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DETERMINATION OF THE DEGREE OF TEXTURAL ORIENTATION IN RECRYSTALLIZED CARBONATE ROCKS

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ABSTRACT

In the phases of late diagenesis - early metamorphism the interrelated change of several parameters can be observed in the texture of carbonate rocks. One of these is the preferred orientation formed alongside the anisometric particles. In petrographic descriptions the textural orientation is determined by a qualitative approach, such as non-, low- or highly-oriented texture. Conversely several stereological methods, applicable for petrographic descriptions too, are used to determine the degree of the textural orientation.

During the examination of thin sections of limestones from the Bükkium (NE-Hungary) the author adopted the method of parallel interapps. Using this slightly complicated method the author could separate textures types of carbonate rocks having different degree of orientation. The measurements has been performed by computer-controlled image analyzing equipment (SIS V3) built and installed on an IBM AT.

The author worked out another method in order to quicken the process of measuring, using data measurement calculated directly by the applied image analyzing equipment. The degree of textural orientation was determined by applying the angular distribution of the Dmax of anisometric particles in the thin sections.

As a result, well-recrystallized textures were sorted out by the degree of preferred textural orientation, characterizing the carbonate rocks on the different stages of late diagenesis and early metamorphism.

Key words: carbonate rocks, orientation, texture.

INTRODUCTION

The textural description of monomineralic sedimentary rocks can be given by qualifying the shape of particles, and also the orientation of anisometric particles. One of the parameters - the degree of preferred textural orientation - can characterize the textures of monomineralic carbonate rocks on the different stages of diagenesis and early metamorphism (Kovács and Árkai, 1987). This preferred textural orientation has been formed during the recrystallization as lineation of elongated anisometric carbonate particles. In petrographic works the degree of textural orientation is treated only qualitatively, such as non-,low-, or highly-oriented texture.

METHODS

Several methods are used to characterize the degree of textural orientation with some quantitative parameters (Saltykov, 1971; Underwood, 1970). These methods usually make the application of image analyzing equipment necessary. At the University of Miskolc the author made experiments, using a software-controlled automatic image analyzing system - SIS V3 (Soft-Imaging Software GmbH). Two different methods of measuring developed by the author and described here are demonstrated on a thin section of a highly-oriented limestone from the Szendrő Mts. (NE-Hungary). The section was selected as parallel with the axis of the lineation.

Using the first method for textures having linear orientation, anisotropy could be determined practically with enough accuracy on one section, which must be taken parallel with the orientation axis (Saltykov, 1971).

By this method, parallel test gridlines were put down on the examined image and the lengths of the grids, lying inside the particles, were measured. In well-oriented textures the average lengths of grids have an ordered distribution as a function of direction, but in the case of non-oriented - isotropic textures this regularity is absent.

The next 4 Figures are showing steps of this measurement; the photo in Fig. 1 was taken of the highly-oriented limestone sample, parallel with the axis of lineation. Fig. 2 shows the binary image of the same visual field.

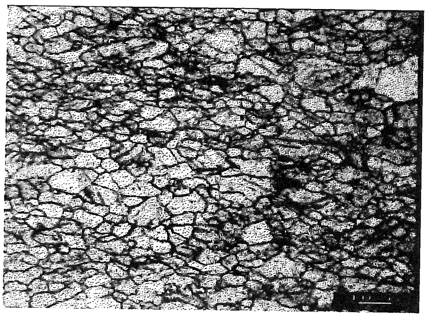

Fig. 1. Highly-oriented limestone from the Szendrő Mts.

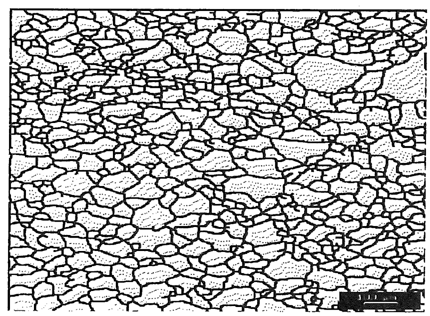

Fig. 2. Binary image of Fig. 1.

In this visual field parallel test gridlines were put down (Fig. 3). Fig. 4 shows only the grids falling inside the particles.

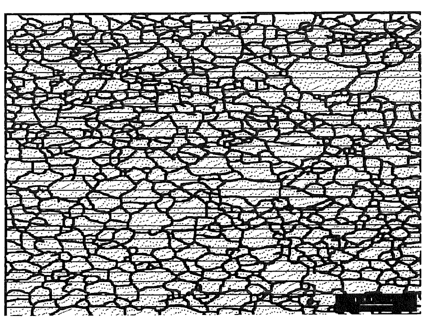

Fig. 3. Parallel gridlines drawn on binary image.

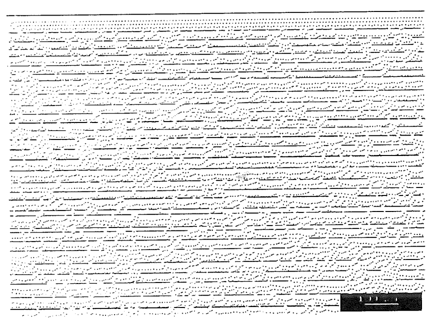

Fig. 4. Grids, falling inside the particles.

The average lengths of grids were calculated by repeated measurement, revolving the test gridlines by15 degrees (Fig. 5):

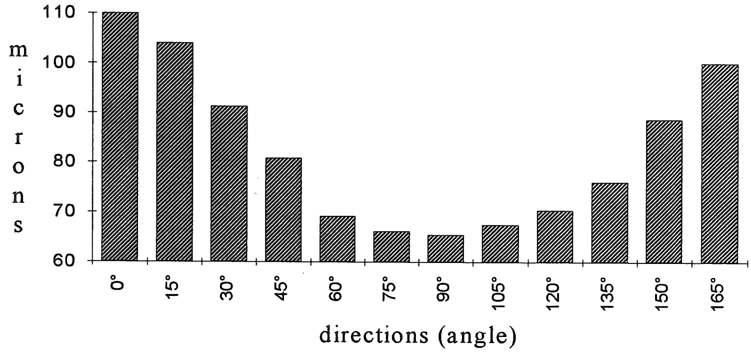

Fig. 5. Average lengths of grids as a function of direction.

As shown in Fig.5, the average lengths of grids were the longest at directions 165°-0°-15° and perpendicularly to that, at 90°-105°-120° they were minimal. The integral-value of the distribution can be used to characterize the textural orientation. Some measurement by this method was carried out on thin sections of well-recrystallized carbonate rocks from the Bükk Mts. (NE-Hungary). All sections were made parallel with the lineation. The descriptive characterization of the recrystallization and textural orientation of these rocks had been done before. We obtained reliable, good results, but the disadvantages of the method were the large number of angular measurement required.

To perform similar measurement rapidly, another method has been worked out, effectively using the possibilities of the used image analyzer, with measured data for each feature as follows:

- maximal distance in the feature (Dmax);
- area of the feature (A)
- angle between Dmax and the horizontal axis (ß), counted by 15 degrees, characterizing the direction of the Dmax of the anisometric particle in the section.
- equivalent circular diameter (ECD) counted by the formula:

$$ECD = \sqrt{\frac{4A}{\pi}} \qquad (1)$$

For the visual field mentioned above, the angular distribution of the Dmax for all particles is shown in Fig. 6:

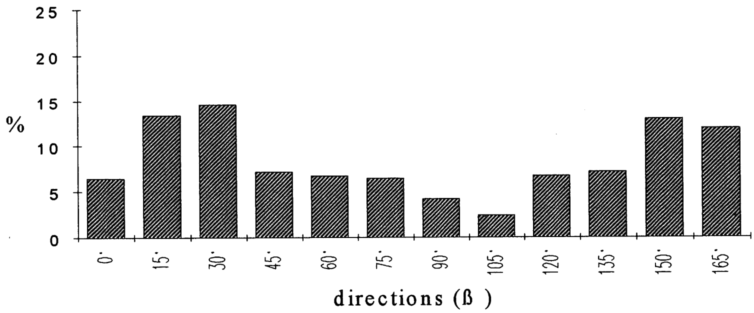

Fig. 6. Distribution of Dmax of particles.

This is unlike the distribution obtained by the first method, a disordered distribution. The reason for this is that in the second case the isometric particles having random-oriented Dmax were also analyzed. It is possible to eliminate the effect of the isometric particles on the distribution by a filtering process using form-factors.

It has been found that a form-factor using the particle diameter (Dmax) and the equivalent circular diameter (ECD) by the formula:

$$anisometry = 1 - \sqrt{\frac{D\max - ECD}{D\max + ECD}} \qquad (2)$$

can be used for filtering isometric particles. The value obtained by formula 2 is decreasing as the elongation of the particle becomes greater, and particles having the value less than 0.7 can be considered anisometric. It has been also found that this form-factor depends less on roughness and surface texture, than the sphericity value defined by Wadell (1932).

Fig. 7 shows the angular distribution of Dmax of particles having factor of anisometry less than 0.7.

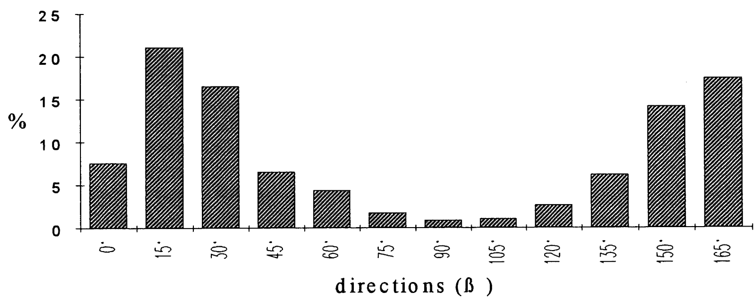

Fig. 7. Disrtibution of Dmax of particles, selected at anisometry < 0.7.

The greatest part of Dmax had an orientation of 165°-15°, and only a few particles were oriented perpendicularly to that. The histogram has more regularity than fig. 6, and correlates much better with the angular distribution of the average lengths of grids, calculated by the method mentioned above.

In order to characterize this distribution, correlation coefficient was computed with function:

$$c(i) = \frac{\cos\left(\frac{\pi}{6} i\right) + 1}{2} \qquad (3)$$

$$\text{as} \quad \Omega = corr(an(i), c(i)) \cdot g \qquad i := 0°, 15°, 30° \ldots 165° \quad (4)$$

where Ω is the degree of linear orientation; an(i) is the angular distribution of Dmax of particles, selected at factor of anisometry < 0.7; g is calculated by

$$g = \frac{|an(i) - 16.66|}{2} \qquad (5)$$

because c(i) also has a single maximum in the domain 0°-180°, and a minimum at 90° to the maximum (like an(i)), and g describes the deviation of an(i) from average value.

RESULTS

The results of the two different methods showed a good correlation. The degree of textural orientation was measured for other 10 thin sections, using the distribution of the orientation of the Dmax (Table 1). The group of thin sections contained isotropic, low-oriented and highly- oriented samples identified by visual investigations on sections parallel with the lineation in case of oriented samples.

Highly-oriented textures had correlation coefficients between 0.6-0.9, low-oriented ones had some between 0.1-0.5 and isotropic textures had varying values.

No of thin section	orientation by visual examination	Ω
806	isotropic	0.318
1001	isotropic	0.152
1238	low-oriented	0.127
1175	medium-oriented	0.192
996	medium-oriented	0.26
951	medium-oriented	0.465
1005	highly-oriented	0.649
1085	highly-oriented	0.716
1100	highly-oriented	0.64
832	highly-oriented	0.938

Table 1. Comparison of the degree of preferred orientation characterized by visually and by measurement.

DISCUSSION

In the course of the measurement and the evaluation of data two problems have been detected, diminishing the petrographic applicability of the method. First, the TV camera of the image analyzer equipment could only detect particles with a high degree of crystallinity, i.e. particles of well-recrystallized rocks. So there is no answer to the important question whether the evolution of recrystallization correlates with an increasing degree of textural orientation, or not.

The second problem is the characterization of isotropic textures with the second method. In the case of isotropic textures the directions of Dmax of all particles must be randomly distributed. As the factor of anisometry slightly depends on roughness and surface texture of the particle, there should be a difference between the factors of anisotropy of isotropic particles with smooth and with rough contour. It has been found that this effect causes large discrepancy of resulting values. Therefore this method is only applicable for the characterization of monomineralic textures having a definite orientation.

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