Annales Societatis Geologorum Poloniae (1986), vol. 56: 109–115
PL ISSN 0208-9068

KARST-CORRASION FEATURES OF DISAGGREGATED LIMESTONES CONTROLLED BY DIFFUSION BANDS

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Dżułyński, S. & Rudnicki, J., 1986. Karst-corrasion features of disaggregated limestones controlled by diffusion bands. *Ann. Soc. Geol. Polon.*, 56: 109–115. Kraków.

Abstract: This paper deals with minor karst-corrasion features in disaggregated limestones. The features occur in the form of parallel sheet-like bodies made up of recemented grains and alternating with zones of soft disaggregated limestones riddled with small corrasion cavities. The sheet-like bodies trend parallel or obliquely to sedimentary interfaces and, if traced far enough, pass into irregular, semi-concentric or concentric configurations. It is suggested that the pattern of sheet structures is controlled by rhythmic diffusion bands developed in the disaggregated and homogenized limestone. Implications are also made concerning similar patterns shown by some metasomatic "ribbon ores" in Mississippi Valley-type Deposits.

Key words: Karst-corrasion, disaggregated limestones, diffusion bands, ribbon structures, karst ores.

Manuscript received May 1985, accepted June 1985

INTRODUCTION

Among the factors which influence and control the development of karst features is the solution disaggregation of carbonate rocks, i.e. the transformation of hard lithified carbonates into a soft semi-coherent or incoherent mass of silt-sized particles. The transformation of this kind is caused by a slow nonintegrated transfer of aqueous solutions through the pore space and is generally preceded by recrystallization. The disaggregation results from dissolution of crystal edges and/or the disrupting action of crystallizing salts. The products of solutional disaggregation are sometimes referred to as "sanded" or "pulverulent" carbonates. In the forthcoming considerations the term "disaggregate" will also be used. It is to be noted that the disaggregated mass may become recemented by secondary calcite and thus, again be transformed into hard crystalline carbonate which is totally devoid of any traces of primary or early-diagenetic structures.

The disaggregated grains are particularly susceptible to dissolution. They are also readily detached, transported and redeposited by underground waters (Bogacz *et al.*, 1973; Dżułyński & Sass-Gustkiewicz, 1977). This gives rise to the formation of corrasion cavities the walls of which may coincide with the boundaries of the sanded bodies. In early stages of disaggregation, the small and isolated disaggregated portions may join to form a complicated "sanded branchwork" which, after the removal of the detached grains, is transformed into a system of spongework cavities. With large bodies of disaggregated carbonates, the settling of crystals reduced in size by dissolution leads to the formation of openings along the upper boundaries of the bodies in question. By taking more and more of the total underground flow and the corrasional removal of grains such openings may eventually develop into sizable cave passages (Dżułyński & Kubicz, 1971; Dżułyński & Sass-Gustkiewicz, 1985).

The processes of solutional disaggregation operate under very diverse conditions. They are also part of karst phenomena, and the disaggregated limestones have been reported from many karst regions, notably from those situated in sub-tropical monsoonal zones (Franco, 1982; Monroe, 1976; Panoš & Štelcl 1968). In this note we discuss the origin of a specific type of corrasion-motivated surficial karst features which exhibit a pattern similar to that of the diffusion bands produced in disaggregated limestones.

CHARACTERISTICS OF KARST-CORRASION FEATURES

The observations presented are made at a quarry at Tres Marias, north-west of Cardenas in the Province of Matanzas (Central Cuba). The corrasion features discussed occur in flat-lying Miocene limestones belonging to the Guines Formation (Franco, 1978). Where not affected by disaggregation, these limestones are coarse--grained, fossilifeorus, relatively hard, thick-bedded rocks with poorly delineated bedding planes. The "sanded" portions are fine-grained and very soft rocks which are entirely devoid of primary sedimentary structures and fossils. Close to the ground surface, the sanded limestones are mantled with a hard crust made up of recemented grains (hardpan).

The recemented, and thus indurated bodies are also common within the disaggregate itself. Such bodies form a solid framework which gives shape and determines the arrangement of corrasion voids. This framework is revealed by differential erosion on vertical rock surfaces exposed to the action of rain-wash and running water. The characteristic features of this framework are as follows:

1. The indurated bodies tend to occur in the form of sheets or "layers".

2. The sheet structure is entirely independent of the pattern of sedimentary structures in the country rock. The sheets may trend parallel or obliquely to the sedimentary interfaces and, if traced far enough, are seen to pass into irregularly curved or semi-concentric and concentric configurations.

3. The different and variously trending sets of sheets may meet along a discordant surface or may be cut by a single sheet structure which deviates from the trend of the remaining sheets.

4. On close inspection, the sheet-like bodies reveal the presence of a very narrow medial crevice along the central axial plane (Pl. II: 1). In such instances, the sheets may be interpreted as cementation rims developed on both sides of the crevices.

5. The inter-sheet spaces consist of the soft disaggregate which also contains isolated recemented bodies showing spherical shapes up to 10 cm in diameter (Fig. 1; Pl. II: 1).

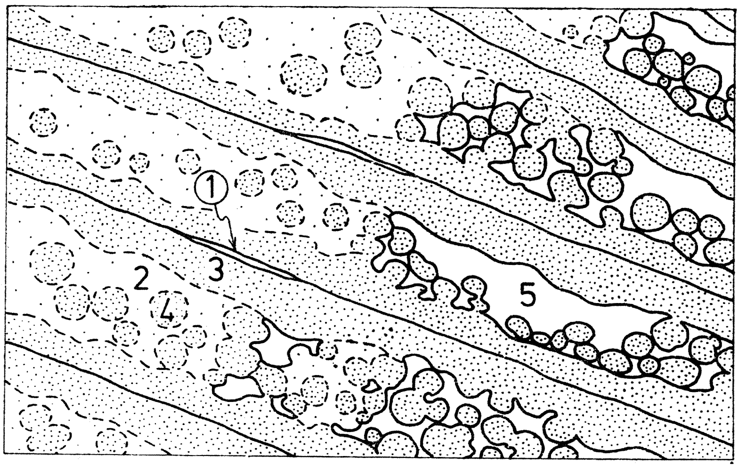

Fig. 1. Schematic presentation of features of disaggregated limestones. *1* — medial crevices, *2* — disaggregated limestone, *3* — linear recementation rims bordering medial crevices, 4 — spherical cementation concretions, *5* — empty voids produced by corrasion

6. On karstified rock surfaces, the inter-sheet spaces are riddled with small variously shaped corrasion openings which approximate the pattern of sponge-work cavities. With a more complete removal of the disaggregated grains, the inter--sheet spaces may be transformed into elongate narrow cavities containing the previously mentioned hard spheroidal bodies. In places, the cavities are partly filled or lined with fine calcareous residues showing shrinkage cracks of presumably syneretic origin.

GENESIS OF FEATURES

The above discussed solid framework can be traced in non-karstified parts of the disaggregated limestones. It may easily be revealed by pouring water upon the newly exposed and smooth rock surfaces. The mechanism leading to the formation of the structure under consideration is simple. It involves differential corrasion and dissolution, the former being particularly effective in removal of the disaggregated particles. The moot point considered here is the pattern of the sheet structure. This structure shows similarity to the so-called "boxwork" (see Bretz, 1942; White & Deike, 1962). However in typically developed box-works, the resistant elements form a network of rectilinear intersecting walls or septae enclosing roughly polygonal empty spaces. Such walls follow the pattern of joints and fractures. In the present case, the protruding resistant elements occur in parallel sets which may follow a curvilinear pattern. As explained above, it is evident that the sheets do not reflect the pattern of sedimentary structures and the previously mentioned medial crevices are not sedimentary interfaces enlarged by dissolution. The alternative explanation that the sheets and cavities are controlled by tectonic fractures seems equally unlikely.

The pattern of the karst features discussed resembles closely the pattern of rhythmic diffusion bands (Liesegang rings). In our opinion, the appearance of such bands in the disaggregated limestone determined the development of the sheet structures. In this connection it is to be noted that spectacular diffusion bands of similar form and size have recently been discovered in disaggregated, though not karstified, limestones in the same formation near Güira de Melena (Province Habana, Cuba). Large diffusion rings (Pl. II: 2) are seen here to follow curved, concentric or semi concentric configurations. Some of them appear to be related to incipient karst conduits (Albear *et al.*, 1985).

Without entering into details concerning the not yet entirely clarified question of diffusion bands in natural rocks, it will be recalled that such bands may result from "many episodes of wetting and drying, solution and deposition, during prolonged periods" (Bastin, 1950, p. 47). Whatever their nature and composition, the diffusion bands reflect a rhythmic spread of alteration fronts which, in most instances, are consequent upon a slow transfer of solutions through the pore space of fine and structurally homogeneous media. The bands once produced represent discontinuities which may influence and control the development of karst forms. The changing pattern of sheet structures at Tres Marias presumably originated from alternation fronts spreading from different directions and/or various centers such as the ground surface, preexisting karst conduits or groundwater tables. The previously indicated cross-cutting contacts between different sets of parallel structures may be interpreted in terms of the interference between separate and competing diffusion bands. The unanswered question at this point is whether the diffusion bands were formed concurrently with the disaggregation and recrystallization processes or, as seems more likely, were superimposed upon the already produced "sanded" carbonate. Whatever the case, once the bands are produced, they represent the discontinuities which may influence the further transfer of underground solutions and may eventually be solutionally enlarged to form the incipient karst cavities.

The karst features under consideration are rare. Although the disaggregated limestones of the Güines Formation are of widespread occurrence, they have not been observed in other localities. Accordingly, the formation of the features in question must have been the result of specific conditions. One can envision the formation of such features as following the appearance of diffusion bands in homogenized bodies of disaggregated limestones. Later some bands or their boundaries became transformed into narrow crevices which served as passageways for underground circulation. This circulation led to the formation of the previously mentioned recementation rims and spheroidal bodies of hard crystalline carbonate within a mass of disaggregated grains. In a further development, the disaggregated grains were removed in preference to the hard, recemented portions of the rock giving rise to the structure observed.

IMPLICATIONS

As the explanation presented must be regarded as speculative, it may be premature to proceed to a further discussion of its implications. However, one implication is worth mentioning. Sheet structures showing similar if not identical patterns with those described above are present in the so-called "ribbon ores" which are of intermediate type between metasomatic sphalerite and cavity filling karst ores (see Sass-Gustkiewicz *et al.*, 1982; Dżułyński & Sass-Gustkiewicz, 1985).

The origin of the ribbon ores is still disputable. The narrow dissolution cavities in such ores were previously thought to be either controlled by fractures or be vestiges of original sedimentary interfaces (Bogacz *et al.*, 1973a). When it was realized that the cavities in question, if traced over sufficiently long distances, might follow highly irregular and even concentric patterns an alternative explanation was advanced. According to this interpretation such patterns develop from rhythmic diffusion banding reflecting the spread of replacing mineralizing solutions (Dżułyński & Sass-Gustkiewicz, 1985). Under such interpretation, the sheet-cavities developed along discontinuity surfaces separating different diffusion bands.

The discovery of karst features showing patterns similar to those exhibited by the ribbon ores is of importance because Mississippi valley-type deposits in which such structures occur, have been recently reinterpreted in terms of hydrothermal karst phenomena (Bogacz *et al.*, 1970; Dżułyński & Sass-Gustkiewicz, 1977). There is also a good reason to suppose that some of the ribbon ores might have originated in solutionally disaggregated or partly disaggregated carbonates.

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Streszczenie

ZJAWISKA KRASOWO-KORAZYJNE W STRUKTURACH DYFUZYJNYCH W ZDEZINTEGROWANYCH WAPIENIACH

Stanisław Dżułyński & Jan Rudnicki

Wapienie mioceńskie na Kubie ulegają często rekrystalizacji i dezintegracji przeobrażając się w mało spoiste i rozsypliwe utwory ziarniste. W utworach tego rodzaju pojawiają się swoiste formy krasowo-korazyjne. Powstają one w wyniku wypłukiwania luźnych ziarn kalcytowych przy pozostawieniu utwardzonego szkieletu zbudowanego z ziarn, które przedtem uległy ponownej cementacji węglanowej. W skład takiego szkieletu wchodzą:

1) kuliste konkrecje cementacyjne rozsiane bezładnie w rozsypliwej masie ziarnistej (Fig. 1; Pl. II: 1);

2) linijne strefy cementacyjne utworzone wzdłuż ścian wąskich i częściowo skorodowanych szczelinek rozmieszczonych równolegle do siebie w mniej lub bardziej równomiernych odstępach (Fig. 1; Pl. II: 1).

Na skrasowiałych powierzchniach linijne strefy cementacyjne wystają pod postacią listewek skalnych (Pl. I: 1, 2). Listewki te są rozdzielone pasmami pustek krasowych, w których tkwią kuliste konkrecje cementacyjne (Fig. 1; Pl. II: 1). Strefy cementacyjne nie wykazują zależności od struktur i powierzchni sedymentacyjnych, które widoczne są w niezmienionych wapieniach i często przebiegają skośnie do uwarstwienia. Powierzchnie stref cementacyjnych bywają proste lub nieregularnie pozakrzywiane, a niekiedy układają się w struktury koncentryczne. Ich wzory przestrzenne są podobne do wzorów przestrzennych pasm dyfuzyjnych (tzw. pierścieni Lieseganga), które zresztą występują w zdezintegrowanych wapieniach (Pl. II: 2). Z pojawieniem się pasm dyfuzyjnych powstają nieciągłości, które mogą ukierunkować przepływ wód podziemnych i w dalszej kolejności doprowadzić do utworzenia się opisywanych form krasowo-korozyjnych.

Przytoczone rozważania rzucają światło na pochodzenie niektórych metasomatycznych struktur kruszcowych ("ribbon ores") związanych genetycznie ze zjawiskami krasowymi. Struktury te mają bardzo podobne wzory przestrzenne, których geneza jest, jak się wydaje, analogiczna do przedstawionej.

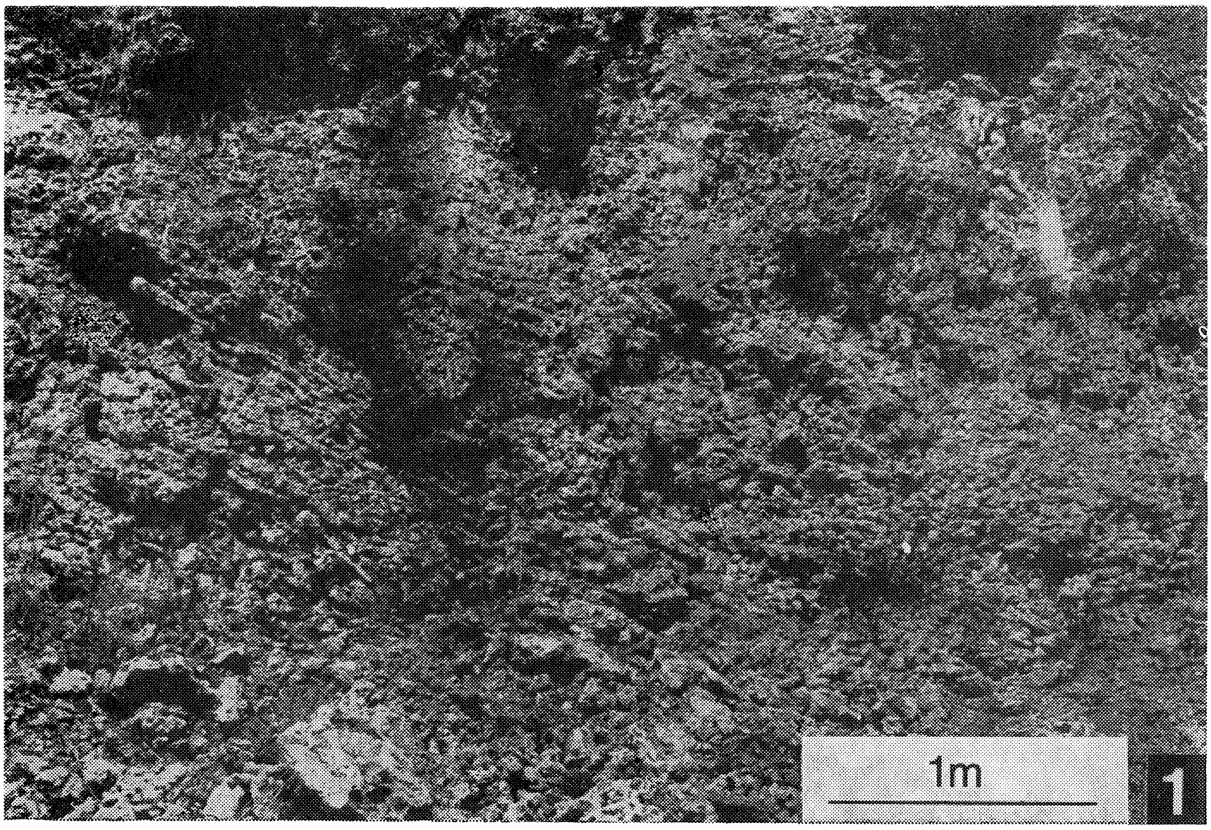
EXPLANATIONS OF PLATES

Plate I

1 — General view of exposure at Tres Marias with sheet structures. Note changes in trend of sheets (upper right)
2 — Detail of exposure showing rectilinear sheet structures trending obliquely to bedding planes and sedimentary interfaces

Plate II

1 — Detail of exposure at Tres Marias showing medial crevices in center of sheet structures (*A*) and globular concretionary recementation bodies in inter-sheet spaces (*B*)
2 — Concentric pattern of diffusion bands in dissaggregated limestones at Güira de Melena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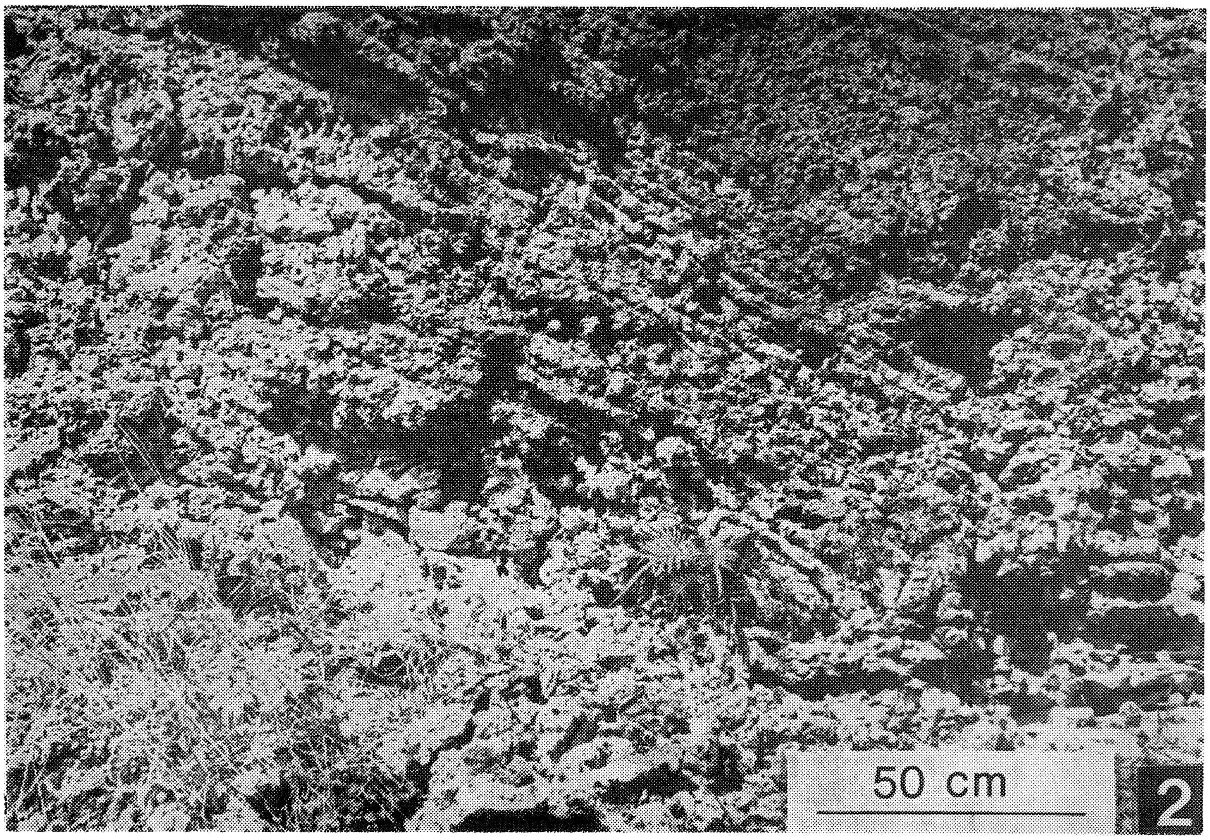
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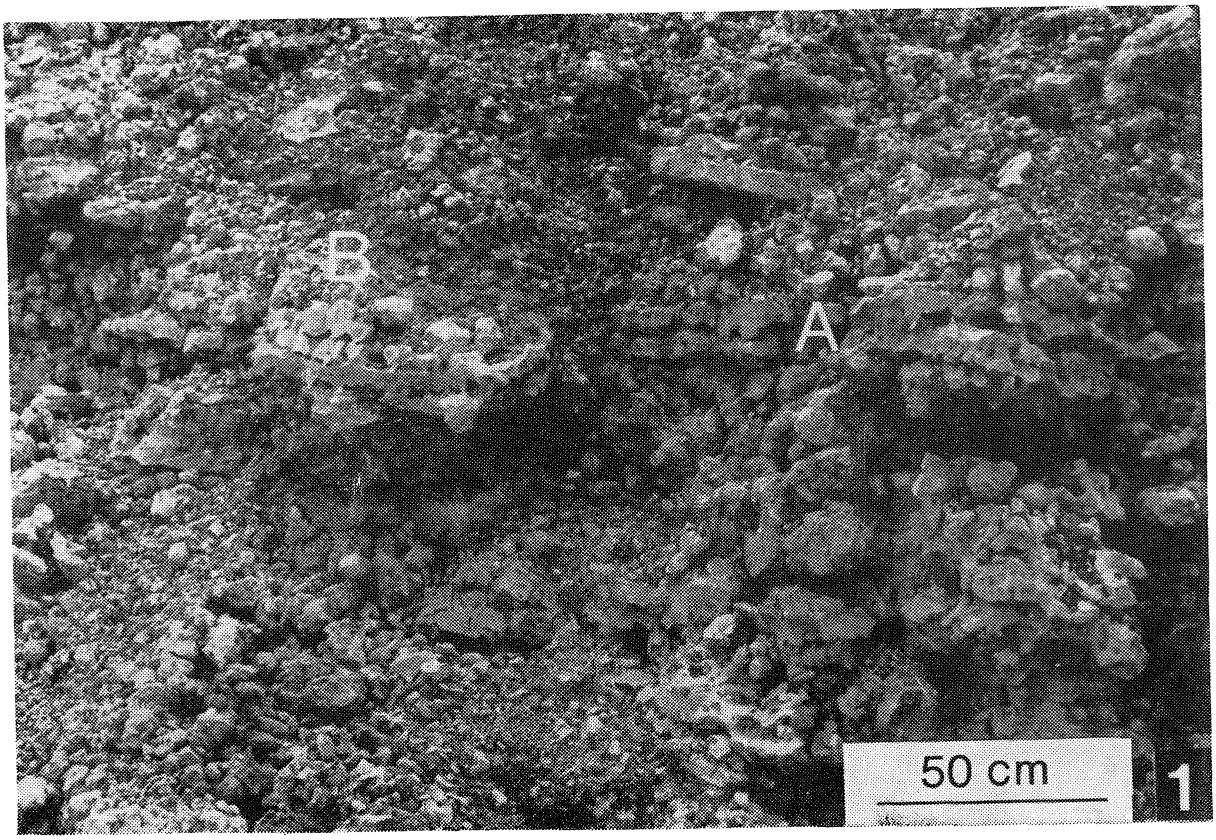
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