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Dissolution of halite within the Middle Miocene (Badenian) laminated gypsum of southern Poland

ABSTRACT: Breccias formed by early diagenetic dissolution of halite occur within the laminated Middle Miocene (Badenian) gypsum of southern Poland. The solution-collapse origin of the breccias is proved by the flat basal contact, the uneven top surface or their gradual transition into the overlying strata, the traces of halite within the breccias or in the adjacent strata, and the common microscale effects of collapse over the dissolved halite cystals. The dissolution took place within soft, water saturated and not fully consolidated, laminated gypsum, and led not only to the brecciation but to the complicated soft-sediment deformations as well. The dissolution produced the residual thin-grained gypsum or clay deposits within the halite-bearing horizons and, in many cases, the zone of the collapse breccias above. The most characteristic collapse breccias are composed of fragments or blocks of the laminated gypsum, practically without any matrix or cement. The horizontal flow or creep of slurry residual gypsum could take place directly on the sea bottom.

INTRODUCTION

Breccias, occurring within the Middle Miocene (Badenian) gypsum deposits in the northern margin of the Fore-Carpathian Depression (the Miechów Upland and the southern slopes of the Holy Cross Mts; Text-fig. 1), form an extremely large assemblage of lithologic and textural varieties (*see* ŁASZKIEWICZ 1957; KWIATKOWSKI 1970, 1972; OSMÓLSKI 1972). The breccias occupy the upper part of the gypsum section which attains about 60 m in thickness (*see* KWIATKOWSKI 1974; KUBICA 1983, 1985; BĄBEL 1984, 1987, 1992; BĄBEL & KASPRZYK 1990; KRYSIAK 1986; KASPRZYK 1990, 1991a, b) and are associated with thin-laminated gypsum composed of the grains as a rule less than 0.05 mm in size (KWIATKOWSKI 1970, 1972; NIEMCZYK 1988a). Most breccias have intraformational character. They are composed of angular or rounded fragments of laminated or homogeneous gypsum enclosed in the matrix of microcrystalline gypsum or clay. The breccias pass gradually into faint- or unlaminated gypsum, described as "alabaster" by KWIATKOWSKI (1970, 1972) or as "compact" or "massive gypsum" by some other authors (*see* KASPRZYK 1991b, p. 213). The horizons of the breccias reach more than several meters in thickness, in places even 15–20 m (*see* KWIATKOWSKI 1972, p. 23; KRYSIAK 1986, p. 88; KUBICA 1985) and are traced in the drill cores for dozen or so kilometers (Kubica 1983, 1985; Kasprzyk 1991a, b). Complicated soft-sediment deformations are ubiquitous within the discussed deposits (*see* Kwiatkowski 1972, Kubica 1985, Kasprzyk 1991b).

The origin of the discussed breccias and associated alabasters is not fully understood. Their the most detailed description and genetic interpretation was given by Kwiatkowski (1970, 1972), who considered both the breccias, alabasters and associated soft-sediment folds as formed by "liquefaction" of the fine-grained, laminated gypsum that took place directly on the sea bottom or beneath the sediment cover. In his opinion the instability of the density layering occurring in some parts of laminated gypsum deposits led to their brecciation and folding generated by shocks. "Liquefied" gypsum could rest *in situ* or flow horizontally both under the cover of overlying strata and directly on the sea floor. Such flowing "liquefied" sediments were deposited by "freezing". Kwiatkowski (1972) believed that some breccias were also transported and deposited by a water current. Other authors described the breccias as products of redeposition of gypsum sediments crushed by subaerial desiccation or eroded by strong water currents (*see* reviews *in* Kwiatkowski 1972, p. 23; *and* Kubica 1985, p. 39). However, the features typical of deposition of the gypsum grains by such currents are relatively scarse (*see* Pl. 3, Fig. 1 *and* Kwiatkowski 1966, Kasprzyk 1991a). The "flow structures" (*see* Pawłowska 1962, Kubica 1985) and features indicating the deposition of the breccias and "alabasters" by "freezing" are frequent (Kwiatkowski 1970, 1972).

The layers of breccias and alabasters formed by process of redeposition described by Kwiatkowski (1970, 1972), according to the modern theories of transport of the clastic materials, can generally be regarded as *sediment gravity flow deposits* (*see e. g.* Lowe 1982). Some folds from the

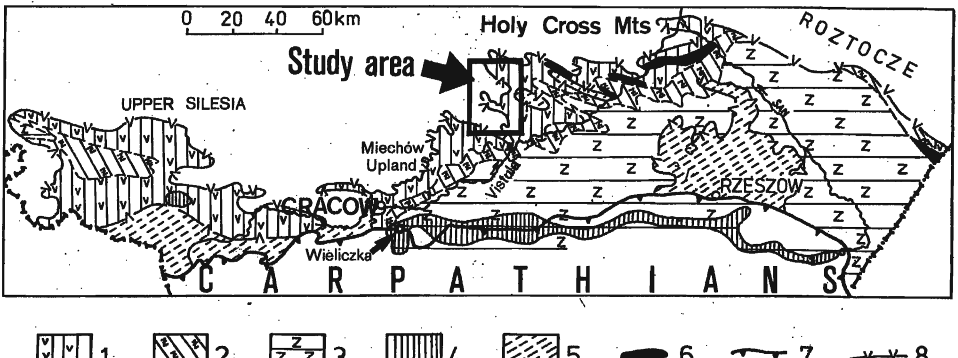


Fig. 1. Middle Miocene (Badenian) evaporites of the Fore-Carpathian Depression in southern Poland (*according to* Garlicki 1979, *and* Pawłowski & *al.* 1987; *modified*)

1 — gypsum deposits, 2 — gypsum and anhydrite deposits, 3 — anhydrite deposits, 4 — salt deposits, 5 — areas without chemical deposits, 6 — post-sulfate native sulfur deposits, 7 — Carpathian overthrust, 8 — extent of chemical deposits

laminated gypsum represent apparent *slump deposits* (*see* Pl. 5, Figs 1–2 *and* KWIATKOWSKI 1970, 1972; KASPRZYK 1991b). Detailed recognition of the mechanism of "liquefaction", transport and deposition of considered gypsum deposits (*see* Pl. 3, Figs 1–2; Pl. 5, Fig. 1), and thus genetic kind of the gravity flows, needs further investigations. Descriptions of KWIATKOWSKI (1972), as well as Author's observations, indicate that *cohesive debris flow deposits* (*sensu* LOWE 1982) can be distinguished within the gypsum breccias and alabasters (*see* KASPRZYK 1991b). KASPRZYK (1991a, b) recognized gypsum *turbidity current deposits* in some core materials.

There are also other explanations of the origin of some types of the discussed breccias. They were regarded as formed by the washing out and dissolution of laminated gypsum by circulating ground waters (BOLEWSKI 1935, pp. 252–253), the collapse of the roofs of karst chambers (NIELUBOWICZ 1961, 1973), the selective leaching (KRYSIAK 1986, p. 86), the weathering phenomena (KWIATKOWSKI 1972, p. 23; WALA 1979; KASPRZYK 1991a), the gypsification of anhydrite (NIELUBOWICZ 1973), the tectonic shocks acting on soft sediments (KRYSIAK 1986; KWIĄTKOWSKI 1972, p. 21) and/or the tectonic crushing of lithified gypsum rocks (KRYSIAK 1986, KASPRZYK 1991a).

Fig. 2. Location of studied sections of the Middle Miocene (Badenian) Nida Gypsum deposits (*black*) exposed at the surface (*according to* FLIS 1954; *simplified*)

Thirty years ago KOWALEWSKI (1957, p. 115) noted that the considered breccias could originate by the dissolution of halitic intercalations and the following foundering of the overlying gypsum sediments; he recognized such *solution-collapse breccias* (*see* terminological remarks *in* PARK & JONES 1985) in some core materials from the northern margin of the Fore-Carpathian Depression. Some authors, before 1957, believed that the halite deposits adequate to the Wieliczka ones of the southern margin of the Fore-Carpathian Depression could be found in its opposite, northern margin (*see* Text-fig. 1; *and* KOSIŃSKI 1884), but until 1957, any traces of halite were not observed within the evaporitic deposits of that area. According to NOWAK (1938, p. 165), gypsum sections in the northern margin of the Depression are reduced due to complete leaching out of halitic intercalations.

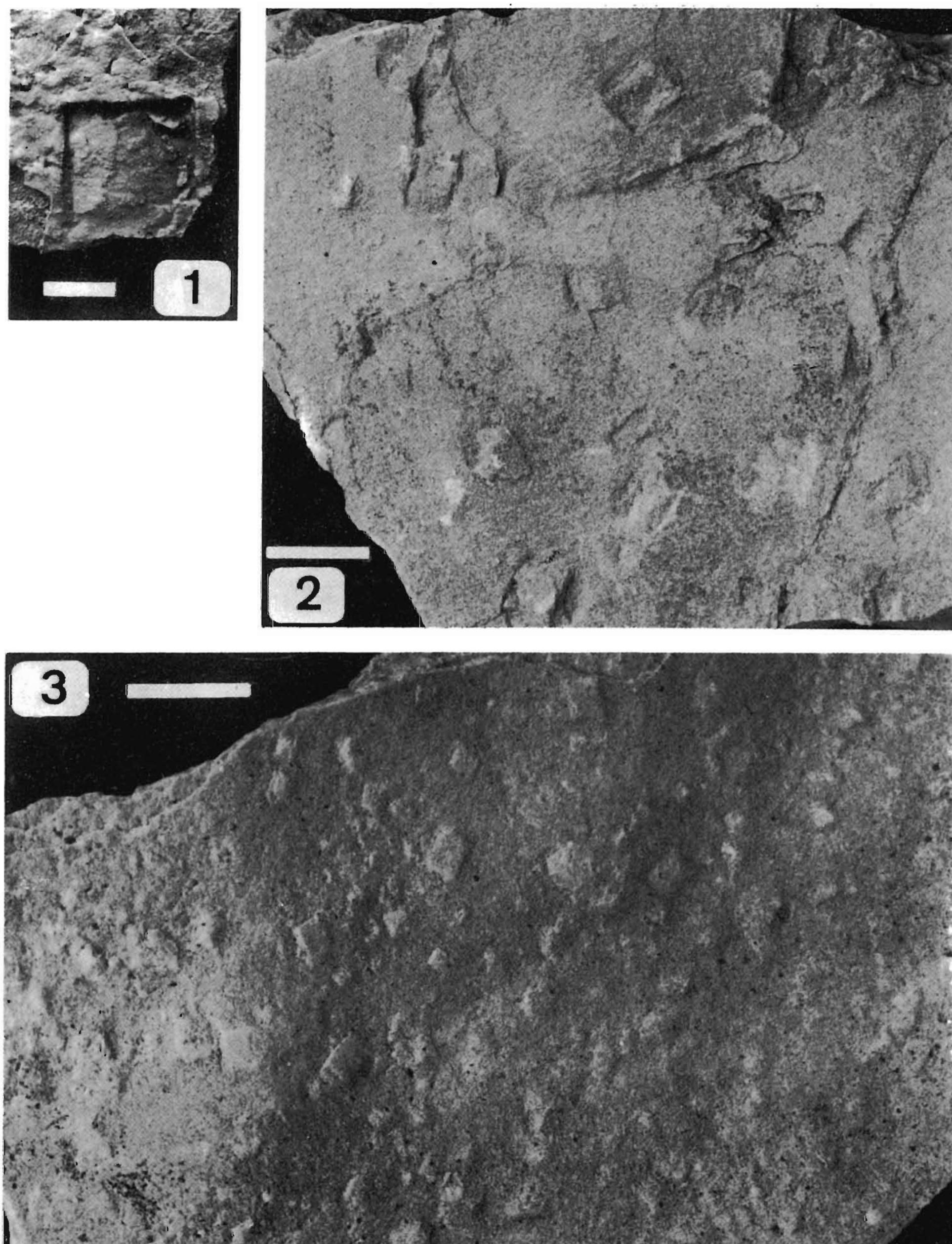
Since the publication of KOWALEWSKI (1957) none of the subsequent authors has supported his opinion about solution-collapse origin of the breccias. However, many persons recognized gypsum pseudomorphs after halite crystals within discussed deposits (KWIATKOWSKI 1972; BĄBEL 1984, 1987; NIEMCZYK 1988a, c; KASPRZYK 1991a).

The present Author found evident breccias formed by dissolution of halite at the newly opened quarry at Borków (*see* Text-fig. 2). This finding fully supports the former interpretation of KOWALEWSKI (1957) and throws a new light on the origin of the other breccias, alabasters, and soft-sediment deformations in the laminated gypsum. The supposition has risen that they are the products of something which disappeared — the halite.

In this paper the view of KOWALEWSKI (1957) is fully accepted and supplemented. The solution-collapse breccias from Borków are described as well as examples of the similar breccias from other outcrops. A new interpretation of some types of alabasters and soft-sediment deformations common within the laminated gypsum is offered.

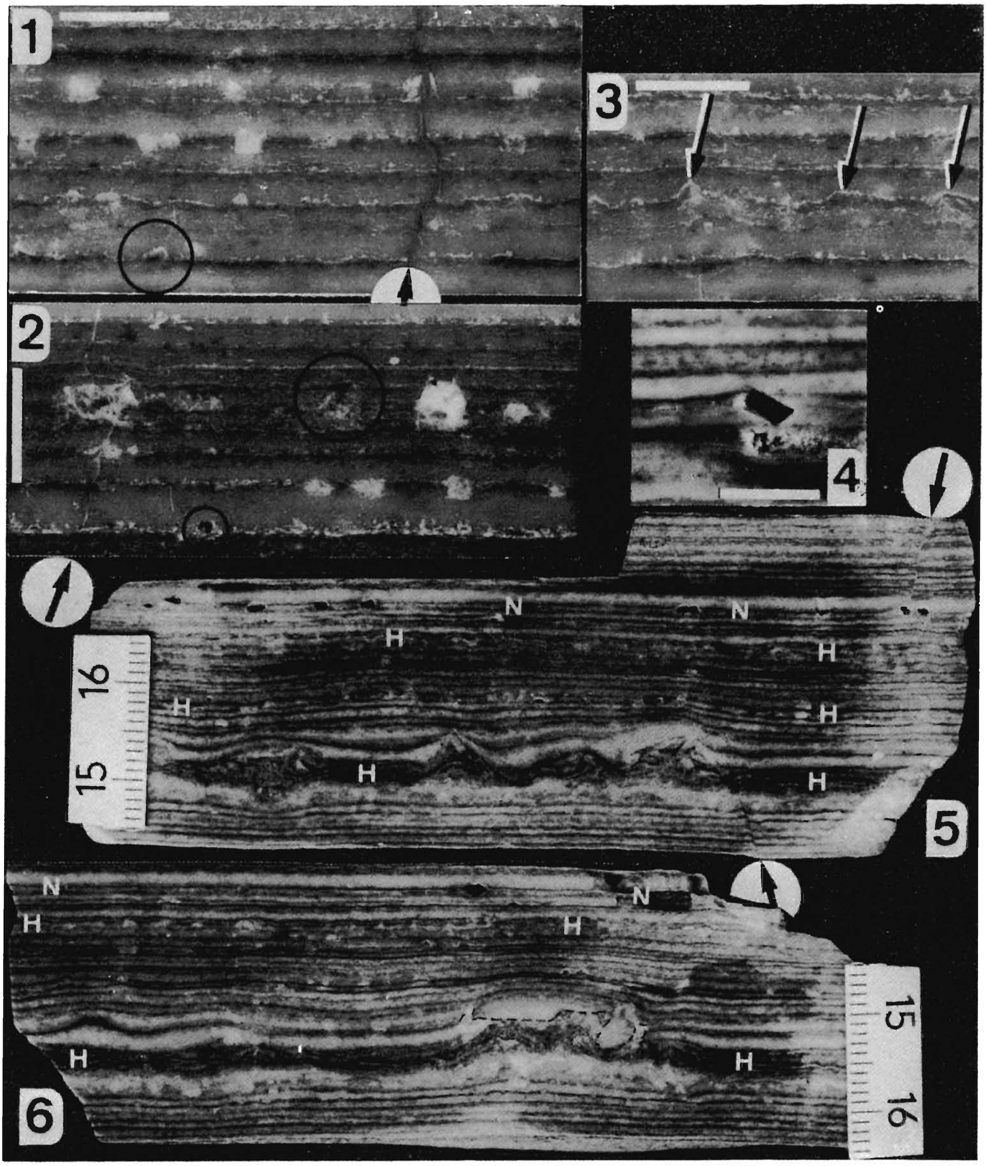
The Author's observations were carried on in the outcrops of the Nida Gypsum deposits, in the largest exposed area of the Middle Miocene (Badenian) evaporites in Poland, especially in the three large gypsum quarries: Gacki (now abandoned), Leszcze, and Borków (*see* Text-figs 1–2). Except of those quarries, the laminated gypsum and the associated rocks described in this paper are exposed in the following places or areas: Marynka-Oględówek, Sędziejowice, Gartatowice, Szaniec, Siesławice-Chotelek, Wola Zagojska, Skorocice-Łatanice, Hołudza, Bilczów, Chotel Czerwony, Aleksandrów, Sielec, Gorysławice-Górki (*see* Text-fig. 2).

The presented material comes from the upper part of the gypsum section, which is very difficult to detailed lithostratigraphic correlation. The Author uses the following designations of the gypsum layers. In the lower part of the section the layers are lettered from (**a**) to (**l**) according to WALA (1963, 1979), only with slight modifications (*see* Text-fig. 3; *and* BĄBEL 1984, Fig. 1; 1992). The layer (**m**) is distinguished according to the same criteria as the lithotype *F* of KUBICA (1985, p. 41), *i.e.* it represents mainly the sabre-like gypsum. This layer occurs at Borków, and only locally at Gacki, Uników, and Gartatowice (*see* WALA 1979).



1–3 — Imprints of halite cubes on surfaces of gypsum laminae; Gacki Quarry, above layer (j) (Figs 1–2), and Borków Quarry, 7.5 m above layer (m) (Fig. 3), scale bars = 1 cm

Photos by K. Zielińska (Fig. 1) and S. Ulatowski (Figs 2–3)



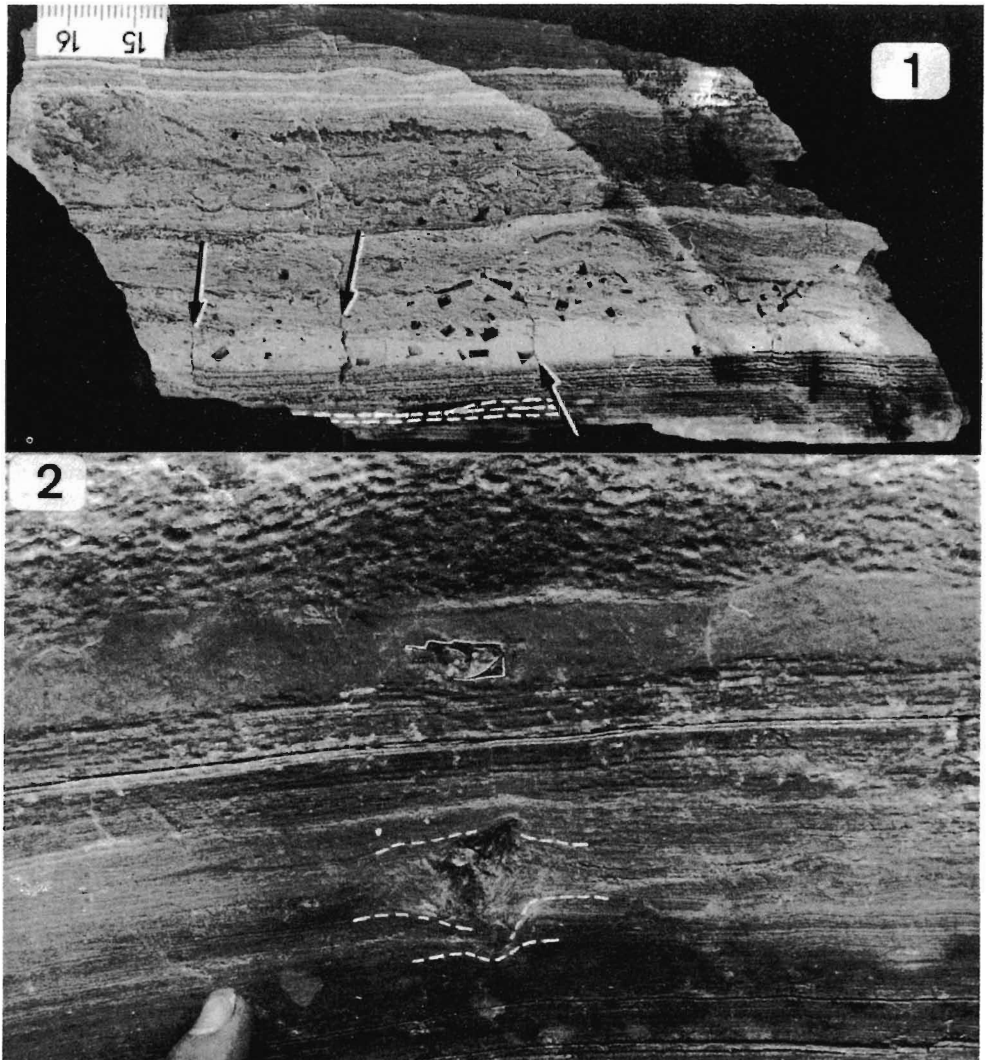
1-2 — Molds of halite crystals in laminated gypsum mud, filled with either thin (*light*) or coarse gypsum crystals (*dark, cricled*); vertical microfaults or fractures crossing the molds are visible (*arrowed*)

3 — Traces of dissolved halite crystals obliterated by subsidence of overlying gypsum mud (*arrowed*)

4 — Negative halite crystal deformed by compaction of surrounding laminated gypsum mud

5-6 — Traces of dissolved halite crystals obliterated by subsidence of overlying gypsum mud (laminae marked H), and negative halite crystals deformed by compaction (laminae marked N); microfaults are indicated by arrows in Fig. 5 (*top and bottom right*)

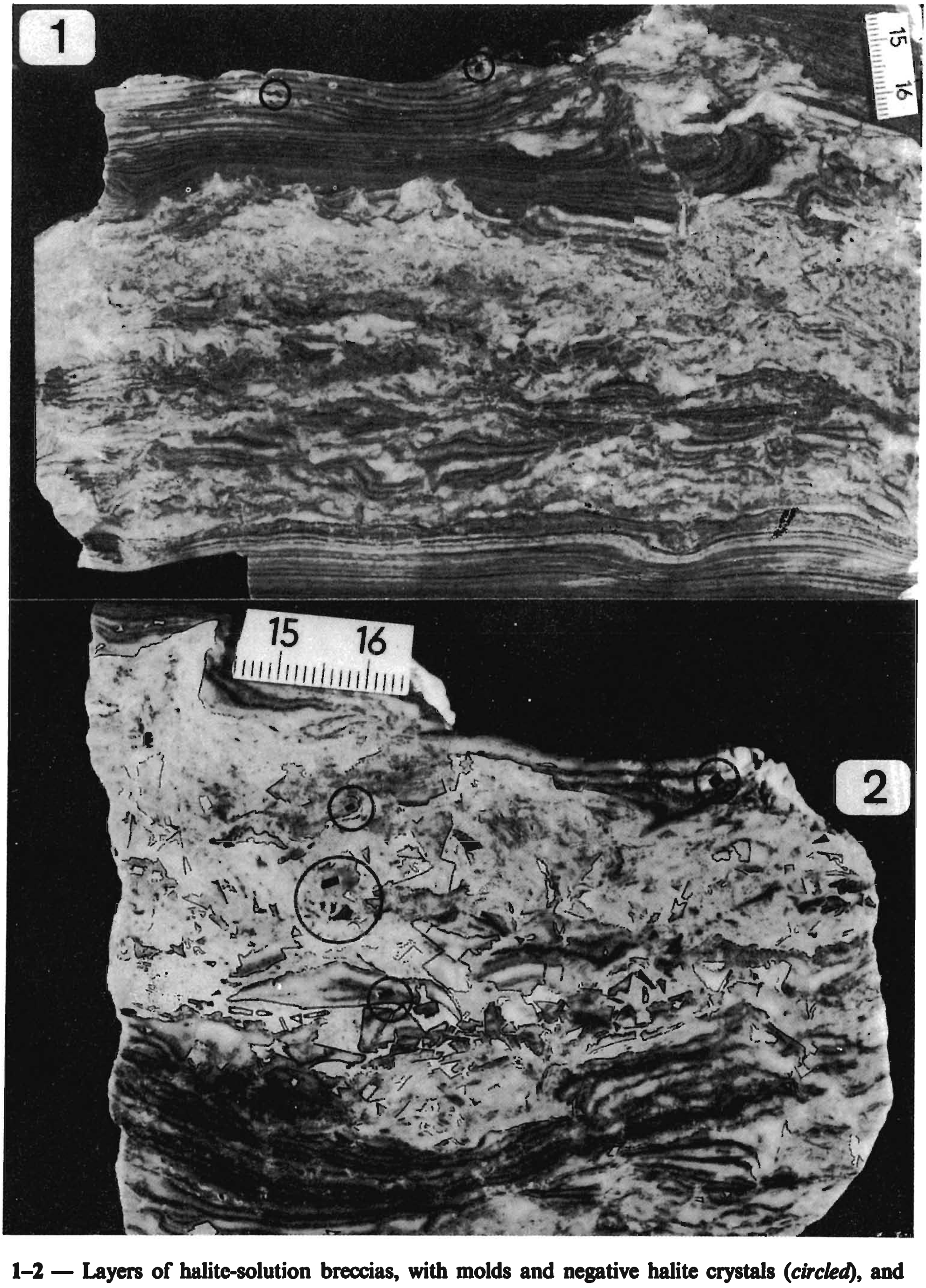
Gacki Quarry, above layer (l) (Figs 1-3) and Borków Quarry, above layer (m) (Figs 4-6); scale bars in Figs 1-4 equal 0.5 cm; photos by S. ULATOWSKI



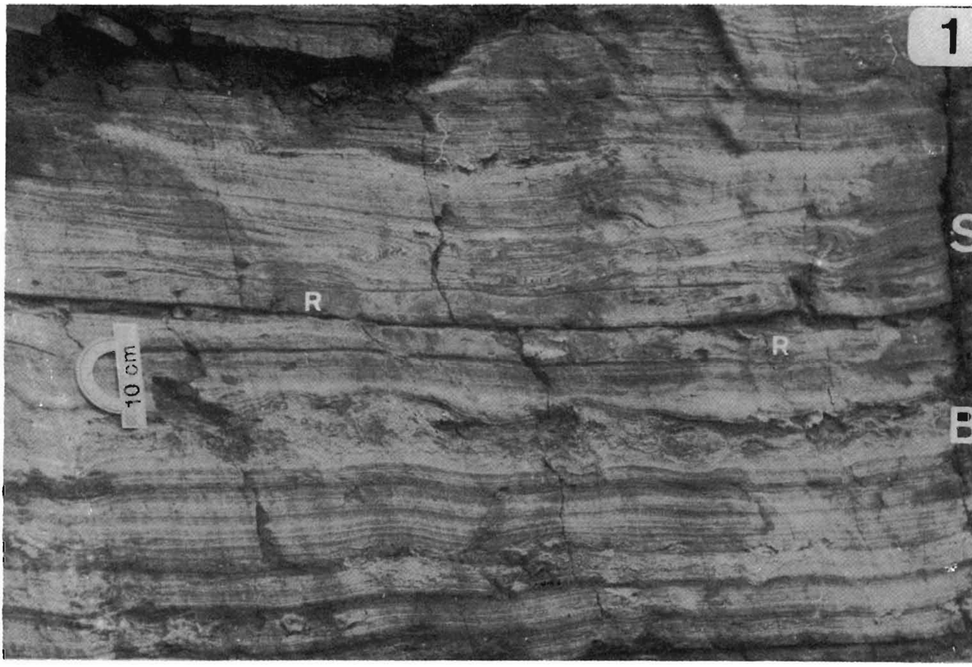
1 — Redeposited gypsum-calcite mud with molds of halite crystals filled with coarse gypsum crystals (*dark*); note the presence of a wash-out surface within laminated gypsum (*outlined*) and vertical fractures, filled with coarse gypsum crystals (*arrowed*); water-etched sample, light parts are enriched in calcite

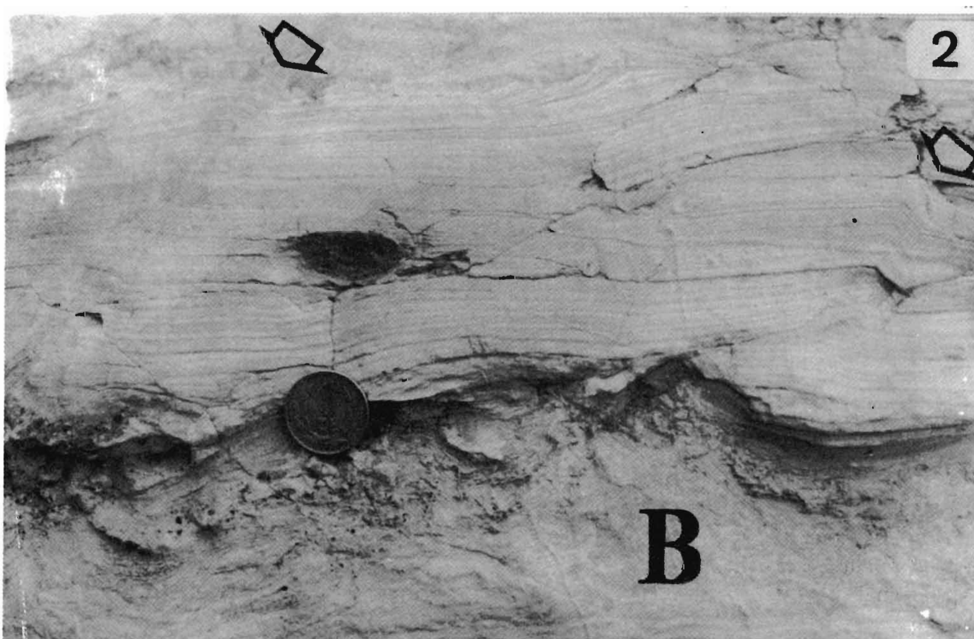
2 — Trace of dissolved halite crystal (*lower center*) obliterated by irruption of surrounding laminated gypsum; bent laminae beneath the trace probably represent load structure; clast (*upper center*) within redeposited gypsum mud shows post-halite rectangular shape

Leszcze Quarry, 2–5 m above layer (f); photo in Fig. 1 by S. ULATOWSKI

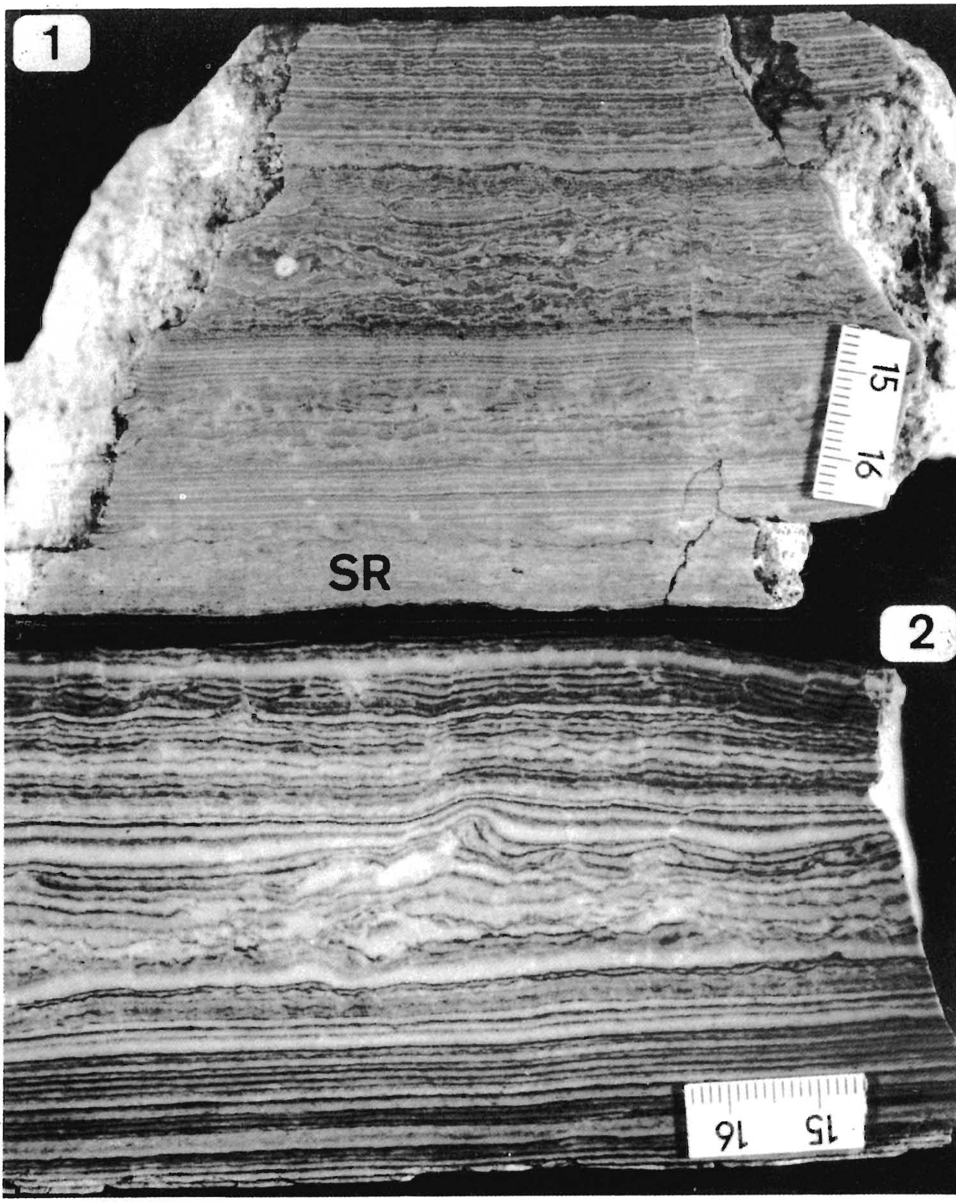


1–2 — Layers of halite-solution breccias, with molds and negative halite crystals (*circled*), and solution-subsidence and solution-collapse deformations of laminated gypsum; Borków Quarry, 0.5–2 m above layer (m); photos by S. ULATOWSKI

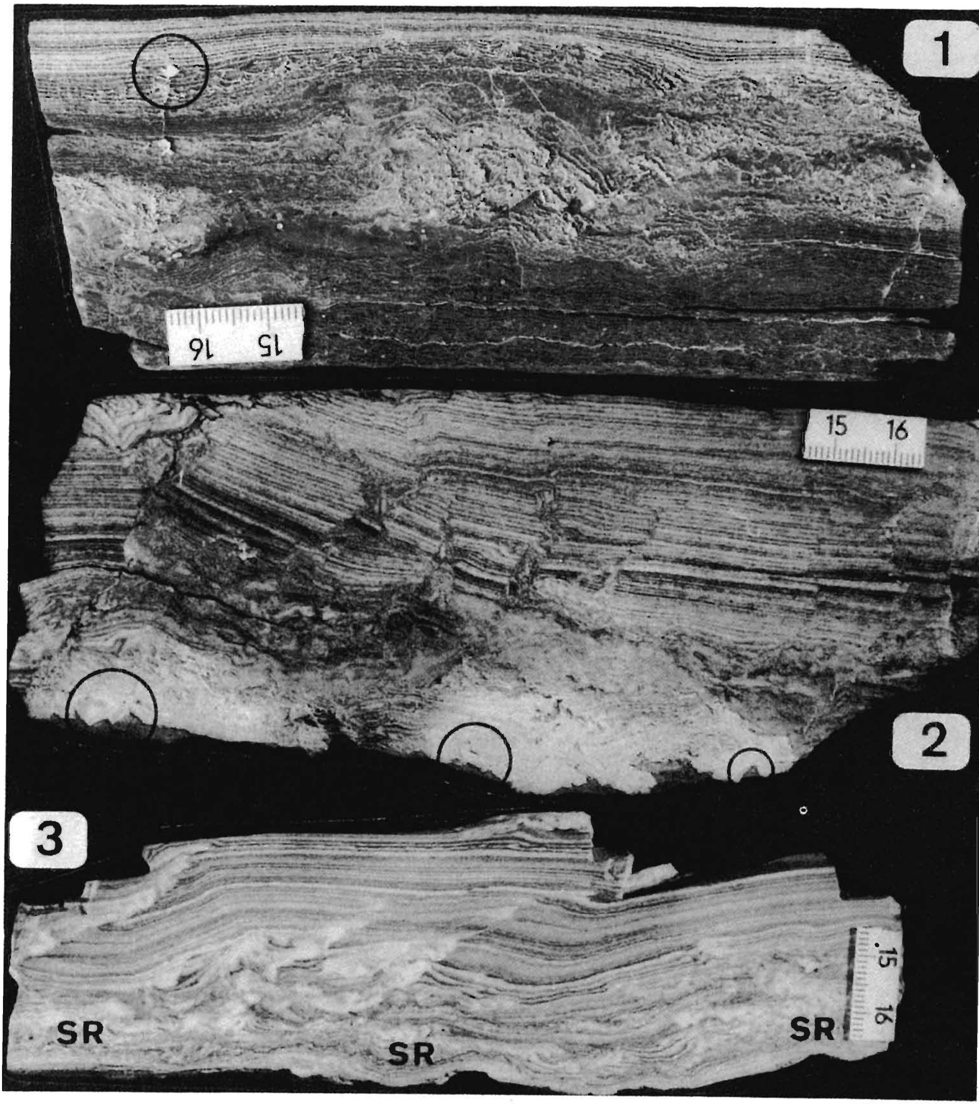




1–2 — Laminated gypsum with layers of halite-solution-callapse breccias (marked B), with flat base and wavy top surfaces, and layers of redeposited gypsum mud (marked R in Fig. 1); slump folds (Fig. 1) are indicated by S, kink folds (Fig. 2) are arrowed; note microfaults, and dark limonitic nodule (in Fig. 2; over the coin, 2.5 cm in diameter); Gacki Quarry, northern wall, 1–5 m above layer (f)



1–2 — Halite-solution-collapse microbreccias, solution-subsidence deformations and residual gypsum mud (marked SR in Fig. 1) within laminated gypsum; Gacki Quarry, above layer (j) (Fig. 1; the same laminae as in Pl. 22, Fig. 2), and Borków Quarry, above layer (m) (Fig. 2); photos by S. ULATOWSKI

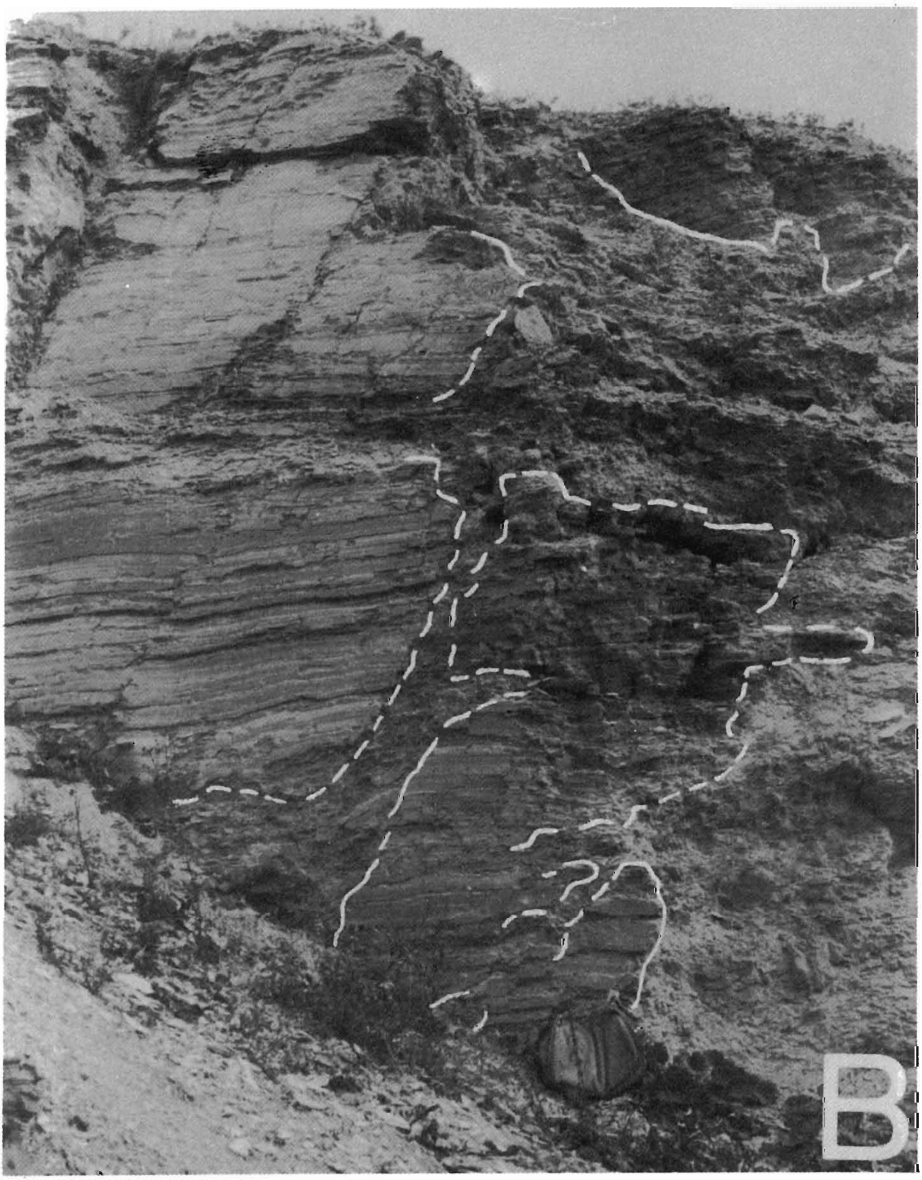


1 — Laminated gypsum brecciated, deformed and homogenized by dissolution of intercalated halite; water-etched surface, light protruding parts represent calcite; calcitized halite cube crossed by microfault is circled; Gacki Quarry, above layer (l)

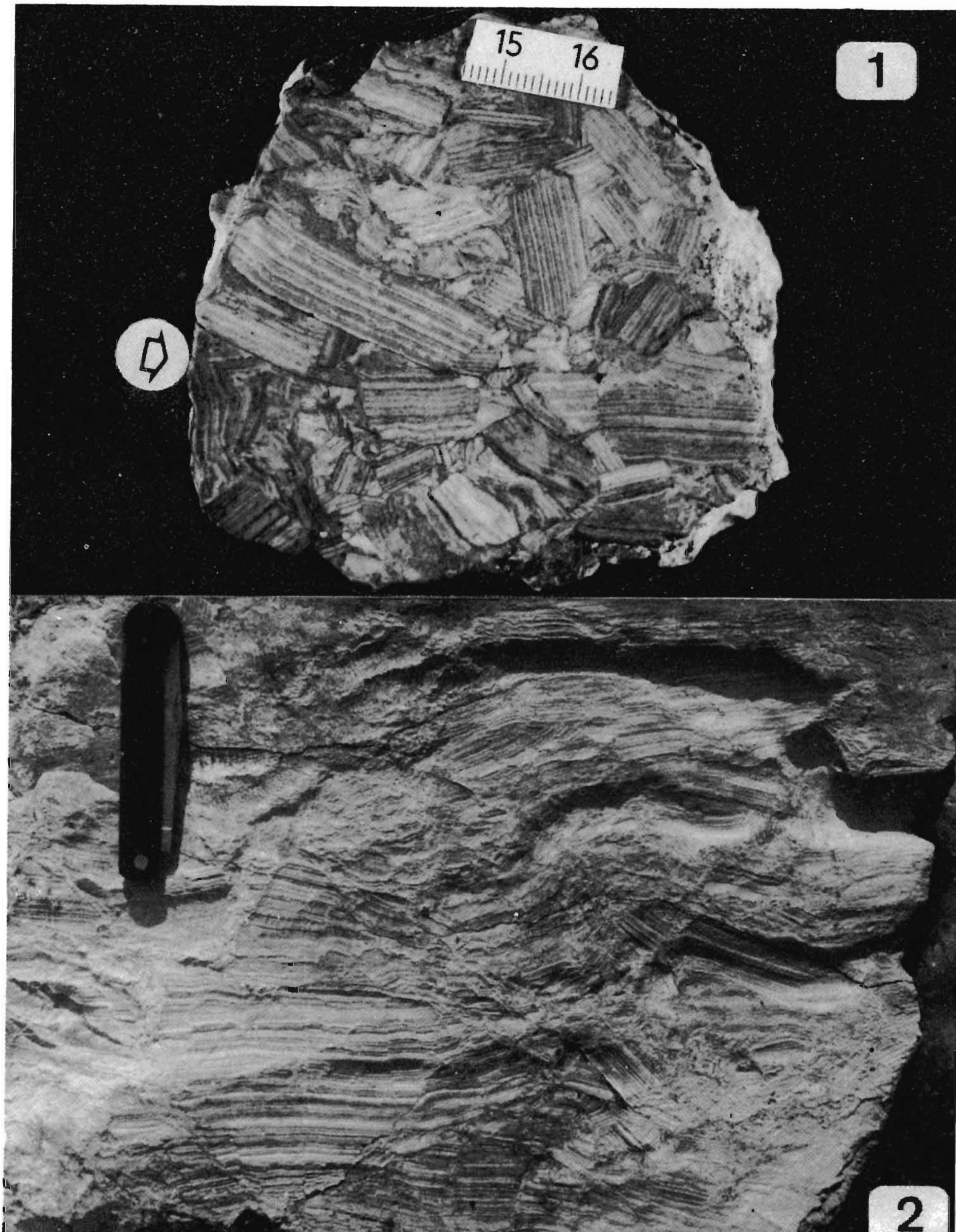
2 — Solution-collapse breccia showing folded clasts of laminated gypsum (*top left*) and angular traces of halite crystals (*circled*) revealed by etching in lower part, locally calcitized (*light areas*); Leszcze Quarry, several meters above layer (l); top of the sample was covered by flat undisturbed laminae

3 — Laminated gypsum with load structures and overthrusts developed above residuum after dissolved halite (marked SR); Borków Quarry, above layer (m)

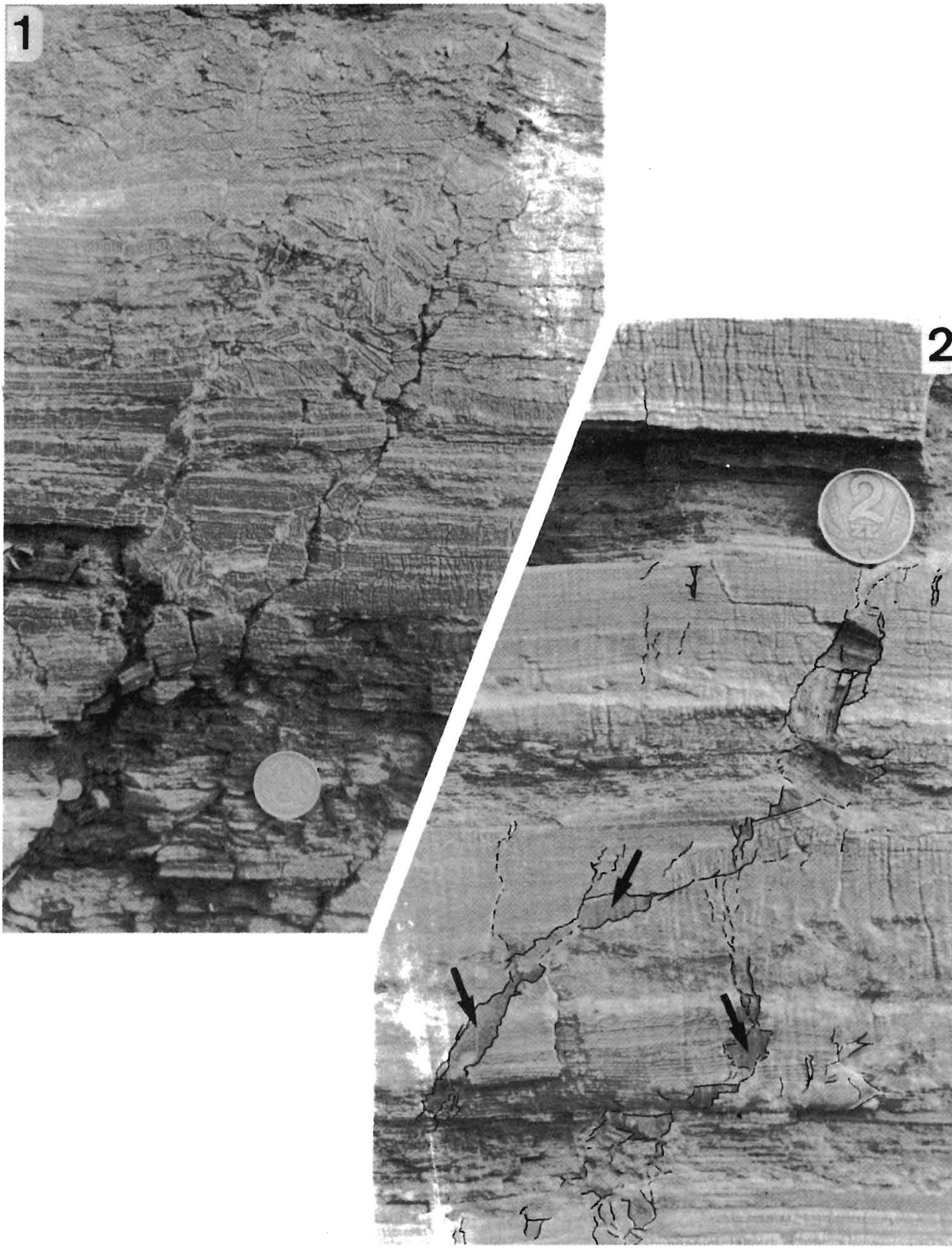
Photos by S. Ulatowski



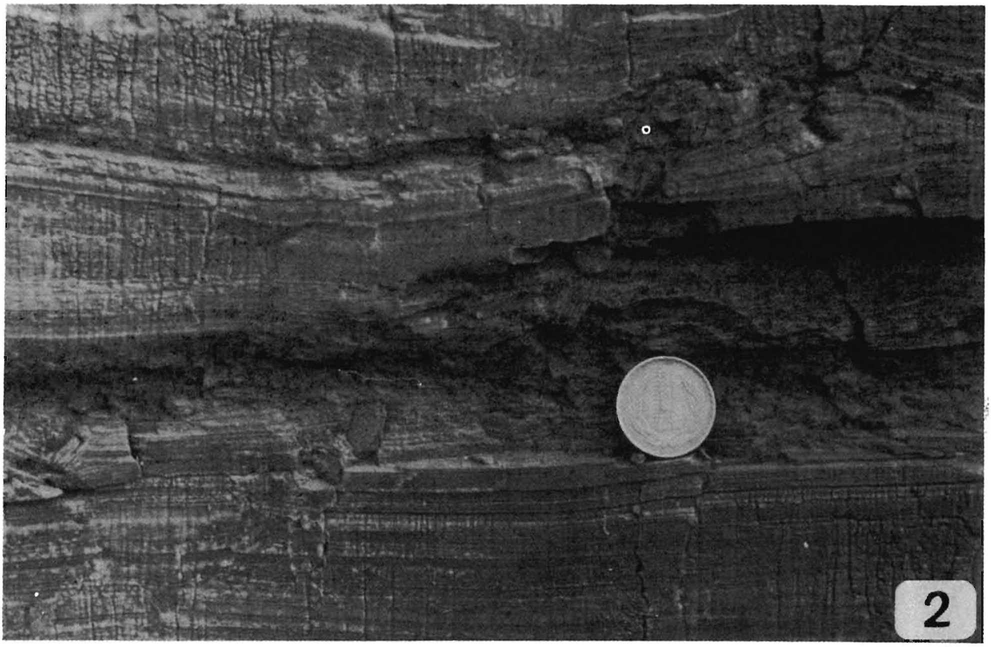
Side and roof parts of collapse breccia chimney (**B**, *outlined*) showing collapsing blocks of laminated gypsum (*see* Pl. 9, Fig. 1 and Plates 10–11 for details); Gacki Quarry, east wall (unexisted part), above layer (I)



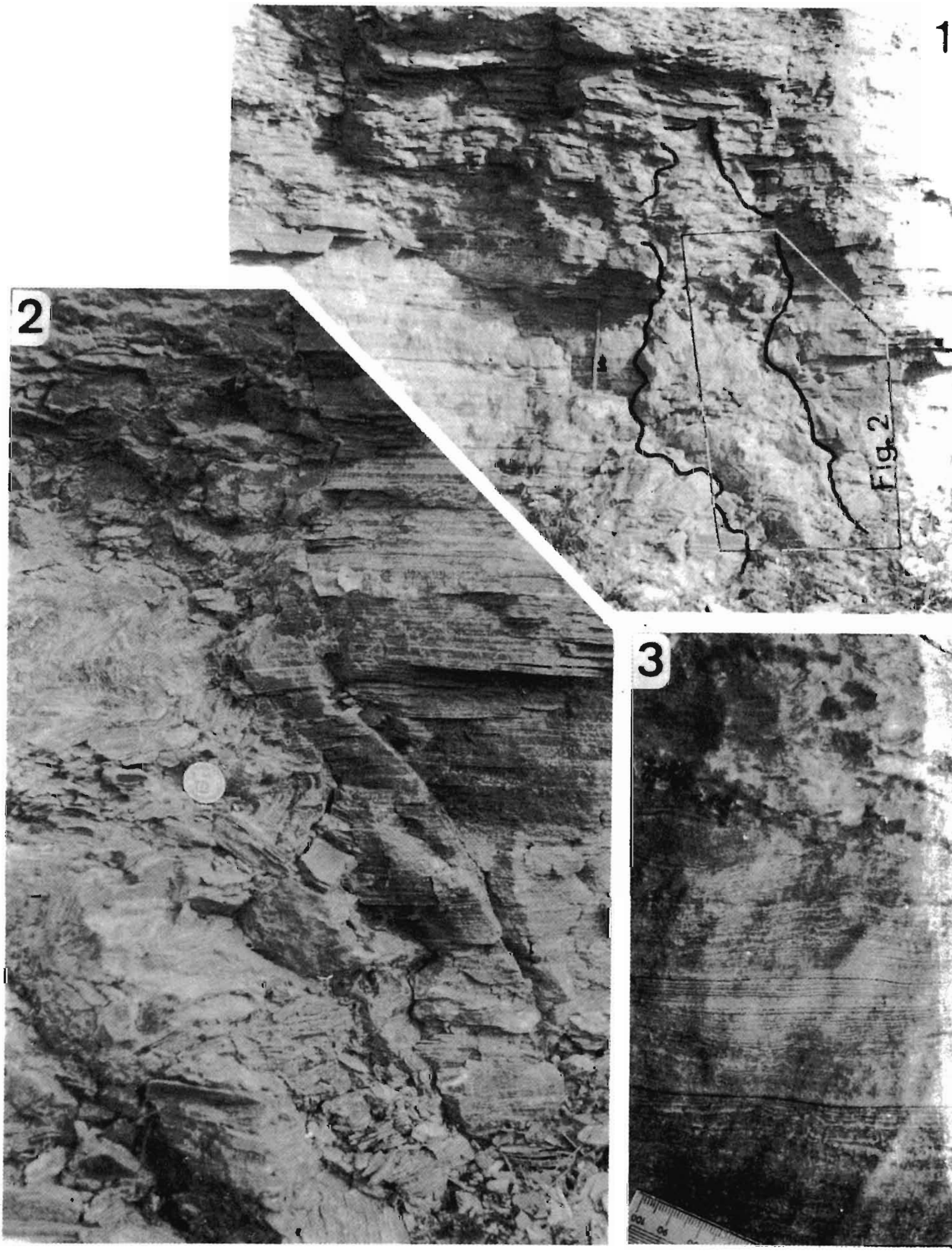
1–2 — Collapse breccias of laminated gypsum showing folded clasts (*arrowed* in Fig. 1); Gacki Quarry, sample in Fig. 1 is taken from breccia chimney marked **B** in Pl. 8, base-top direction in Fig. 2 is unknown; photo in Fig. 1 by S. ULATOWSKI



1–2 — Collapse breccias of laminated gypsum with fractures filled with homogeneous gypsum mud (*arrowed*) and clasts of laminated gypsum torn- and sucked-out of their walls; details of exposure shown in Pl. 8 (*left*); diameter of coin = 2.5 cm (Fig. 1) and = 2.1 cm (Fig. 2)



1–2 — Collapse breccias of laminated gypsum with fractures filled with homogeneous gypsum mud (*arrowed*) and clasts of laminated gypsum torn- and sucked-out of their walls; details of exposure shown in Pl. 8 (*left*); diameter of coin = 2.1 cm (Fig. 1) and = 2.5 cm (Fig. 2)



1-2 — Vein of collapse breccia (*outlined*) in laminated gypsum; Górki, diameter of coin = 2.4 cm in Fig. 2 showing detail of Fig. 1

3 — Flat laminated gypsum intercalated with deformed, homogenized gypsum representing residuum after dissolution of halite; Leszcze Quarry, several meters above layer (I)

The upper part of the section above the layer (l) at Leszcze and Gacki, and above the layer (m) at Borków remains undesignated (*see* Text-fig. 3). The location of samples from this part of the section is given in relation to the designated layers lying below.

TRACES OF HALITE IN LAMINATED GYPSUM

Gypsum pseudomorphs after single halite crystals were described from the laminated gypsum by KWIATKOWSKI (1972), NIEMCZYK (1988a) and KASPRZYK (1991a). The Author noted them in the layers (k), (l), and in many places above the layer (l) at Gacki and Leszcze (*see* WALA 1979; BĄBEL 1984, Fig. 1) and above the layer (m) at Borków (*see* Text-fig. 3). At Gacki and Leszcze they are especially numerous and well preserved within the laminated gypsum above the layer (l).

The formerly existed halite is recognizable as imprints, molds (*see* KWIATKOWSKI 1972, NIEMCZYK 1988a), negative crystals and traces after dissolved crystals, obliterated by subsidence of the overlying gypsum.

The imprints are noticeable on the surfaces of lamination as square, rectangular or, rarely, triangular forms, usually less than 5 mm long (*see* Pl. 1, Figs 1–3; *and* KWIATKOWSKI 1972, NIEMCZYK 1988a). The largest imprint found by the Author is 1.8 × 2.0 cm in size (*see* Pl. 1, Fig. 1). The shape of the imprints indicates that most halite crystals laid with the 100 form parallelly to lamination. The imprints occur in the relatively flat laminated gypsum showing exact continuity of laminae. They are hardly noticed in sections perpendicular to lamination. Traces of collapsing are not observed above the imprints. The laminae above them are neither disrupted nor significantly thinned. There are two possible explanations of those features. The halite crystals which laid on the surfaces of lamination were very flat or they were dissolved before the deposition of the overlying gypsum laminae. The cubic halite molds with destroyed upper parts were described by KWIATKOWSKI (1972, Fig. 13) as traces of halite crystals partly dissolved by bottom water before their burial.

The well preserved molds of halite cubes occur especially within the relatively thick and flat laminated gypsum (*see* Pl. 2, Figs 1–2). The molds, chaotically arranged, are also observed within some redeposited-gypsum layers (*see* Pl. 3, Fig. 1). The molds are filled with microcrystalline gypsum more whitish than the surrounding one, with large, transparent gypsum crystals or, sporadically, with microcrystalline calcite (*see* Pl. 7, Fig. 1). In some redeposited-gypsum layers, the clasts show rectangular shapes, probably being the relic of the negative halite crystals (*see* Pl. 3, Fig. 2).

The negative halite crystals occur at Borków above the layer (m) (*see* Pl. 2, Figs 4–6; Pl. 4, Figs 1–2). The drusy gypsum cement, composed of the lenticular crystals, was observed in some of them. The negative crystals are flattened parallelly to lamination. Some of them are deformed in such a way that they resemble rhombohedrons (*see* Pl. 2, Figs 4–5). The flattening evidently is due to compaction. It is obvious that the dissolution of halite in this case took place before the compaction, in consolidated but not fully lithified gypsum sediments.

The traces of dissolved single halite crystals obliterated by the subsidence or collapse of the overlying material are more frequent than well preserved pseudomorphs. The effects of collapse or subsidence are well visible in sections perpendicular to lamination and they display a large number of forms (*see* Pl. 2, Figs 2–3, 5–6; Pl. 3, Fig. 2; Pl. 6, Figs 1–2; Pl. 7, Fig. 1; Pl. 22, Figs 2–3). The laminae are disturbed, thinned or disrupted in places previously occupied by the halite crystals. Many laminae are bent upwardly in the place of disruption and create there a small-scale diapir-, tepee-, or flame-like structure. Such a shape is the most common form of disturbance and is quite different from halite pseudomorphs deformed by irruption of the surrounding material and compaction recorded by

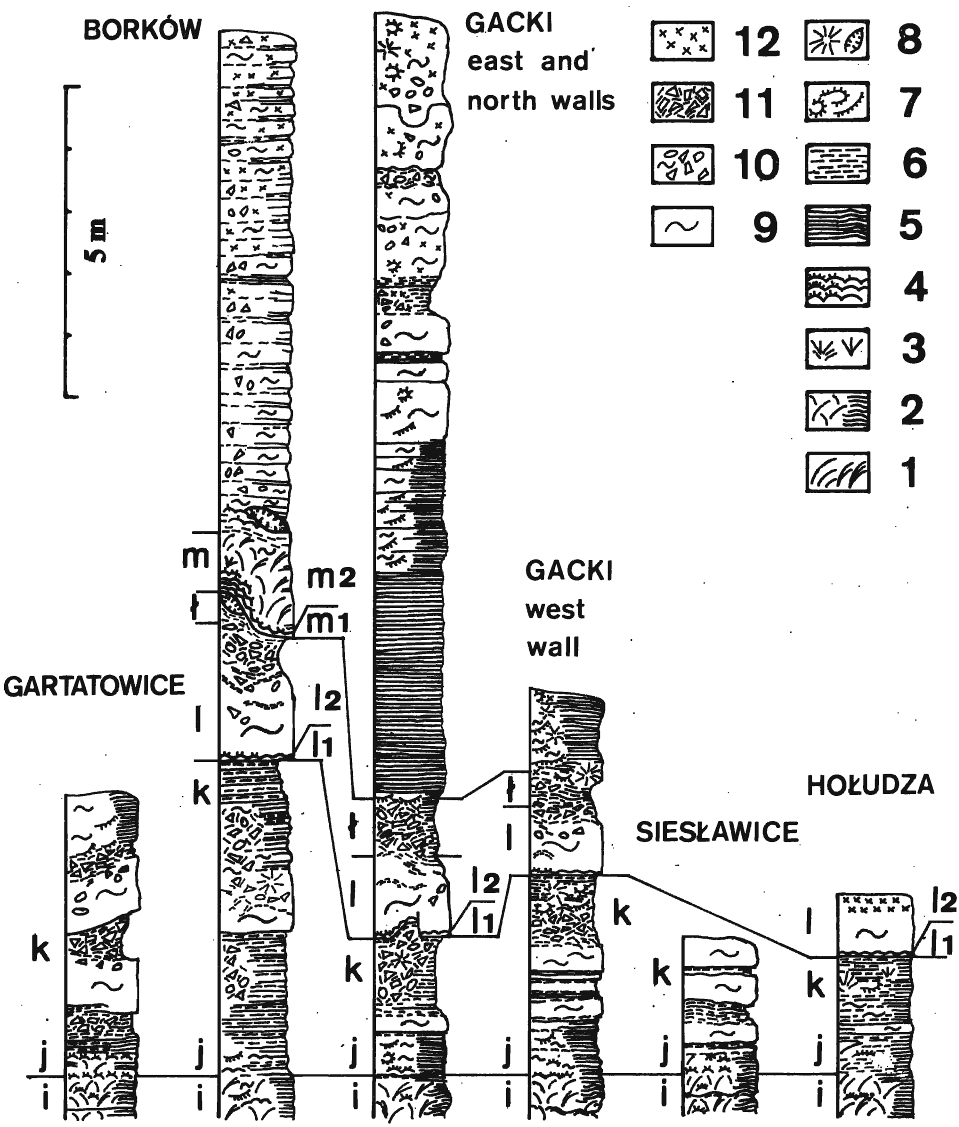


Fig. 3. Sections and lithostratigraphic correlation of the upper part of the Middle Miocene (Badenian) Nida Gypsum deposits; the layers are lettered *according to* WALA (1979; *modified and supplemented*)

1 — sabre-like gypsum crystals (*left*) and their aggregates (*right*), 2 — sabre-like gypsum crystals enclosed within the laminated gypsum, 3 — clustered aggregates of gypsum crystals resembling tufts, 4 — laminated gypsum domes (*right*) covered with rows of gypsum crystals (*left*), 5 — flat (*left*) and wavy laminated gypsum, 6 — clay and clay-bearing gypsum, 7 — arcuate and elliptical aggregates of gypsum crystals (*see* KWIATKOWSKI 1972), 8 — radial (*left*) and geode-like aggregates of gypsum crystals (*right*), 9 — banded alabasters, spotted alabasters, and alabasters with relic lamination (*see* KWIATKOWSKI 1972), 10 — gypsum breccias with alabaster matrix, 11 — gypsum breccias with clay matrix, 12 — gypsum porphyroblasts

many authors (*see* HAUDE 1970). This shape results from the subsidence or collapse of the gypsum laminae which coated sides and tops of the halite crystals "standing" erected on the flat bottom. The shape of deformational structures depends on the size of dissolved crystals. The dissolution of large crystals led to the more complicated deformations (*see* Pl. 2, Figs 5–6; Pl. 3, Fig 2). Some laminae are bent beneath the spots after halite crystals and it seems that these bendings represent the load structures developed due to the weight of halite (*see* Pl. 3, Fig. 2; Pl. 4, Fig. 1; *and* KWIATKOWSKI 1972, Fig. 13; NIEMCZYK 1988a, Fig. 3). Since in most cases the gypsum deposit covering the halite crystals entirely fills the empty space remained after their dissolution, it is evident that the dissolution took place within the loose, soft and unconsolidated, or only partly consolidated gypsum sediments.

The halite crystals, lying on the bottom usually with the 100 face parallel to the depositional surface, grew separately, but it seems that in some spots they formed clusters of several crystals (*see* Pl. 2, Fig. 6). The traces of halite crystals occurring very densely in some levels indicate that in some places the crystals could create continuous laminae or even thicker layers of salt, as KOWALEWSKI (1957) suspected. It is highly possible that the halite-gypsum or halite-gypsum-clay laminites were deposited primarily in the Middle Miocene (Badenian) evaporitic basin in the northern margin of the Fore-Carpathian Depression.

The halite-bearing deposits adequate to the studied ones are preserved in the southern margin of the Fore-Carpathian Depression (*see* Text-fig. 1). A good analogue of halite-gypsum laminites seems to be the halite-anhydrite laminites occurring there within the same Badenian evaporites (*see* GARLICKI 1979, 1980). In the southern margin of the Depression, in the Badenian evaporites of the Wieliczka salt mine (*see* Text-fig. 1), the clusters of halite crystals, perhaps similar to the supposed dissolved ones, were described by PAWLIKOWSKI (1978). The halite clusters grew directly on the bottom on the surface of the laminated anhydrite-bearing mud and reached up to 1 m in size. The mud was pushed downward and squeezed under the weight of the growing halite (*see* PAWLIKOWSKI 1978, Phot. 9) in similar way as beneath some traces of halite crystals studied by the Author (*see* Pl. 3, Fig. 2; Pl. 4, Fig. 1).

SOLUTION-COLLAPSE BRECCIAS

The breccias showing very apparent features of the origin by dissolution of halite were found by the Author at Borków in the part of the section lying directly above the layer (**m**) (*see* Text-figs 2–3). They form at least several 1–15 cm thick layers placed within the laminated gypsum. The layers have flat base surfaces and uneven, wavy, frequently obliterated tops (*see* Pl. 4, Figs 1–2; Pl. 7, Fig. 3). Such a geometry of the breccia bodies is a very characteristic feature of the dissolution breccias (*see* MIDDLETON 1961; BEALES & OLDERSHAW 1966; STANTON 1966, 1978; BOGACZ, DŻUŁYŃSKI & HARAŃCZYK 1970; SASS-GUSTKIEWICZ, DŻUŁYŃSKI & RIDGE 1982; MAMET & *al.* 1986; SWENNEN, VIAENE & CORNELISSEN 1990).

Numerous load structures and microfaults occur along the top surface of the layers indicating the subsidence or collapse of the overlying material. The layers are composed of the fragments of the gypsum laminae placed within the white, thin-grained gypsum matrix. The laminae show soft-sediment deformations — folds, crenulations, microfaults, disruptions, etc. The boundaries between the fragments of laminae and the matrix are frequently unclear and obliterated. Many fragments show angular shapes or tooth-like outlines, evidently resulted from the dissolution of 1–10 mm large halite cubes. The well preserved molds and negative halite crystals observed within the breccias (*see* Pl. 4, Figs 1–2) prove their derivation from the dissolution of that mineral.

The collapse or subsidence structures developed above the dissolved halitic intercalations show the features of soft-sediment deformations. Thus, it is evident that the dissolution of halite within the described breccias took place in the loose of slightly consolidated gypsum sediment.

The similar thin layers of the breccias or "alabasters" with a flat base and an uneven or undefined top surface occur relatively frequently within the flat laminated gypsum (*see* Pl. 5, Figs 1–2; *and* OSMÓLSKI 1972, Pl. 4, Fig. 3; NIEMCZYK 1988a, Fig. 1). The material within the breccia is completely mixed and the clasts are hardly recognizable. Although the apparent traces of halite are lacking within those layers, they are found in the surrounding laminated gypsum. This enables to interpret the breccias in the same way as those from Borków — as dissolution ones. The breccias were probably formed in such places where the single isolated halite crystals occurred very densely or they created continuous halitic laminae.

BRECCIAS WITHOUT MATRIX

The small-scale synsedimentary faults, both normal and reverse, and the vertical zig-zag or wavy fractures are observed above the traces of dissolved single halite crystals or above the horizons of dissolved halite (Pl. 2, Figs 1–2; Pl. 3, Fig. 1; Pl. 4, Fig 1; Pl. 5, Fig. 2; Pl. 6, Figs 1–2; Pl. 7, Figs 1–3; Pl. 16, Fig. 1; Pl. 22, Fig. 2). In many places the faults and fractures form a network, and the rock has an appearance of the breccia entirely composed of fragments of the laminated gypsum without any matrix (*see* Pl. 7, Fig. 2).

KWIATKOWSKI (1972, p. 24) named such deposits as "the breccias without the matrix". This variety of breccia is quite widespread. It often grades into breccias with small amount of thin-grained gypsum or clay matrix. The examples are illustrated by ŁASZKIEWICZ (1957), PAWŁOWSKA (1962), KWIATKOWSKI (1972), OSMÓLSKI (1972), KRYSIAK (1986). KWIATKOWSKI (1972) noticed such breccias as forming thin layers. The present Author found them as vertical bodies several meters in height, placed within the relatively undisturbed layers of gypsum in several places at Leszcze (Pl. 13; Pl. 15, Fig. 2), Gacki (Pl. 8; Pl. 9, Figs 1–2; Pl 10, Figs 1–2; Pl. 11, Figs 1–2; Pl. 14, Fig. 1), Górki (Pl. 12, Figs 1–2), and Gorysławice. KRYSIAK (1986, p. 86) noted the similar veins with breccias, up to 0.5 m thick, also at Chotel Czerwony and Wola Zagojska.

The breccias show features of the brecciation *in situ*. No other rocks than occurring within the surrounding part of the gypsum section were found in the breccias. The transitions between the host rock and the breccias are both sharp and gradual. The collapse seems to be the best explanation of their origin. The example from Gącki (*see* Pl. 8) probably illustrates a transitional zone between the collapse breccia chamber or chimney and the uncrushed surrounding and overlying rocks, exactly as recorded by many authors (*cf.* "cracle breccia" zone of NORTON 1916 *fide* DŻUŁYŃSKI 1976; and of HOAGLAND, HILL & FULWEILER 1965; *see also* BOGACZ, DŻUŁYŃSKI & HARAŃCZYK 1970; SASS-GUSTKIEWICZ 1974, 1975; SASS-GUSTKIEWICZ, DŻUŁYŃSKI & RIDGE 1982). The large blocks of laminated gypsum are well visible, stopped or frozen during their falling down from the roof or wall of the collapsing zone. The blocks are penetrated by a network of fractures propagating mainly from their downs towards the tops (*see* Pl. 10, Figs 1–2; Pl. 11, Figs 1–2). The brecciation in this case took place within the deposits not fully consolidated, which is proved by the occurrence of thin-grained homogeneous gypsum matrix evidently sucked from the side walls of the opening fractures. This matrix apparently was not derived from the mechanical crushing of the hard rock because of the very small translation along the fractures (*see* Pl. 10, Fig. 2; Pl. 11, Figs 1–2). The open fractures or cracks within some layers of the solution-collapse breccias are also filled with the similar gypsum mud but not with the gypsum cement (*see* Pl. 6, Fig. 2; Pl. 7, Fig. 2).

The other features indicating that the brecciation took place within unlithified deposits are the following (*cf.* ELLIOTT & WILLIAMS 1988): the "plastically" folded clasts of the laminated gypsum (*see* Pl. 7, Fig. 2; Pl. 9, Fig. 1; *and* PAWŁOWSKA 1962, Fig. 1; OSMÓLSKI 1972), the unmineralized fault surfaces, the lack of open pores filled with the drusy gypsum cement within the breccia matrix (*see* KWIATKOWSKI 1972, OSMÓLSKI 1972). However, it is to note that in the highest part of the section at Gacki and Leszcze, intensely fractured gypsum rocks form such a variety of the breccia in which the cracks are filled only with the transparent gypsum crystals (*see* Pl. 15, Fig. 1).

At the Leszcze Quarry the whole, about 200 m long, exploited east wall is built of brecciated gypsum representing the highest part of the section lying above the layer (**i**) (*see* Text-fig. 3; Pl. 13; Pl. 15, Fig. 2). The interval of the layers (**k-ł**) is the mostly brecciated and contains a significant amount of clay-gypsum matrix (*see* Pl. 13, *lower part*). The brecciated zone passes laterally into the stratified deposits where the layers (**k**), (**l**) and (**ł**) are well recognizable and show only undulations or contortions. The base of the brecciated zone is formed by flat top surface of the sabre-like gypsum of the layer (**i**).

Although it is not always possible to localize the horizon of dissolved halite at the base of the all discussed breccia bodies, it seems very probable that they were formed by the fracturing and gravitational collapse of the sediments covering the zone of dissolving halite. The halite could occupy the layers (**k**), (**l**), and (**ł**) (see the next chapter). Moreover, the form of occurrence — a vertically elongated body — is typical of many solution-collapse breccias (*see* BOWLES & BRADDOCK

1963; CLIFTON 1967; SMITH 1972; SASS-GUSTKIEWICZ 1974, 1975; RUBIN & FRIEDMAN 1977; SASS-GUSTKIEWICZ, DŻUŁYŃSKI & RIDGE 1982; PARK & JONES 1985).

The same looking collapse breccias without the matrix, entirely built of fragments of laminated anhydrite, were described by ANDERSON & *al.* (1972), ANDERSON, KIETZKE & RHODES (1978), ANDERSON & KIRKLAND (1980), and DEAN & ANDERSON (1982) just from above the horizons of dissolved halite in the Permian Castile-Salado evaporites of Texas and New Mexico. They form both strata and vertical pipes extending many meters above the dissolved halitic layers. Effects of collapse can appear even 100 m above the dissolved deposits (*see* STANTON 1978).

KRYSIAK (1986) believed that such breccias in the studied deposits could result from synsedimentary tectonic movements. The example from Gacki (Pl. 8) could be interpreted in such a way because the illustrated spot was situated exactly nearby the large fault crossing the whole quarry (*see* KRYSIAK 1986, Pl. 3, Fig. 1 and Pl. 4, Fig. 1). But the recently exposed brecciated wall of the Leszcze Quarry, as well as the breccia from Górki, do not show any connections with faults crossing the underlying layers (a-i). The breccia from Górki (*see* Pl. 12, Figs 1–2), and the breccia veins from Gacki and Leszcze observed by KRYSIAK (1986, p. 86), are covered with the flat laminated undisturbed layers of gypsum.

SOLUTION-RESIDUUM "ALABASTERS"

The matrix of the dissolution breccias or solution residuum from Borków (see Pl. 4, Figs 1–2; Pl. 7, Fig. 3) is composed of thin-grained gypsum. The residual gypsum mud is not exactly homogeneous but it consists of wavy, uncontinuous bands composed of gypsum differing in color, sizes of grains, and porosity. Within such a gypsum mud, the ghosts or relics of the primary laminae are hardly recognizable. They are wavy, crenulated, frequently thinned and disrupted. A very characteristic feature is their uneven thickness.

The residual gypsum mud displays the same features as some types of "alabasters" described by KWIATKOWSKI (1970, 1972). Such unlaminated gypsum mud or "alabaster" deposits, surprisingly similar in appearance to the matrix of the dissolution breccias from Borków, are very common especially in the highest part of the studied evaporitic section (*see* Text-fig. 3; Pl. 12, Fig. 3; Pl. 15, Fig. 1; *and* WALA 1979; BĄBEL 1984, 1987). It seems possible that many of such "alabasters" represent residual accumulation of gypsum after early diagenetic or synsedimentary dissolution of halite. The best example of such solution-residuum "alabaster" and solution-residuum clay deposits are the layers (l) and (ł), described below. Their residual post-halite derivation is supported by the occurrence of obliterated traces of halite crystals in the layer (l) at Leszcze (for example in the sample illustrated in Pl. 16, Fig. 2).

It is possible to correlate the layer (l) precisely in the sections at Borków, Gacki, Leszcze, and Hołudza, because the lower part of this layer is occupied by the 6 cm thick, laminated gypsum stratum (designated (l1); *see* Text-fig. 3) with characteristic stromatolite-like domal structures and locally short sabre-like gypsum crystals. The layer (l) has constant 1–2.5 m thickness which, however, changes in order of 0.5 m within the range of a few meters in the particular outcrops. The changes result from the irregular transition into overlying clay deposits of the layer (ł).

The layer (l) consists of fine-grained gypsum, somewhere with scattered larger 0.5–2 mm crystals. The gypsum displays bandy structures parallel with stratification (*see* Pl. 16, Fig. 2; Pl. 17, Fig. 1; Pl. 18, Fig. 2), and locally brecciation (*see* Pl. 17, Fig. 2; Pl. 19), or complete homogenization.

The bands of gypsum are characteristically folded or contorted (*see* Pl. 14, Fig. 2; Pl. 18, Figs 1–2). The folds show generally vertical axial planes, and never are recumbent. In sections parallel with lamination it is seen that the folds represent irregular domes or brachyanticlines. Because of the lack of any constant vergency it seems improbable that they could originate from slumps. The better explanation is that they result from uneven subsidence generated by the solution of underlying halite. The subsidence was probably associated with the horizontal flow or creep of slurry gypsum residuum into local sink depressions developed over the zones of more intense dissolution. Such a flow could probably produce the bandy structure of the deposits. The bands can also represent the *in situ* relics of primary structures of the halite-bearing gypsum-clay laminites.

In places, the boundaries of bands are sharp and it is easy to split off the rock along them (*see* Pl. 14, Fig. 2; Pl. 18, Fig. 1). Some boundaries resemble the solution seams or stylolites. Slickensides, and surfaces exactly resembling slickolites, are found on some boundaries after splitting the rock. It is to note that slickolites were originally described and defined by Bretz (1940, 1950), from filled sinks and slumps in limestones. According to Bretz (1940, 1950), slickolites are more often met in solution-subsidence zones than in diastrophic ones. Numerous slickolites showing vertical orientation were observed in the solution breccias by Clifton (1967).

In many places, vertical and subvertical cracks or fractures occur, and they are filled with transparent gypsum crystals (*see* Pl. 3, Fig. 1; Pl. 15, Fig. 1; Pl. 16, Fig. 2; Pl. 18, Fig. 2). Other similar fractures are filled with microcrystalline gypsum (*see* Pl. 6, Fig. 2; Pl. 10, Fig. 2; Pl. 11, Figs 1–2; Pl. 17, Fig. 2). All of them are adequate to subaqueous shrinkage cracks (*see* Astin & Rogers 1991), and not to the desiccation ones reported from the studied deposits by Kwiatkowski (1972, p. 91) and Kasprzyk (1991b). The discussed fractures or cracks are interpreted by the Author as originated in the areas of local tension generated in the collapsing sediments due to the halite dissolution.

The layer (l) passes vertically into clay deposits of the layer (ł), and the contact is always gradual and uneven (*see* Pl. 18, Fig. 1). In the upper part of the layer (l) the clay forms numerous small flakes, wavy uncontinuous subhorizontal streaks or lenses, "floated" within the gypsum matrix (*see* Kwiatkowski 1972, p. 26, Pl. 6, Fig. 1). Such a deposit grades vertically or laterally without any sharp contact into a clay-gypsum rock, in which the clay becomes matrix and encloses gypsum micronodules or relic laminae, both rounded and/or angular in shape. Such deposits are described as the breccias with the clay matrix (*see* Text-fig. 3; *and* Bąbel 1984, 1987). Higher the rock grades into clay with disturbed structure and not showing parallel lamination.

The Author interprets that this contact is a result of halite dissolution and the clay represents also the solution residuum, *i.e.* accumulation of clay minerals previously intercalated between halitic and/or gypsum laminae of the primary deposits. Similar unlaminated clay horizons can be noted within the whole upper part of the section (*see* Text-fig. 3).

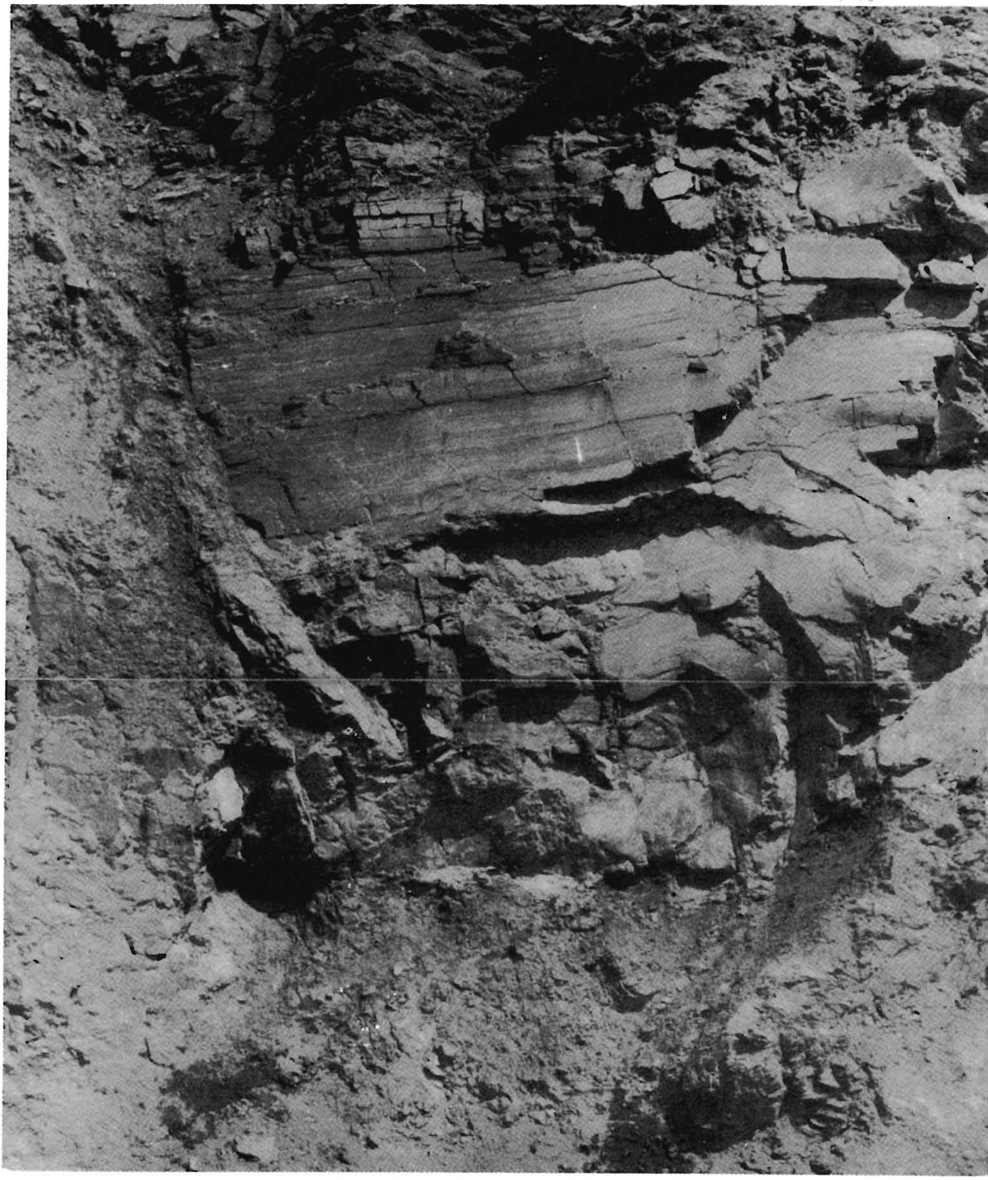
The base of the layer overlying the clay deposits of the layer (**l**) is wavy and in places shows evident load structures, spectacularly developed along the base of the layer (**m**) at Borków. These structures can be interpreted as a result of subsidence into empty holes produced by the dissolution of underlying halite.

The Author is not the first who described such solution-residuum sulfate sediments. Intraformational residual anhydrite deposits formed by dissolution of halite were recognized in the Zechstein Basin of Europe (*see* Richter-Bernburg 1972; Taylor 1980, pp. 103, 105). Similar carbonate and gypsum-anhydrite deposits were noted in the Messinian evaporites of the Mediterranean (Richter-Bernburg 1973). Anderson, Kietzke & Rhodes (1978) described halite-solution breccias consisting of more than 50% of the matrix from the Permian Castile-Salado evaporites of Texas and New Mexico, the matrix of which is a mixture of anhydrite, calcite, and organic matter, and shows a band-like appearance very similar to the studied "alabasters". This matrix, according to Anderson, Kietzke & Rhodes (1978) was able to flow laterally and to carry blocks of laminated anhydrite. Effects of lateral flow of solution residuum was noted by many authors (Stanton 1966; Smith 1972, p. 261, Fig. 4). Slump deformations of laminated gypsum, originated by dissolution of halitic intercalations, were recognized by Rouchy, Bernet-Rollande & Maurin (1986, p. 118 and Pl. 3.13, Fig. 2) in the Messinian evaporites of Cyprus. Finally, it is to note that the solution breccias from the Castile-Salado evaporites are exactly similar in appearance to the studied ones (*compare* Pl. 19 *with* Dean & Anderson 1982, Fig. 12).

DIAGENETICALLY MODIFIED SOLUTION-RESIDUUM AND COLLAPSE DEPOSITS

The diagenetic crystals of gypsum and calcite were reported from the studied evaporites (*see* Kwiatkowski 1972, Kasprzyk 1991a). These minerals considerably changed the appearance of some residual deposits or solution-collapse breccias, particularly in the highest part of the section (*see* Text-fig. 3).

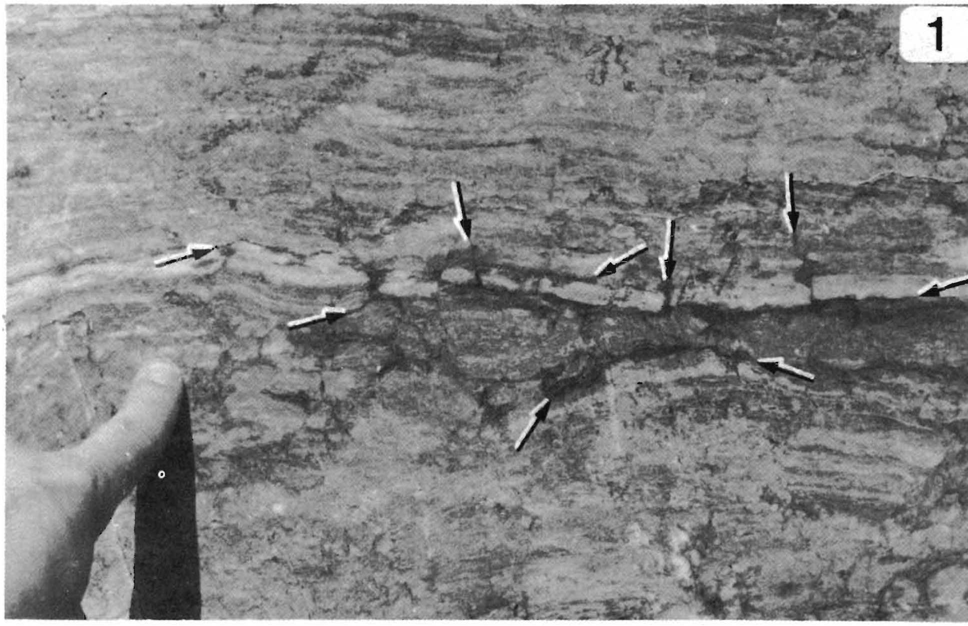
The gypsum probably crystallized within the matrix or inside the empty spaces remained after dissolved halite crystals. This gypsum formed thin-grained masses, usually more whitish than a surrounding one, or larger transparent, frequently honey crystals (*see* Pl. 7, Fig. 1; Pl. 21, Figs 1–2; Pl. 22, Fig. 1). Thin-grained masses created nodular bodies of various shapes and sizes. The



Giant-scale collapse breccia of laminated gypsum; Leszcze Quarry, east wall, above layer (I); the exposure is 8 m high

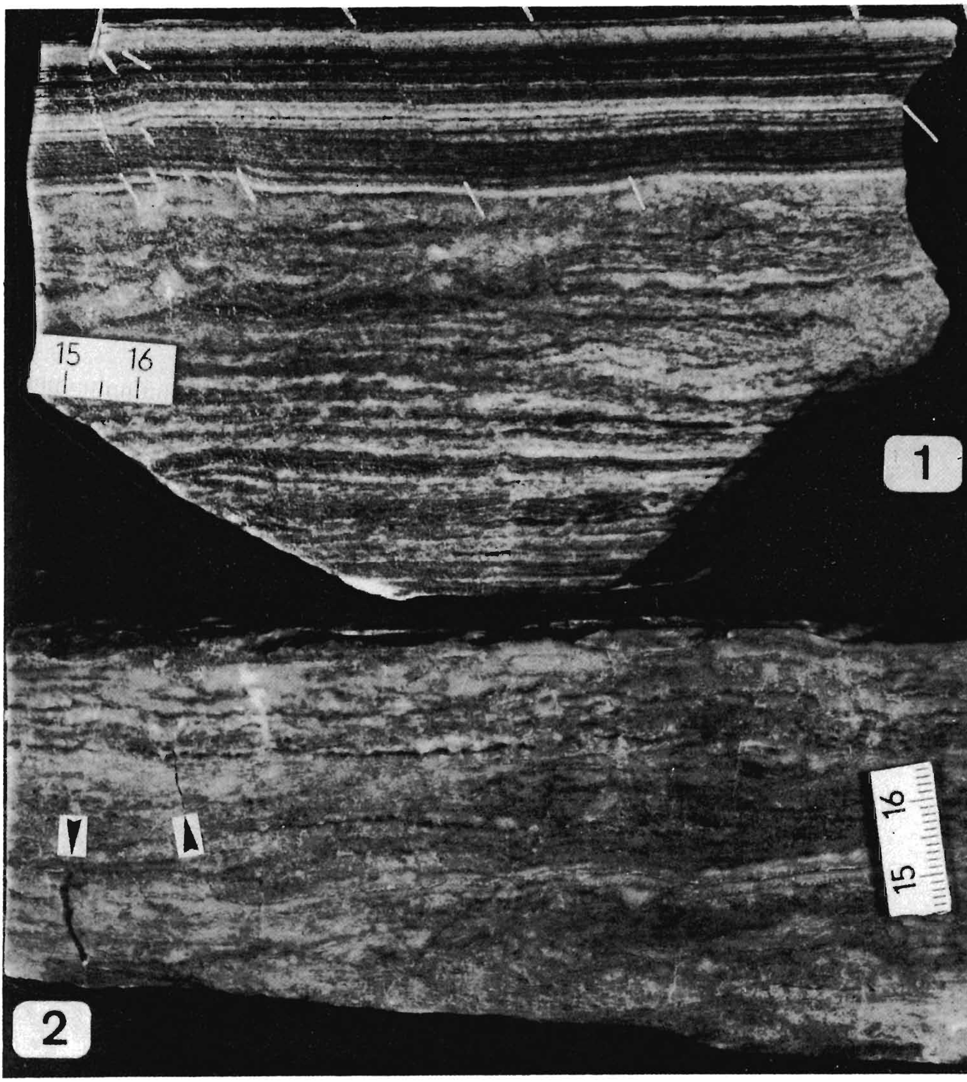
1 — Blocks of laminated gypsum floated in gypsum-clay matrix; collapse breccia chimney shown in Pl. 8 (photo taken right from the site marked B)

2 — Gypsum and clay deposits interpreted as residuum after dissolution of halite; some clay streaks resembling solution seams or stylolites are visible (*arrowed*); detail of Pl. 17, Fig. 1



1 — Brecciated gypsum mud with fractures filled with coarse transparent gypsum crystals (dark, *arrowed*); Leszcze Quarry, several meters above layer (I)

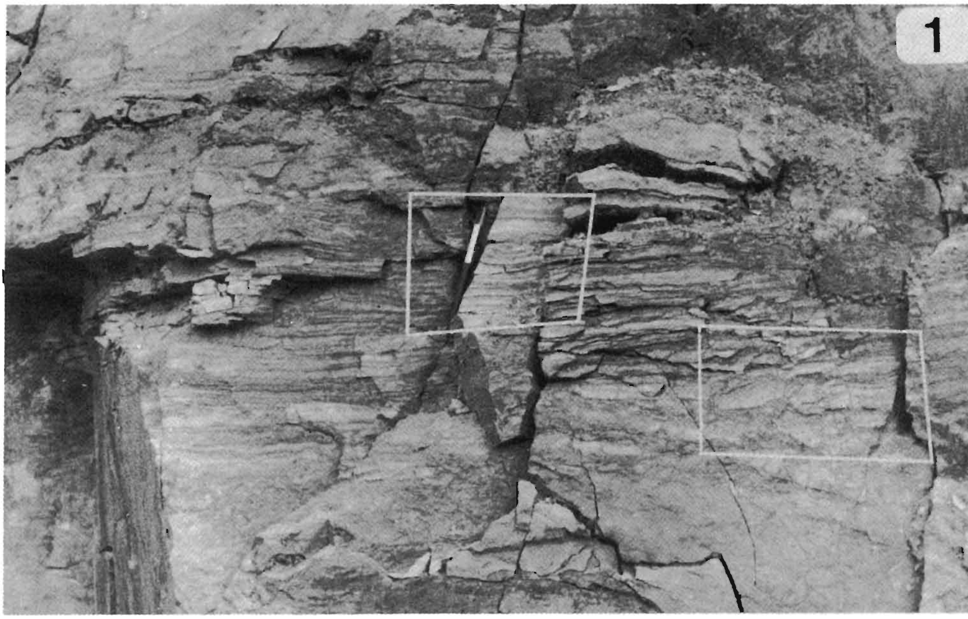
2 — Giant-scale collapse breccia; Leszcze Quarry, east wall; laminated gypsum above layer (I); the exposure is 10 m high



1 — Gypsum mud with obliterated, disturbed, relic lamination, interpreted as residuum after dissolution of halite, covered with flat laminated gypsum with microfaults (*indicated by white bars*) developed due to solution-collapse

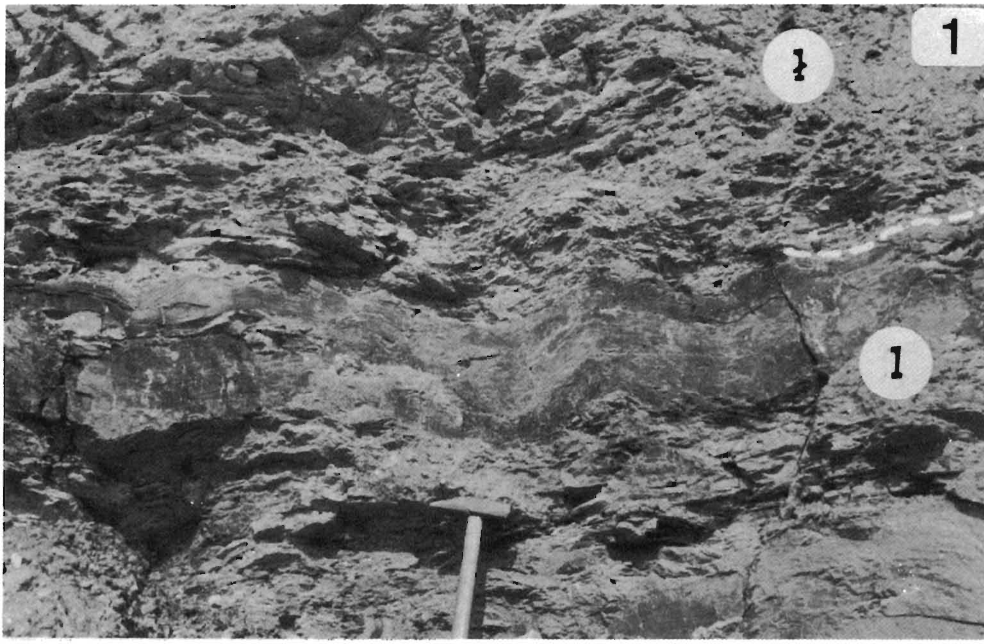
2 — Gypsum mud with obliterated, wavy, disturbed, relic lamination interpreted as residuum after dissolution of halite; vertical fractures are filled with coarse transparent gypsum crystals (*arrowed*)

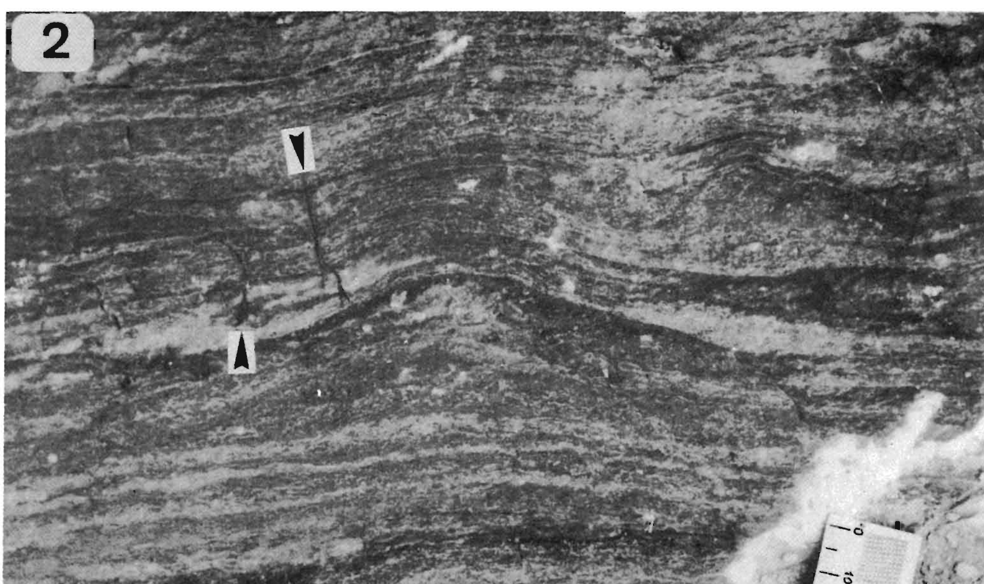
Gacki Quarry, above layer (j) (Fig. 1); and Leszcze Quarry, layer (I2) (Fig. 2); photos by S. Ulatowski



1 — Brecciated and banded gypsum mud formed probably by dissolution of halitic intercalations; Borków Quarry, layer (12), outlined fields are shown in Fig. 2 (below) and Pl. 14, Fig. 2

2 — Collapse breccia of banded gypsum mud representing solution residuum; detail of Fig. 1

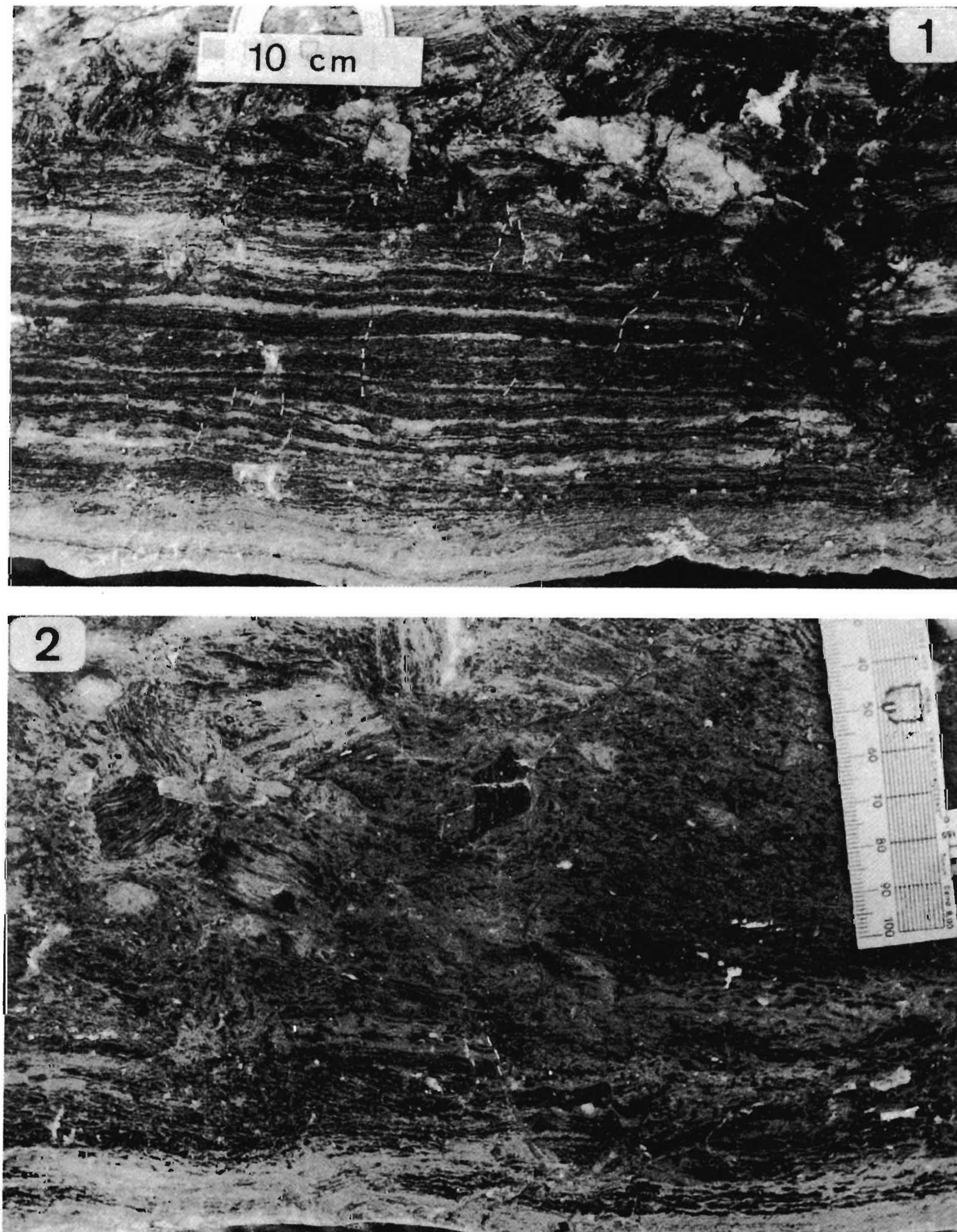




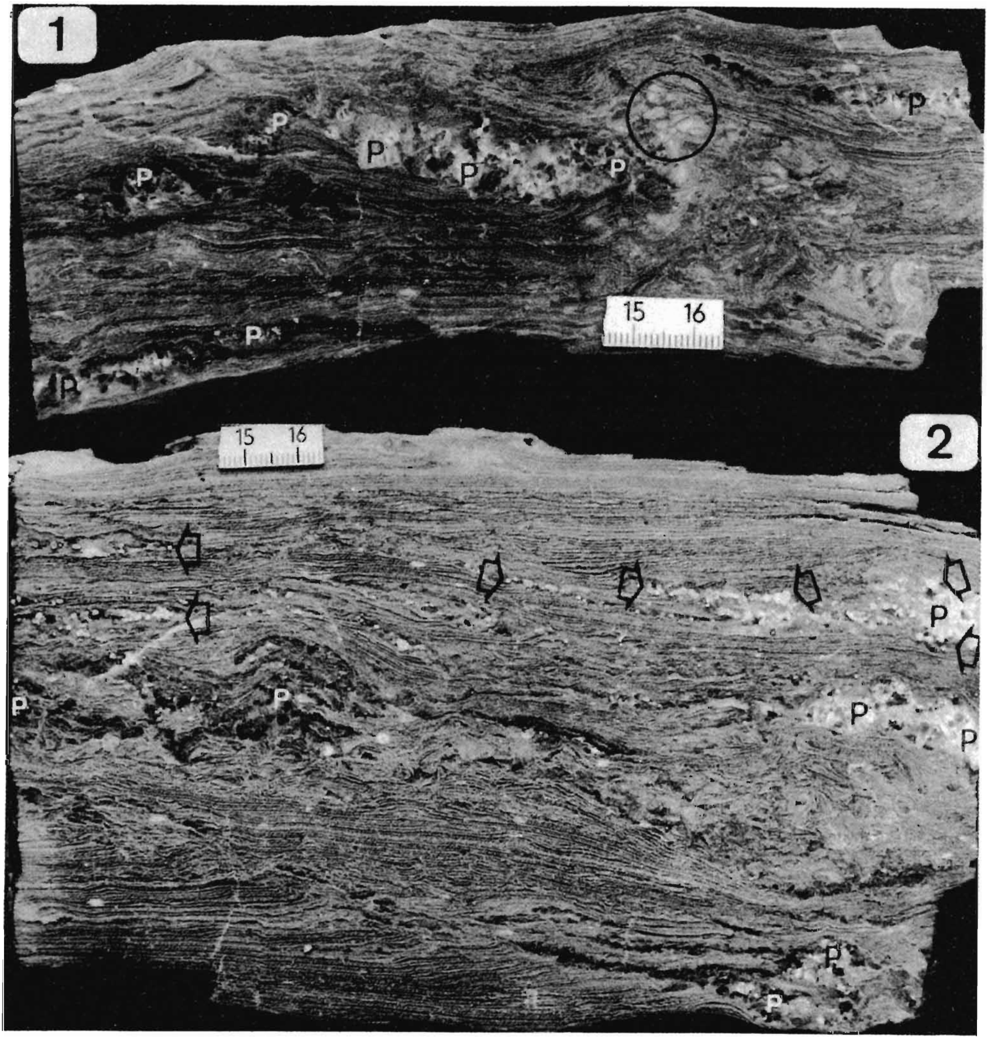
1 — Gypsum and clay, interpreted as residuum after dissolution of halite, brecciated and folded due to solution-subsidence; Gacki Quarry, layers (ł-l) (*marked*) near Grabowiec forest

2 — Gypsum mud, interpreted as residuum after dissolution of halitic intercalations, folded due to solution-subsidence; more transparent and less porous gypsum is dark; vertical fractures are filled with coarse gypsum crystals (*arrowed*); Leszcze Quarry, above layer (k)

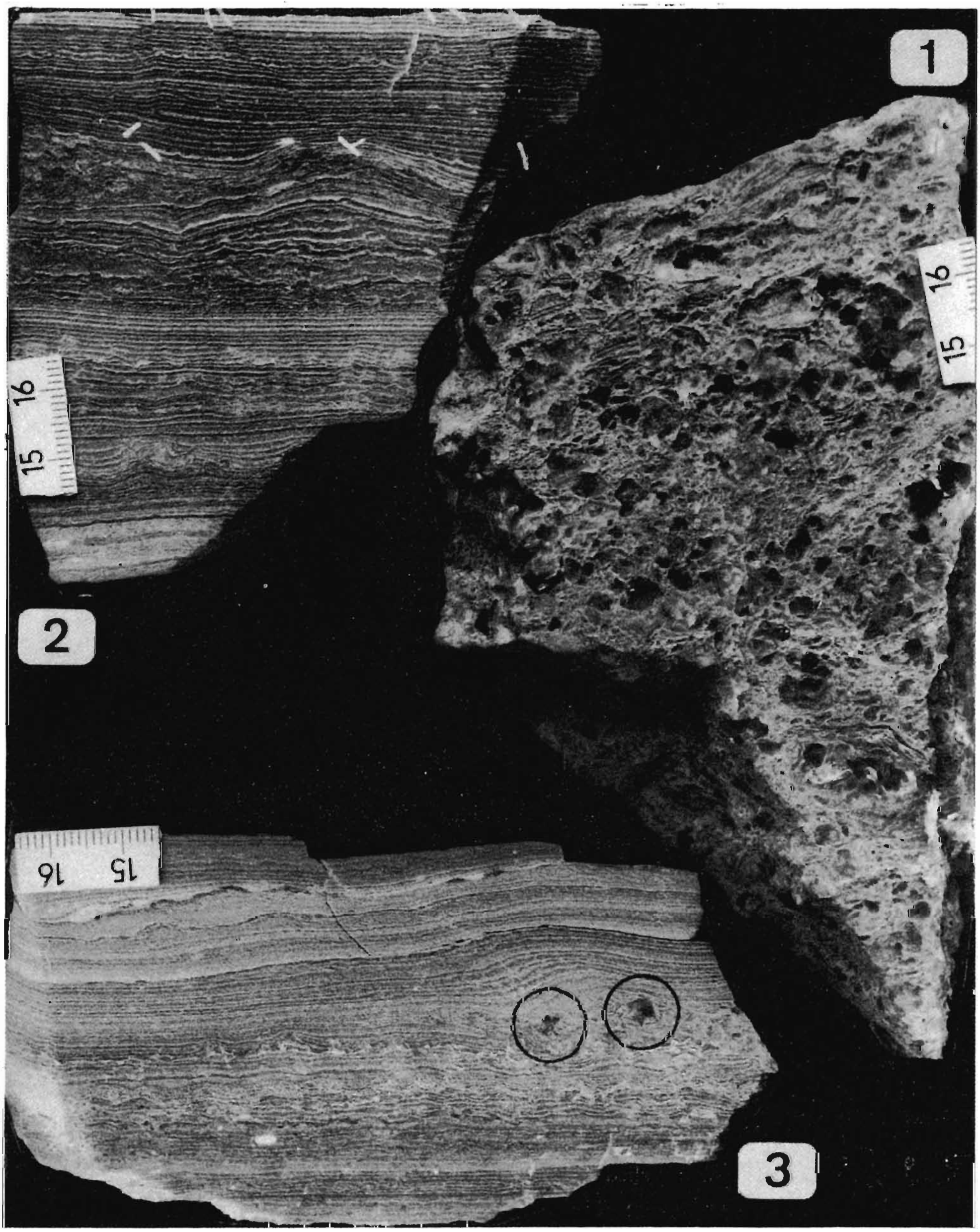
Brecciated gypsum mud interpreted as residuum after dissolution of halite; Borków Quarry, layer (12)



1-2 — Gypsum mud with disturbed, disrupted lamination, and its breccia, interpreted as products of multiple dissolution of intercalated halitic laminae and crystals; more transparent and less porous gypsum is dark; Leszcze Quarry, above layer (k)



1-2 — Microbreccias and deformations of laminated gypsum interpreted as formed by: collapse and subsidence due to dissolution of halitic intercalations, gravity creep or slumping, and displacive growth of clustered gypsum porphyroblasts (dark and light spots, *indicated* by P) or micronodules of thin-grained gypsum (light, *circled* in Fig. 1); groups of white-colored chalcedony spherules (*arrowed* in Fig. 2) protrude from water-etched surface; Gacki Quarry, 3.5 m above layer (I) (Fig. 1) and several meters above (I)(Fig. 2); photos by S. ULATOWSKI



1 — Gypsum porphyroblasts (dark) within thin-grained gypsum showing relic of lamination and brecciation (*top left*); etched surface, protruding calcitized parts are light; Gacki Quarry, 6.5 m above layer (I)

2 — Laminated gypsum with traces of dissolved halite crystals and solution-subsidence or solution-collapse deformations; microfaults are indicated by white bars; Gacki Quarry, the same laminae as in Pl. 6, Fig. 1

3 — Laminated gypsum showing traces of dissolved halite crystals obliterated by subsidence of overlying gypsum mud; transparent (dark) gypsum crystals with nearly rectangular shapes are circled; Gacki Quarry, above layer (J)

Photos by S. ULATOWSKI

large crystals grew as single *porphyroblasts* (or *porphyrotopes*, FRIEDMAN 1965; the first term is used according to the traditional older literature; *see e. g.* BORCHERT & MUIR 1964) or as their clusters. Many porphyroblasts represent the 100 twins. Some porphyroblasts display rectangular shapes, possibly related to the outline of a dissolved halite cube (*see* Pl. 22, Fig. 3). Some gypsum nodules and porphyroblasts show the effects of *displacive growth*. It seems that in many places they grew within not exactly lithified deposits and pushed them apart (*see* Pl. 7, Fig. 1; Pl. 21, Figs 1–2; *and* STEMMERIK, ROUSE & SPIRO 1988).

In some layers, especially in the highest part of the gypsum section at Borków, Sędziejowice, Szaniec, Gacki, Bilczów, and Gorysławice-Górki area (*see* BĄBEL 1984, 1992), the single porphyroblasts occur within the fine-grained matrix so numerously that the rock has an appearance typical of the porphyroblastic gypsum (*see* Text-Fig. 3). This variety of gypsum (*see* Pl. 22, Fig. 1) was earlier described by KWIATKOWSKI (1972, pp. 17, 87) under the name of "coarse-crystalline" or "grainy" (KWIATKOWSKI 1974, pp. 304–305, 342). NIEMCZYK (1988b) used a term "porphyritic gypsum" for such rocks from environs of Gorysławice, Górki, and Bilczów. In places, porphyroblasts grouped into clusters form large lens-like bodies, some of them reaching metric sizes (*see* KWIATKOWSKI 1972, Pl. 6, Fig. 1).

The origin of this porphyroblastic variety of gypsum, occurring mainly in the southern margin of the Fore-Carpathian Depression, is unknown. KWIATKOWSKI (1972) believed that it is secondary. The diagenetic growth of gypsum porphyroblasts, at least in some places of a displacive character, is undoubtful (*see* KWIATKOWSKI 1972, Pl. 6, Fig. 1). At this stage of recognition it is to remark that the remobilisation of gypsum (its dissolution and reprecipitation) during of the halite dissolution is worth of consideration. The porphyroblastic gypsum is noted within some cap rocks, so in the typical area of halite leaching (*see* GOLDMAN 1952, p. 13).

The matrix of some dissolution breccias is greatly enriched in thin calcite crystals. In places, the calcite grew evidently replacing the gypsum, cutting its lamination or the earlier deformation structures (*see* Pl. 7, Fig. 2), and producing limestone bodies with diffuse boundaries. The effects of calcitization are observed along the fracture surfaces (*see* Pl. 3, Fig. 1) and in the horizons formerly containing numerous halite crystals (*see* Pl. 3, Fig. 1; Pl. 7, Fig. 1; Pl. 22, Figs 1, 3). The calcitization is the most common in the highest parts of the section where, at Gacki and Leszcze, limestones with negative gypsum crystals and their 100 twins are noticed.

Locally, tiny chalcedony spherules form dense accumulations in the areas of diagenetically grown gypsum crystals (*see* Pl. 21, Fig. 2).

DISCUSSION AND FINAL REMARKS

As evidenced above, the dissolution of halite in the Middle Miocene (Badenian) Nida Gypsum sequence took place either within the soft, not fully consolidated gypsum sediments or, as KWIATKOWSKI (1972) believed, directly on the sea bottom. Such dissolution in the soft, water saturated sulfate sediments led to their gradual slow subsidence or collapse. The residual slurry gypsum sediments were able to creep or flow towards the nearest sink depressions formed within the collapsing layer. The residual deposits created in such a way do not show effects of brecciation, but first of all display complicated "flow structures" and soft-sediment deformations. To imagine better the formation of such deposits it is worth to compare them with the melt-out tills (*see* BOULTON 1972), which can show a remarkably similar appearance. It is obvious that the structure of such residual gypsum sediments can be very variable and depend on amount and geometry of halite intercalations, degree of consolidation of gypsum, shape of the front of halite dissolution, etc. (*see* SMITH 1972, STANTON 1978).

When the dissolution took place within gypsum sediments on the inclined slope of the basin, the overthrusts and asymmetric folds, frequently kink-like, were formed (*see* Pl. 5, Fig. 2; Pl. 7, Fig. 3; Pl. 21, Figs 1–2). It is highly probable that dissolution of halite within the near-surface layer of unconsolidated sediments led to their slow gravity creeps or hydroplastic flowages along the slope. It seems also possible that the slides along the halite-bearing horizons were generated due to the halite dissolution. Slump folds resembling the pahoehoe lava, described by KWIATKOWSKI (1970; 1972, p. 90), could be created in such a way.

The dissolution of halite within the water saturated sediments was probably realized by the upward ionic diffusion of NaCl through the porous gypsum cover in a similar way to that as a salt dissolution process acting nowadays within the bottom sediments of the Red Sea and the Mediterranean (*see* RANGANATHAN 1991; TEN HAVEN, DE LANGE & MCDUFF 1987). The large vertical extent of some collapse breccias in the Nida Gypsum deposits indicates that the dissolution could take place beneath the cover of at least 10 m of sediments (*see* Pl. 13; Pl. 15, Fig. 2). Such a situation allows to suppose that the halite could remain somewhere within the gypsum deposits and be preserved for a long time below the sufficiently thick strata, and thus could be subjected to the dissolution later within the completely lithified gypsum rocks. Whether the dissolution of halite operated within lithified gypsum rocks or not in the investigated area, remains an open question.

The presented survey on the origin of the breccias, alabasters, and soft-sediment deformations within the laminated Middle Miocene (Badenian) gypsum of southern Poland, does not devaluate the previous hypothesis of KWIATKOWSKI (1972) who, as referred in the introduction, recognized correctly the main mechanism of the process: the gravitational instability of the density layering. The new idea of the present Author is that it was the dissolution of halite which promoted such instability within the soft sediment column. The dissolution of halite drastically increased the porosity within the halite-bearing horizons changing the density and cohesive properties of the sediments to such a degree that they were able "to liquefy" or to flow in hydroplastic state. Simply saying, it changed the volume relations between the pore waters and the grains in such direction that the previously consolidated halite-gypsum rock could become the soft slurry mud or soupy suspension of gypsum grains and other clasts. Thus, the dissolution of halite enabled the action of the soft-sediment deformational processes such as hydroplastic folding or flowage, "liquefaction" or brecciation, which could be very easily generated by any machanic impuls, like a tectonic shock, a storm, a strong current, etc.

Some structures found by KWIATKOWSKI (1970, p. 38; 1972, p. 25, Pl. 5, Figs 1–2), such as the fragments of breccia within the breccia and the brecciated fragments of alabasters, as he wrote himself, were *"difficult to explain"*. KWIATKOWSKI suggested that they were formed by the second event of "liquefaction" and displacement. The present Author offers another explanation — two or more stages of the halite dissolution (*see* Pl. 15, Fig. 1; Pl. 17, Figs 1–2; Pl. 19; Pl. 20, Figs 1–2). The brecciated breccias seem to be typical of the solution-collapse processes (*see* BEALES & OLDERSHAW 1966; SASS-GUSTKIEWICZ 1975; SWENNEN, VIAENE & CORNELISSEN 1990).

Finally, the present Author would like to emphasize that the offered interpretation concerns only some types of breccias, alabasters and soft-sediment deformations — many other forms, recognized in drill holes and exposures, still need more investigations to recognize precisely their nature.

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M. BĄBEL

ROZPUSZCZANIE HALITU W GIPSACH LAMINOWANYCH PONIDZIA

(Streszczenie)

W badeńskich gipsach laminowanych Polski południowej (*patrz* fig. 1) występują liczne i bardzo różnorodnie wykształcone brekcje śródwarstwowe, ławice „alabastrowe" i struktury deformacyjne, których geneza nie była dotychczas w pełni zrozumiała (*patrz* KWIATKOWSKI 1972, KUBICA 1985, KASPRZYK 1991b). Stosunkowo najlepiej odsłaniają się one na obszarze Ponidzia, gdzie były badane przez autora (*patrz* fig. 2–3 *oraz* pl. 1–22).

W niniejszej pracy autor uzasadnia pogląd, potwierdzający przypuszczenia NOWAKA (1938, s. 165) i KOWALEWSKIEGO (1957, s. 44), iż utwory te w przeważającej części powstały w wyniku wczesnodiagenetycznego rozpuszczania halitu znajdującego się w obrębie laminowanego mułu gipsowego. Rozpuszczanie halitu zachodziło w miękkim, na ogół nieskonsolidowanym osadzie bezpośrednio na dnie zbiornika. Prowadziło ono do powstawania nagromadzeń rezydualnego mułu gipsowego („alabastru"), brekcji zawałowch, oraz deformacji związanych z zapadaniem lub osiadaniem materiału gipsowego pokrywającego rozpuszczający się halit. Na skutek rozpuszczania halitu na skłonach basenu dochodziło do grawitacyjnych przemieszczeń laminowanego osadu gipsowego.

Opisane utwory świadczą o tym, iż wytrącanie halitu zachodziło nie tylko na południowych, lecz również na północnych rubieżach Zapadliska Przedkarpackiego, i to w ilości znacznie większej niż sądzić można było z liczby znajdowanych poprzednio (*patrz* KWIATKOWSKI 1972, NIEMCZYK 1988a) pseudomorfoz gipsu po pojedynczych kryształach halitu. W świetle tej konkluzji dotychczasowe poglądy o przebiegu sedymentacji, diagenezy, a nawet epigenezy gipsów w północnej części Zapadliska wymagają weryfikacji.
