The globulins do not settle, and remain in suspension for many days. The pH of the solution plays an important part in the phenomenon; but this side of the question will be taken up in another paper. Suffice it to say at present that the solution must be slightly acid in order to observe an immediate difference in the rate of sedimentation. With less acidity, the phenomenon is only postponed.

In the serum unheated, or heated below 57°, the phenomenon of sedimentation starts very abruptly, and is very rapid at first, as in a given volume the number of scattering particles is more than halved in 5 minutes. However, as Rayleigh's formula only holds for particles which are small with respect to the wave-length of light, and as we have at present no information concerning their size, we can not as yet interpret the figures satisfactorily.

Nevertheless, a new phenomenon can be added to the four which, as we have already shown, characterize the critical temperature of serum, namely, viscosity, rotatory power, scattered light, depolarization factor. But this last one brings forth something more, as it applies to the behavior of the globulins alone, when the total serum was heated at or above 58°. Without drawing any hasty conclusions, one can not help wondering if the destruction of the complement might not be connected primarily with the globulin fraction of the serum.

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THE POSSIBLE RÔLE OF MICRO-ORGANISMS IN THE PRECIPITATION OF CALCIUM CARBONATE IN TROPICAL SEAS[1]

FOLLOWING the same procedure carried out in the investigation of marine "calcium bacteria" by Drew, Kellermann and Smith, Lipman and others, extensive personal observations were made in the region of Andros Island, while the experimental studies were carried out in the laboratories of soil microbiology at the New Jersey Agricultural Experiment Station, at New Brunswick, New Jersey. Only a brief summary of these experiments may be presented here. The results so far obtained make it appear that the question concerning the rôle of micro-organisms in the formation of sediments in the ocean, especially their activity in the precipitation of calcium carbonate, may be reopened again.

In the course of a trip of three weeks' duration during the months of March and April, 1930, to the Great Bahama Banks, to Andros Island and to a smaller island off the west coast of Andros, or Williams Island, various samples of mud were collected with special instruments, at several carefully selected locations and from different depths, in order to carry out the investigations in the laboratory named above; likewise direct microscopic observations of the microflora of the material collected were made immediately, soon after the samples were taken.

At the laboratory in New Brunswick, experiments were begun first by counting the numbers of micro-organisms in the mud, since to date there is no sufficiently definite information dealing with the number or with the quantitative distribution of organisms which might possibly take a direct or indirect part in the process of calcium carbonate precipitation. These experiments led to the discovery of certain interesting and characteristic differences in the different regions of the ocean.

In agreement with the observations of the earlier investigators, it was discovered—if we disregard the water of the high seas with its well-known low bacterial population—that relatively few bacteria occur in the white calcium carbonate mud of the Bahama Banks and off the west coast of Andros; the numbers of bacteria in the different layers of this mud, as determined by the plate method, vary from a few cells to 5,000, 10,000 and 100,000 cells per gram of moist mud. At other locations, however, as on the coast of Williams Island, and especially in the mangrove swamps situated farther inland, the number of bacteria increase considerably. The surface layers of the mangrove swamp of Williams Island, for example, contain over sixteen million bacteria per gram and, even at a depth of four feet, over two million bacteria could be found in one gram of material.

Among the organisms which have been isolated by special culture methods from the samples, there were many forms which have been for the first time found to exist on the coast of this interesting island. The existence of a typical microbial population was found both by direct examination and by laboratory studies.

Of this population, sulphur bacteria, Oscillatoria, certain diatoms and Protozoa play the chief part. It was possible to identify several colorless and red colored Thiobacteria and it was further possible to

[1] This is one of a number of papers resulting from The International Expedition to the Bahamas in 1930. The object of the expedition was to collect all possible data concerning the relation of the stability of the Bahama "Block" to the origin, migration and alteration of the sediments which mantle its surface. A further paper "On the Decomposition of Agar-agar by an Aerobic Bacterium," by Dr. Selman A. Waksman and Dr. Bavendamm, is being published. Dr. Bavendamm was appointed to the staff of the expedition by the Deutsche Forschungsgemeinschaft. All the bacteriological work was done with the advice and under the direction of Dr. Waksman at the New Jersey Agricultural Experiment Station.—Richard M. Field.

assign a new position to the rare *Beggiatoa mirabilis* of the Bahama Islands.

It is astonishing that such conspicuous forms, such as the sulphur bacteria, have never been mentioned before. It is equally surprising that the numerous anerobic bacteria found in the mud have been similarly disregarded.

As to the organisms which may be responsible for the precipitation of calcium carbonate, the following observations may be reported here:

Apart from the kinds which Drew and others have termed erroneously "calcium bacteria," going so far as to attach special names to them, there were found in many places numerous urea bacteria which to this day have escaped observation. These bacteria, like the denitrifying forms observed by Drew and other scientists, are able to precipitate calcium carbonate under certain conditions. Also the strictly anerobic sulphate reducing bacteria, which seem important in the process of calcium carbonate precipitation, were found to exist everywhere.

The presence of very active cellulose and hemicellulose destroying bacteria attracted special attention. These organisms were subjected to a closer investigation. Some of the bacteria are noted for their ability to dissolve agar-agar made from brown and red algae; these bacteria occurred in such vast quantities that they are believed to be responsible not only for the decomposition of the abundant organic matter in the mangrove swamps, but together with other bacteria they might be indirectly partly responsible in the precipitation of $CaCO_3$.

The author does not agree with Lipman's ideas (1929), whose conclusions on this subject have been based on experiments which were not sufficiently convincing; rather he is of the opinion that in reference to the vast calcium carbonate sediments in the tropical sea of to-day and of former geological periods we have to deal not with strictly chemical-physical, but primarily with microbiological processes. These results were obtained not only from the inspection of crude and pure cultures of the various organisms in the laboratory, but also from personal observation of the conditions *in situ,* as considered from the botanical-bacteriological-hydrobiological view-point; finally, from simple conclusions resulting from a study of bacteriological, botanical, geological, chemical, physical and oceanographic literature.

The author believes that the bacteriological process of calcium carbonate precipitation may be confined to certain locations. The shallow and richly manured mangrove swamps in particular may assist one in reaching this conclusion, for they represent an ideal habitat of bacteriological life, and it is here that we find especially pronounced bacterial activities.

The assumption that mangrove swamps or similar places represent the natural locations for the microbiological calcium carbonate precipitation is strongly supported by the observations of the geologists participating in the expedition. It is their opinion that we were possibly dealing with fresh or brackish water sedimentations. This view is in no way opposed to the results of the microbiological investigations, since we know that many of the bacteria mentioned may adjust themselves easily to a varying concentration of salt in the water, also that for similar processes related conditions have been found to exist.

The chemical-physical factors of this important geological process should of course not be disregarded. However, their importance may be no more than secondary and may serve to explain why such large quantities of calcium carbonate have not been precipitated at other places on the earth which possess virtually the same microflora and the same external features as the tropical sea.

We are dealing here with a complicated but not inexplicable collaboration of various factors which serve to make the problem of calcium carbonate deposits intelligible. How the different processes are probably related to each other and how the necessary investigations in the future must be carried out is to be discussed later in a detailed publication in German, probably to appear in the *Internationale Revue für die gesamte Hydrobiologie und Hydrographie.*

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