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ELECTRON MICROSCOPY AND ULTRASTRUCTURE OF A MAGNETOTACTIC MICROORGANISM

by

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ABSTRACT

Transmission and scanning electron microscopy of magnetotactic microorganisms with diameter in the order of 6 μm show a complex internal structure indicating that they are a colony or aggregate of similar cells, with a large number of high density regions responsable for the observed magnetotaxis.

In a recent work[1] we described magnetotactic microorganisms found in waters of Rio de Janeiro. One of these is a large South seeking microorganism collected in Rodrigo de Freitas lagune, with approximately spherical shape and dimensions between 5 to 7 μm, as is illustrated in fig. 7 and 8 of ref.[1]. These microorganisms have been recently observed in marine waters (Guanabara Bay) and similar ones with North seeking orientation at Woods Hole (R. Blakemore and R. Frankel, personnal communication 1982).

We report here transmission (TEM) and scanning (SEM) electron microscopy as well as preliminary results from X-ray microanalyses which show that a complex microorganism presents specialized regions responsible for the magnetic interactions with the geomagnetic field.

Whole cells were put in grids covered with colodium films, fixed with osmium vapour and observed in TEM. To obtain ultra-thin sections the magnetically concentrated samples were fixed in Glutaraldeyde and processed inside small plastic tubes until the EPON inclusion.

For SEM the samples were concentrated magnetically over a slit with Poli-L-Lysine. In a few minutes a convenient cell population was obtained which was next fixed in Glutaraldeyde. The preparation was dried by the CO_2 critical point technique and after the sputtering with Au (∿200 Å) we examine the slit in an optical microscope. By this procedure it was possible to observe the same microorganism optically and in SEM.

Figures 1 show the results obtained in TEM of a whole cell fixed in osmium vapour. With abundant fibers at the external surface these microorganisms contain a number of high density grains with dimensions around 700 Å, shown in fig. 1b. These grains with more or less regular shape, are distributed in groups of approximately parallel chains. Micrograph analyses gives an estimation of more than 1000 dense regions in the interior of these microorganisms.

Figures 2 show one of these microorganisms in an ultra-thin section. More than 10 cells are observed, separated by double membranes and envolved by a radial periodic arrangement of some coat. X-ray microanalyses of the high density grains in their citoplasm shows the presence of iron. This grains must contain a percentage of magnetite (Fe_3O_4) forming magnetic specialized regions to make possible the magnetic orientation observed, and possibly surrounded by a membrane around each dense region. It is also observed invaginations on the double membrane of some cells and some other specialized structures in the interior of each cell, similar that found in some magnetotactic bacteria[2,3] and in the Rhodospirillum[4,5].

In SEM we observed apparently two types of microorganisms, or the same at two different stages of evolution. We have not observed flagela or cilius, but these microorganisms possess great mobility (more than 20 diameters/sec). In Fig. 3a something like a globular substructure disposed in an helicoidal arrangement is observed. In Fig. 3b the presence of a great number of filaments around the surface make difficult the observation of this shape.

The presence of two types of microorganisms have also been suggested by specific characteristics of the movement and populations such as the distribution of velocity centered in two points, one near 60 μm/s and the other at 100 μm/s. The low magnification optical observations (c. 400 x) shows a behavior similar to flagelar unicelular microorganisms with a light green coloration which suggests the presence of chlorophil.

These results indicate that this microorganism is a kind of an unusual aggregate or colony. If we suppose that all the dense regions are magnetic with parallel magnetic moments we estimate the each dense region must be constitued by about 10% of magnetite, to be consistent with our measurements of the total magnetic moment of this microorganism[1].

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FIGURE CAPTIONS

Figure 1 - a) Osmium vapour fixed transmission electron microscopy of a whole magnetotactic microorganism surrounded by fibers. (x 14500).

b) High dense grains containing iron (x 23000).

Figure 2 - Ultra-thin sections of magnetotactic microorganism with high dense grains

a) [g] High dense grains containing iron, [p] radial periodic structure, [dg] dense granules (x 17500).

b) [dm] double membrane, [m] possible membrane around the grains, [pm] structure similar to polar membrane (x 94000).

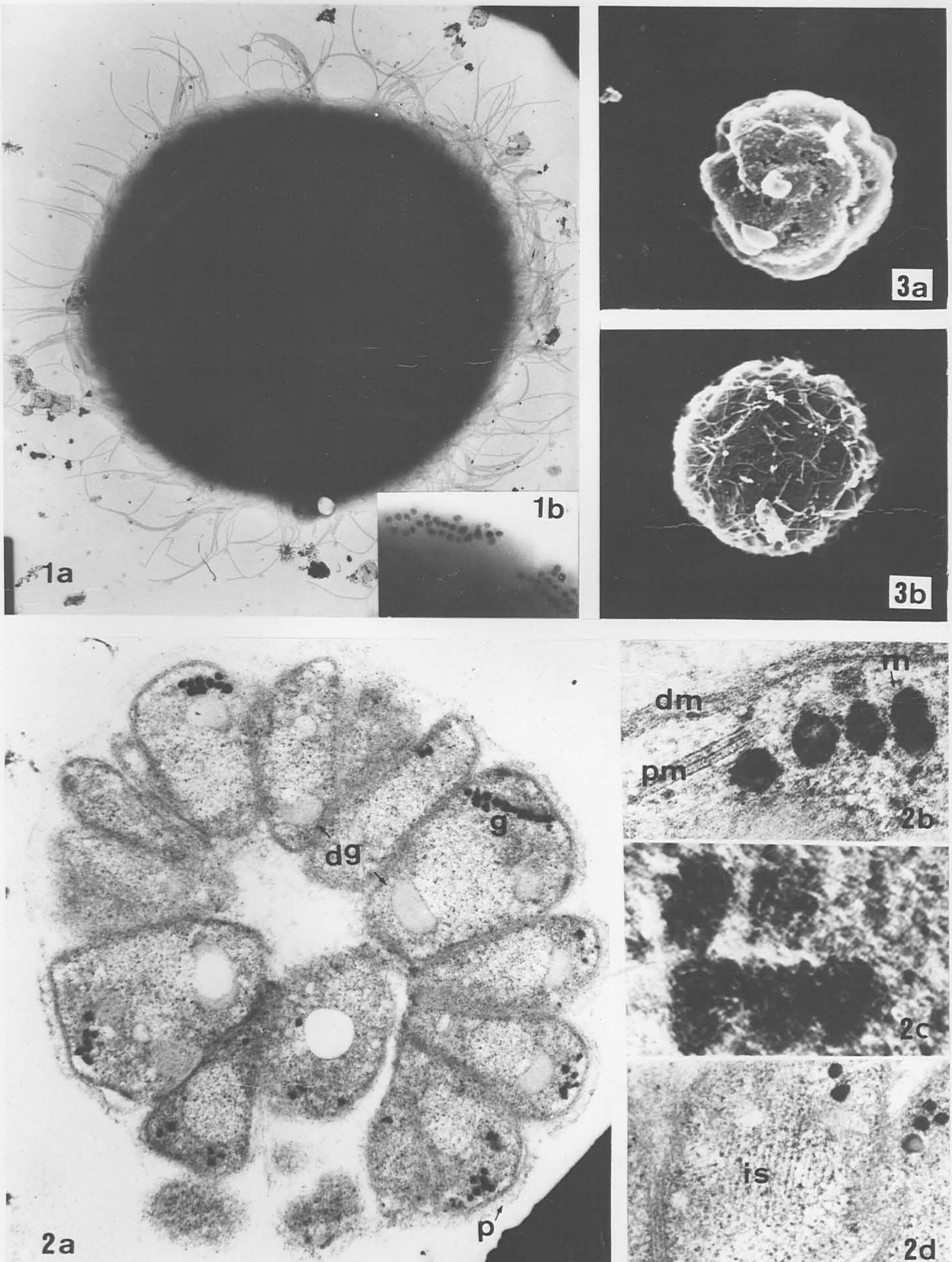
c) Great magnification (x 170.000) of grains showing possible substructure.

d) [is] internal structure found inside some cells (x 32000).

Figure 3 - Scanning electron image of magnetotactic microorganisms found in the same preparation

a) x 9000

b) x 7500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