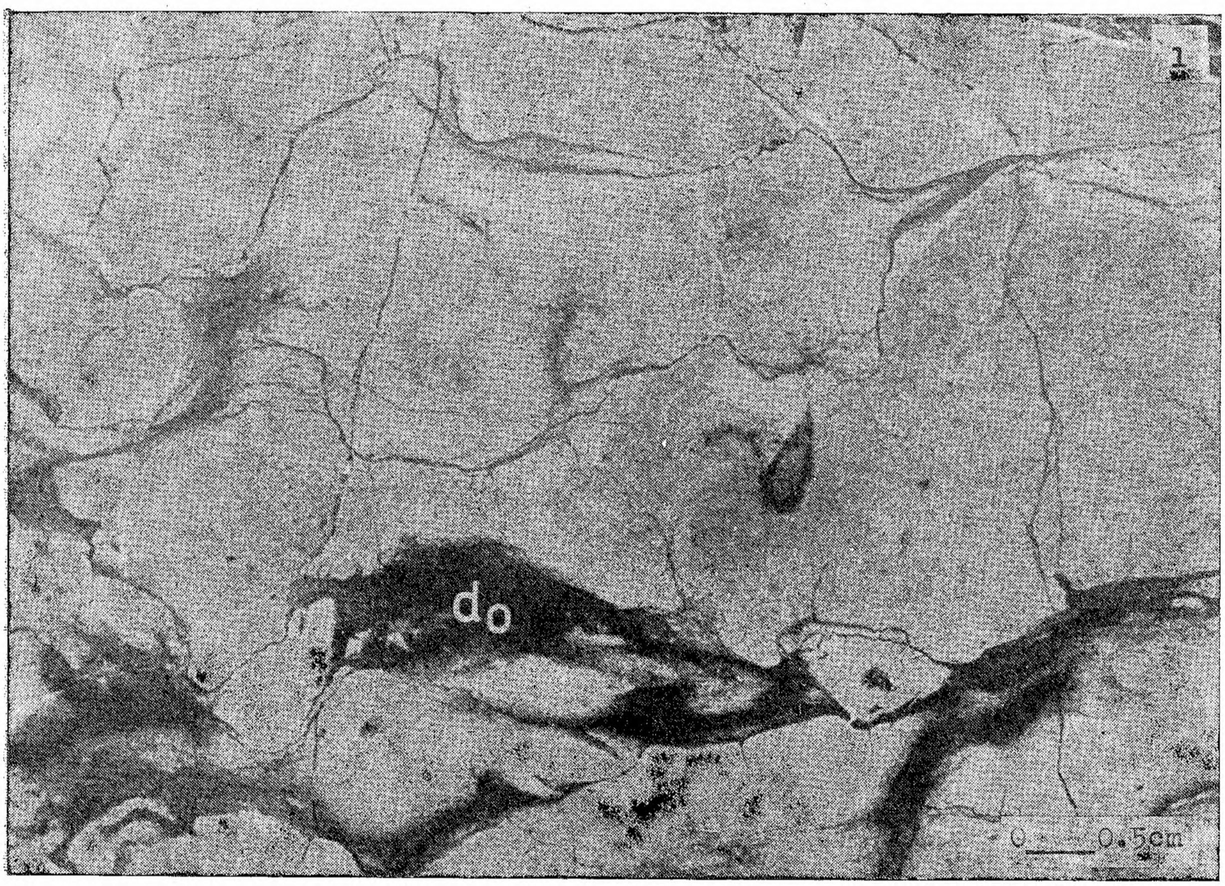

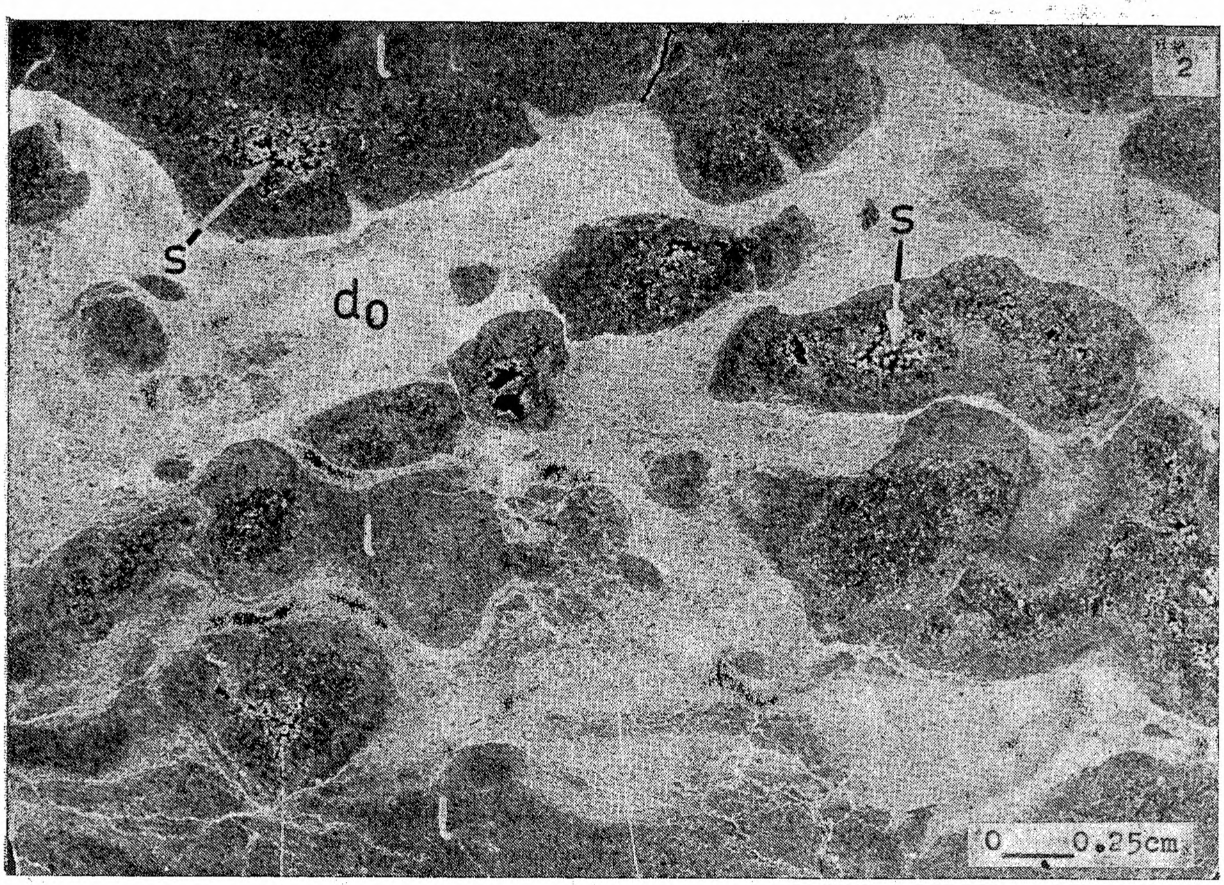

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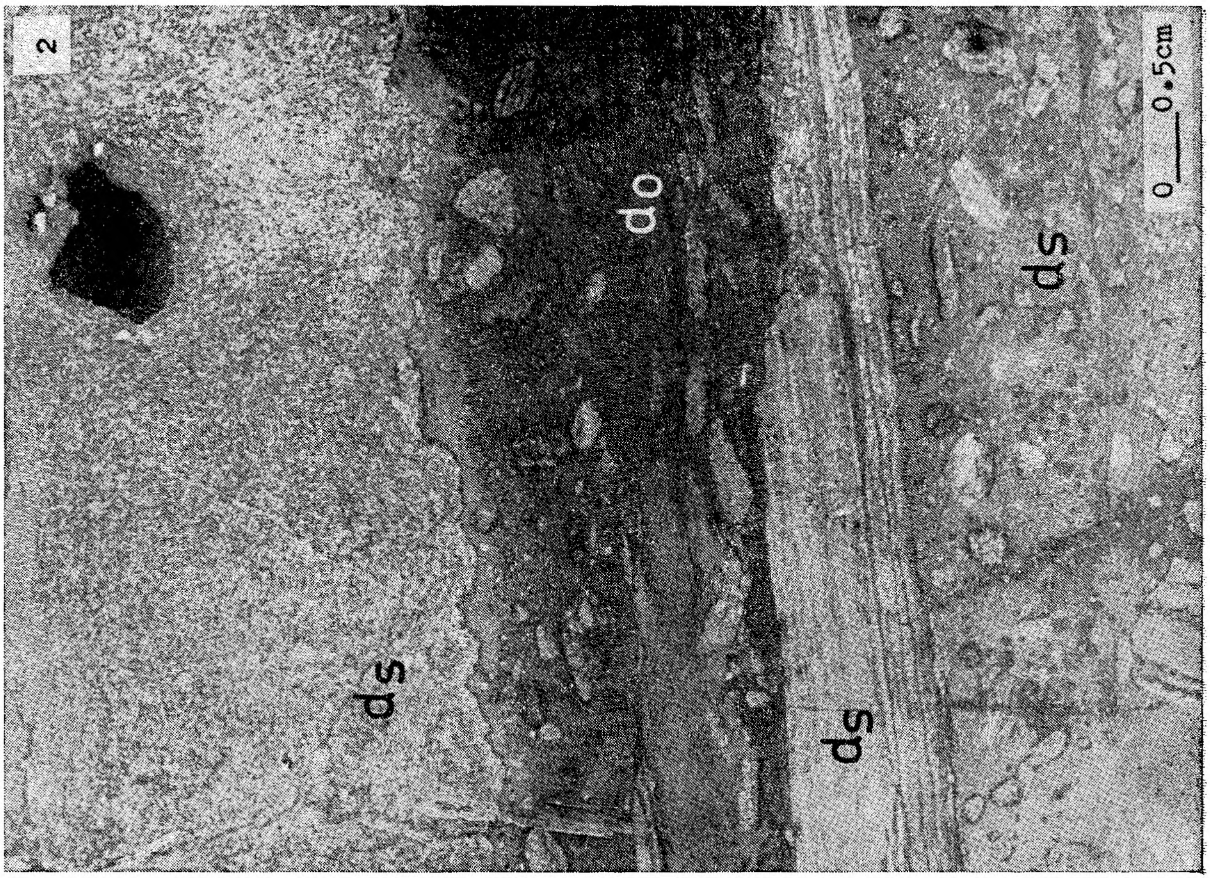

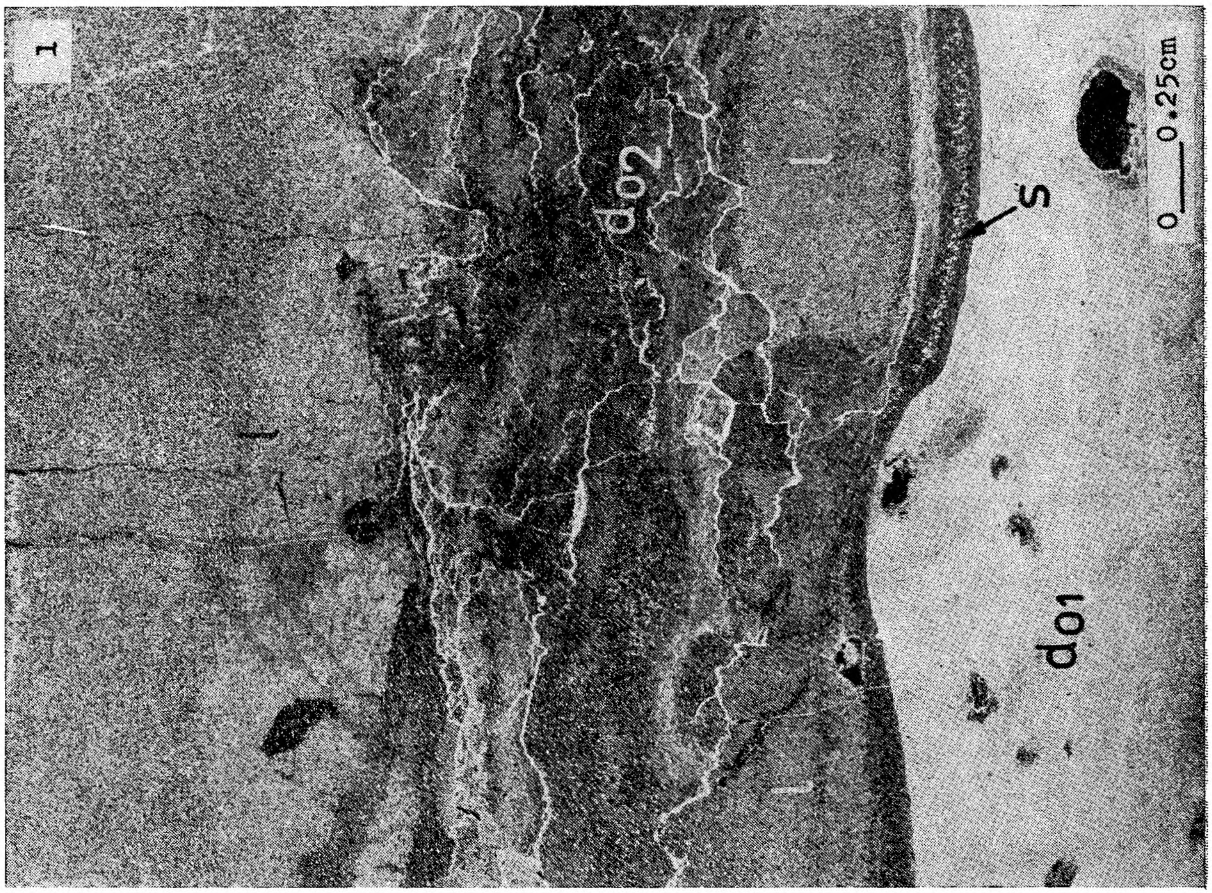

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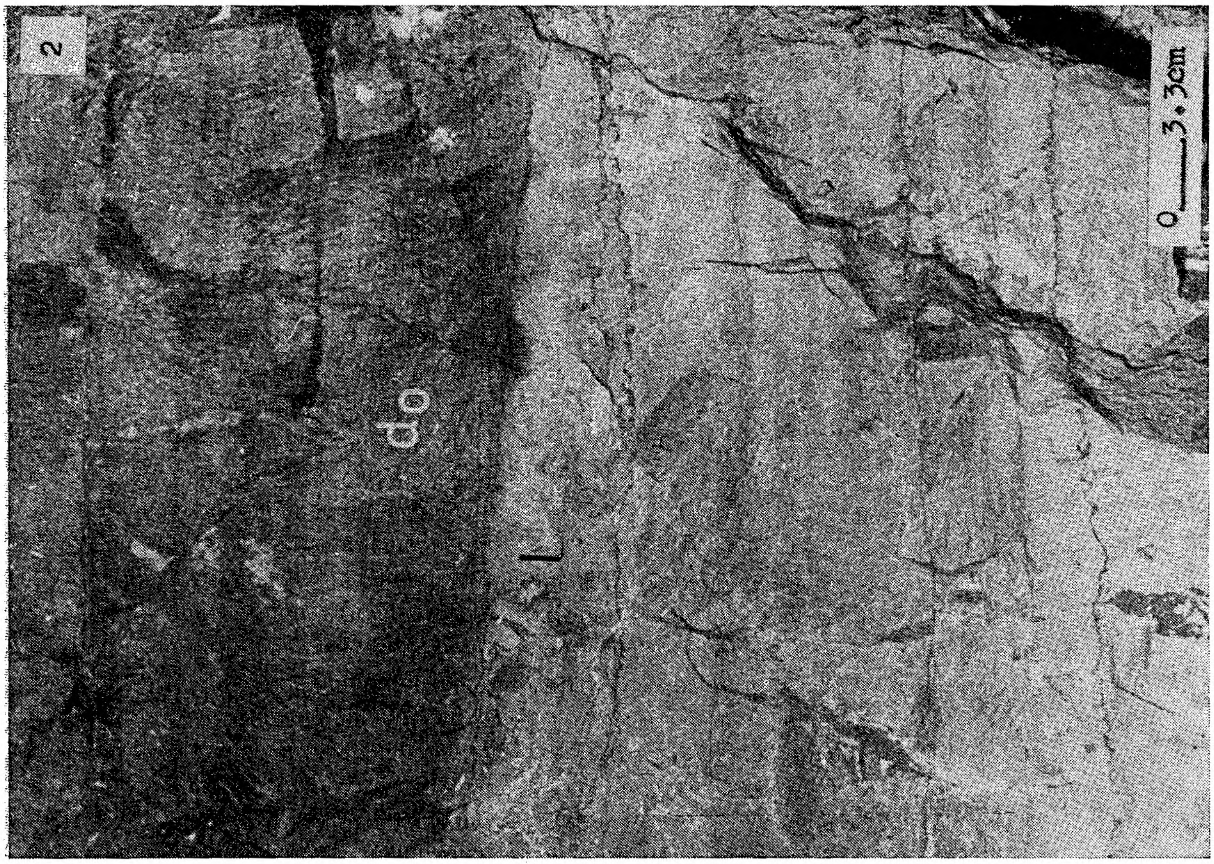

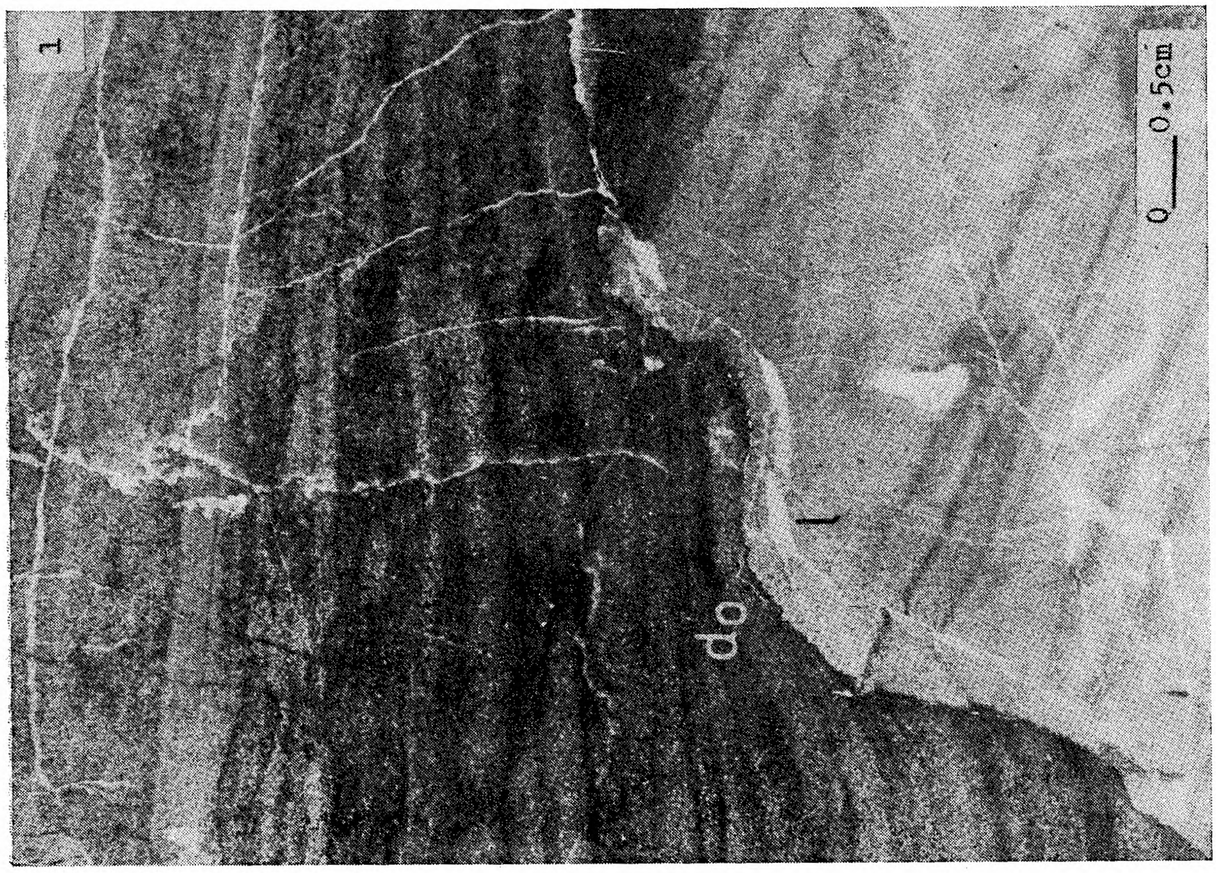

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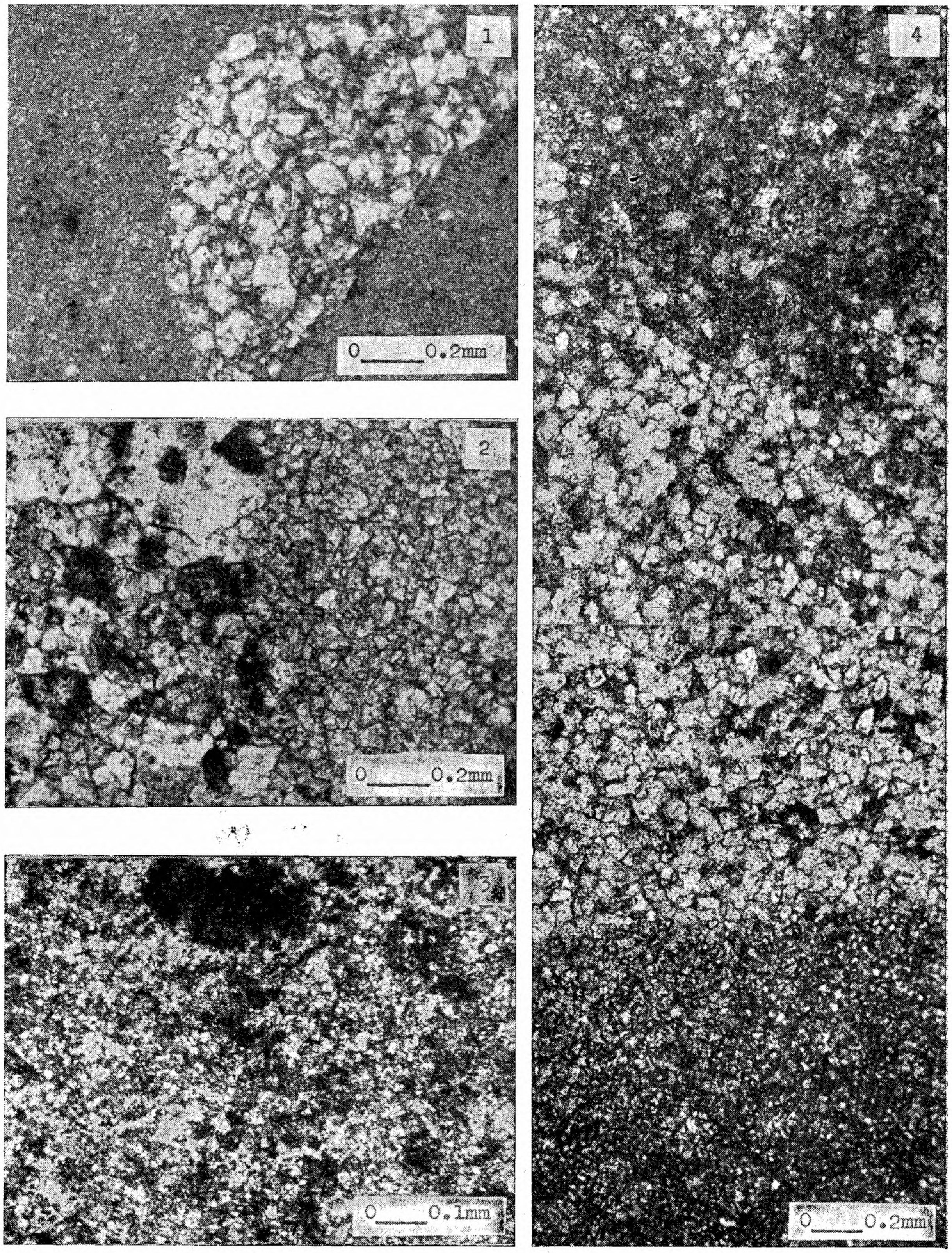

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