THE EFFECT OF MANGANESE ON THE GROWTH OF *SPHAEROTILUS DISCOPHORUS*

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INTRODUCTION

Bacterial mineral transformation is an important component of mineral cycling in the sea. Depending on in situ physical parameters such as pH and oxygen tension and biological parameters such as nutrient availability, bacteria can either oxidize or reduce minerals, precipitating or solubilizing them.

This study will focus on one portion of this overall picture, bacterial manganese oxidation. This process has been implicated in the formation of manganese nodules (6). These concretions of manganese, iron, and trace elements are found widely distributed on the ocean floor.

For the purposes of this study, the bacterium Sphaerotilus discophorus was chosen as a test organism as it was readily available and has been used in previous similar studies (1, 7, 9). Although S. discophorus is not a marine bacterium, detailed knowledge on the physiology of its ability to oxidize manganese may provide a model against which other systems may be compared.

Sphaerotilus discophorus is a filamentous sheathed bacterium that can deposit ferric and manganic oxides in its sheath. It is generally found in aquatic environments, particularly streams and drainage ditches. (15, 5)

Considerations such as morphology, taxonomy, and nutrition are comprehensively treated in available review articles. (15, 5). Pringsheim (15) reviews early studys on Sphaerotilus and similar organisms. The recent work of Dondero (5) reviews the entire

literature from 1888 to 1974 including a comprehensive listing of previous reviews. More recent works include a study on the effect of manganese on the growth of S. discophorus (7) and a study of the role of iron oxidation in S. discophorus (17).

The question of autotrophy in the filamentous sheathed bacteria has been controversial since 1888. In that year Winogradsky (19) concluded, from his observations of Leptothrix, closely related to Sphaerotilus, that the organism was autotrophic, obtaining energy from the oxidation of ferrous iron. In 1911, Molisch (13) published findings that disagreed with those of Winogradsky. He concluded that Leptothrix was heterotrophic, requiring low levels of organic carbon for growth. In 1919 Lieske (12) suggested that Leptothrix was able to grow mixotrophically, obtaining energy for the assimilation of organic carbon from the oxidation of inorganic material, i.e. manganous or ferrous ions. Subsequent studies by Cholodny (4) and Cataldi (3) failed to demonstrate either autotrophy or mixotrophy in the members of the Sphaerotilus-Leptothrix group.

As ferrous iron can spontaneously oxidize at physiological pH, whereas manganous manganese does not, the latter has been preferred in modern studies of the problem. Work by Pravé (14) suggested that manganese autotrophy might exist. Johnson and Stokes (9) reported that S. discophorus did actually produce Mn(IV) from Mn(II), consuming oxygen in the process, and that this oxidation was mediated by an inducible enzyme system. Ali and Stokes (1) reported that heterotrophic growth was stimulated by the presence of

manganous ions, and that autotrophic growth occurred in a mineral salts medium containing Mn(II) as the only energy source and trace levels of biotin, thiamine, and cyanocobalamin. More recent reports, however, have presented evidence casting doubts on these results. (18, 7)

Thus, the question of whether Sphaerotilus can obtain useful energy from the oxidation of manganese has remained unanswered. Previous studies have focused on protein as an estimate of biomass (1, 18, 7). In the present study, the level of high energy nucleotides consisting primarily of Guanosine-5'-triphosphate (GTP) and Adenosine-5'-triphosphate (ATP) were used as an estimate of biomass in an attempt to outline the response of Sphaerotilus discophorus to various concentrations of dissolved manganese, and provide some insight as to whether the oxidation process provides useful energy for the cell, or is a means of detoxification.