11. SYMMETRY OPERATIONS ON THE QUASI-PERIODIC BIOPOLYMER STRUCTURES OF THE WALL OF BOTRYOCOCCUS BRAUNII KÜTZ. I.

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Abstract

Using the two dimensional symmetry operations on the biopolymer structures of the partially degraded colonies of *Botryococcus braunii* isolated from Upper Pliocene oil shale from Pula, new data were obtained. Connected regular pentagons (biopolymer A and B) and one in oblique position (biopolymer C) were rotated with fivefold and tenfold primary rotation. The fivefold primary rotation resulted the quasi-crystalloid molecular structure of one globular biopolymer unit. At biopolymer C three globular units were observed in the TEM pictures, the fivefold rotation revealed the complete regular pentagon. A great number of secondary points of symmetry appeared, which may be useful for further symmetry operations.

Key words: Botryococcus braunii fossil, biopolymer symmetry operations.

Introduction

The different kinds of pecularities of the oil producting alga, *Botryococcus braunii* KÜTZ., were pointed out in several papers. During previous times the chemical composition of the wall was separated from the sporopollenin and the terms alganeane, later botryococcene (for the recent) and botryococcane (for the fossil colonies) were introduced, cf. BERKALOFF et al. (1983), KADOURI et al. (1988), ARAUJO et al. (1998). Biopolymer structures which may be modelled with the fullerenes were observed first on the partially degraded and fragmented wall of *Botryococcus* colonies. (KEDVES, ROJIK and VÉR, 1991). The metastable quasi-crystalloid biopolymer skeleton which is also present in the wall of *Botryococcus braunii* was investigated in detail by KEDVES, TÓTH and FARKAS (1993) and KEDVES, TÓTH and VÉR (1995). The quasi-periodic and quasi-equivalent biopolymer symmetry are in contradiction, this is also a peculiarity of the biopolymer organization of the *Botryococcus* colonies. To obtain information concerning the connections of the two kinds of organization, the first attempt were made by KEDVES, TRIPATHI, VÉR, PÁRDUTZ and ROJIK (1998). In this paper it was pointed out, that in spite of some advancement, this problem is not sufficiently resolved.

During our new combined researches, different kinds of partial degradations were carried out and the investigations were made with LM, SEM and TEM method (KEDVES et al., 2000). TEM results of some partially degraded colonies are suitable for symmetry operations. Three peculiar regular pentagons were the subject of the present investigations.

The aim of this paper to obtain fresh informations about the peculiar biopolymer system of this kind of colony.

Materials and Methods

In one previous paper (KEDVES et al. 2000) the first part of the results of the new experimental study of *Botryococcus* colonies were published. The experiment No. AKP-99-7. resulted in suitable biopolymer structures for symmetry operations. Negatives taken with Opton Zeiss instrument (resolution 2-3 Å), were used. The basic two-dimensional rotation methods were used (KEDVES, 1989a, b) with new combinations.

Two complete and one incomplete regular pentagons were the subject of our investigations.

Results

Biopolymer "A" and "B" are connected with one "common" globular biopolymer unit of the regular pentagons. In consequence of the position of the pentagon "C" three globular units were well seen in our picture. Two units are "common" with the pentagon "B". The units C/3 and C/4 were supposed (Plate 11.1.). The primary rotations centre (P) and the rotation axes P-A/X are indicated in this figure.

Biopolymer "A"

C.P.5.A.5.5. (Plate 11.2.) rotation was carried out twice. There are minor differences between the two results. The basic pentagon was reinforced and a light stellate area appeared. At the apices of this light star there are characteristic dark points of symmetry. At the first globular unit of the second fivefold rotation the cyclic molecular cluster was also appeared. The tenfold rotation resulted ten dark points of symmetry, this circle is followed by ten not so characteristic light points of symmetry. Large dark units are around this light sometimes radially elongated light area. Further dark points of symmetry are in the deepest part of the light radiating area its number is in all probability 20. It is a dark border around the light radiating zone composed of several globular points of symmetry.

Biopolymer "B"

C.P.5.A.5.5. (Plate 11.3.) resulted in two regular pentagons composed by not so characteristic points of symmetry. The first point of symmetry of the outer pentagon is in the direction of the rotation axis. The points of symmetry of the inner pentagon are oriented in the middle of the sides of the outer pentagon. A light pentagon represent the rotation area. Around of this area there are characteristic dark points of symmetry. C.P.5.A.5.10. (Plate 11.3.). In one circle ten not so characteristic, more or less triangular points of symmetry, appeared. This circle is surrounded by a light radiating zone. Around this zone there are characteristic dark points of symmetry.

Plate 11.1.

Botryococcus braunii KÜTZ. TEM picture of the biopolymer system of the partially degraded colonies with experiment A.K.P.-99-7A. The biopolymers A, B and C, and its rotation axes are indicated, 2,000.000x.

Plate 11.2.

Rotation pictures of the biopolymer A. The upper two and the lower picture left is 1,000.000, the lower right picture, 2,500.000x.

Plate 11.3.

Five and tenfold rotation pictures of biopolymer B and C: 1,000.000x.

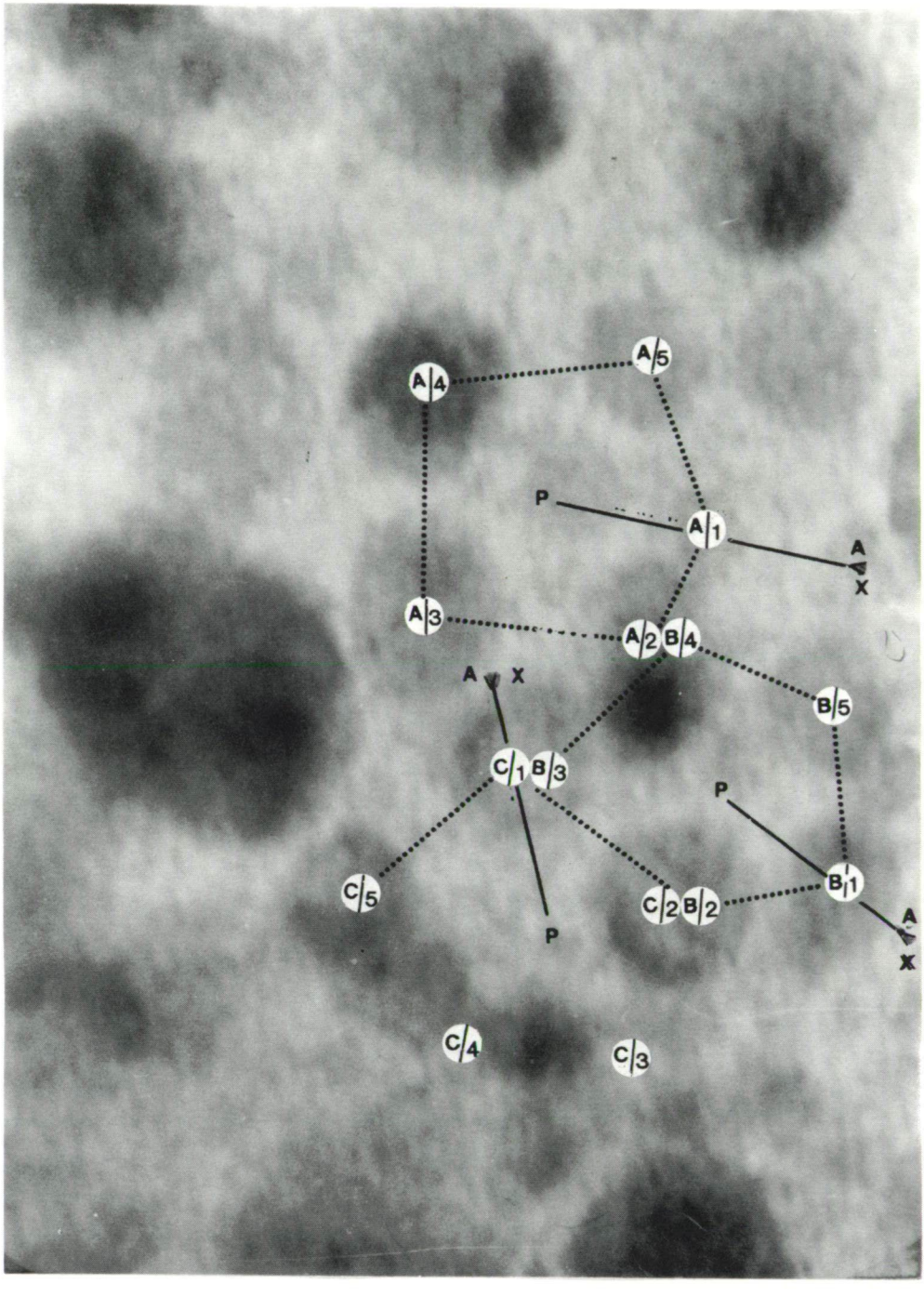
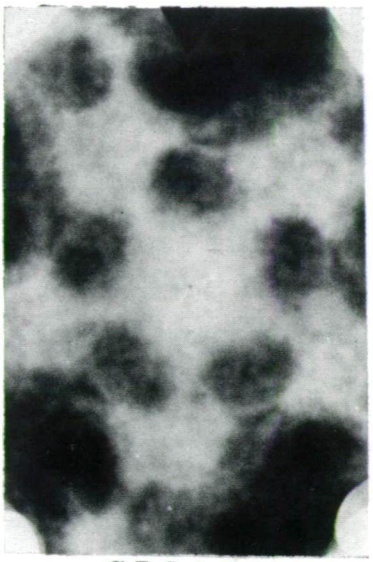


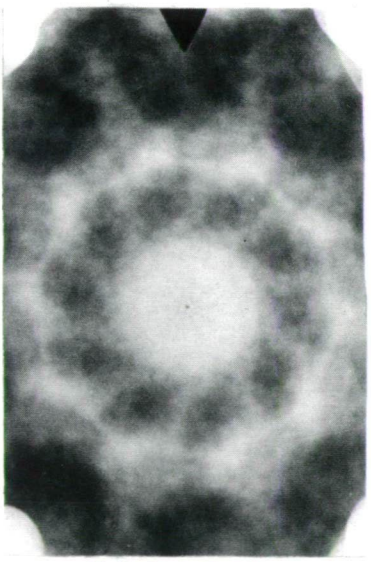
Plate 11.1.

BIOPOLYMER A



C.P.5.A.5.5.

C.P.5.A.5.5.

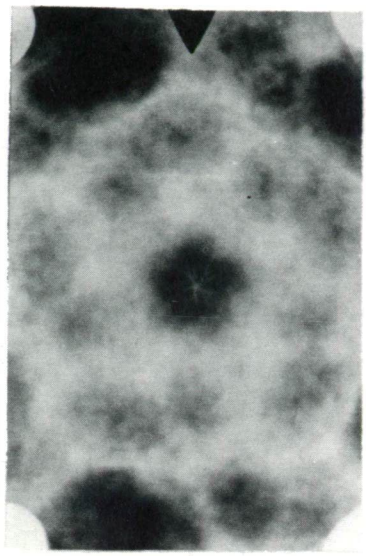


C.P.5.A.5.10.

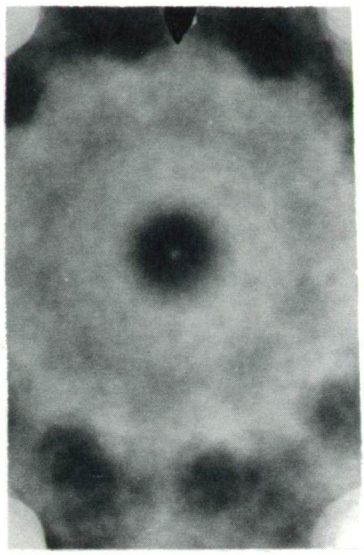
C.P.5.A.5.5.

Plate 11.2.

BIOPOLYMER B

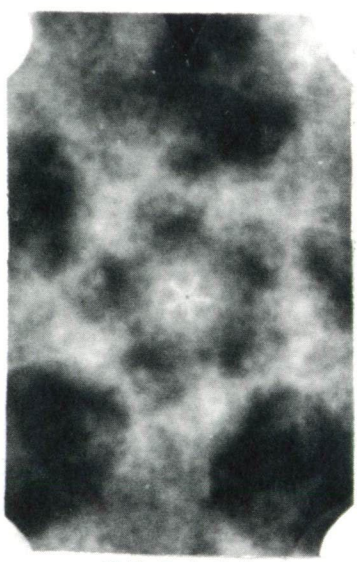


C.P.5.A.5.5.

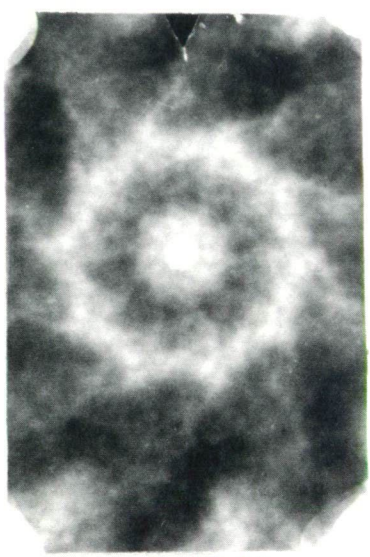


C.P.5.A.5.10.

BIOPOLYMER C



C.P.5.A.5.5.



C.P.5.A.5.10.

Plate 11.3.

Biopolymer "C" (Plate 11.3.)

C.P.5.A.5.5. were made with three globular units of the pentagon two units were expected. The fivefold rotation verified the "absent" two units , but in the centrum of the rotation another small pentagon appeared also. This is surrounded with a light more or less star forming area. The large "original" biopolymer units of the pentagon are in the sides of the light stellate area. C.P.5.A.10. rotation verified the "small pentagon". Ten characteristic dark points of symmetry appeared in a radially oriented triangular zone. A light oblique radiating zone follow the dark points of symmetry. This is surrounded by ten also oblique dark fields composed of small dark globular units.

Discussion and Conclusions

Two regular pentagons were rotated (A, B) with one common unit (A/2, B/4). The presumed pentagon C was originally represented with three globular units (C/1, C/2, C/5). C/1 is common with B/3 respectively C/2 with B/2. C/3 and C/4 was presumed.

1. The repeated rotation revealed that there are differences between the results.
2. Molecular cluster was demonstrated.
3. Fivefold rotation resulted two pentagons in opposite position at biopolymer B.
4. At the tenfold rotation at biopolymer B the points of symmetry of the extra rotation area are characteristic.
5. The pentagon C was represented by three globular units, the fivefold rotation discovered the total regular pentagon. Small pentagon appeared in the middle of this large pentagon. The tenfold rotation picture verified the oblique position of this regular pentagon.

Taking into consideration the interesting results of the secondary rotations of the extra areal points of symmetry further rotations are planned on larger photographic paper to get more informations about the remote points of symmetry from the rotation centrum.

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