MARINE ORGANISMS AND BIOGEOCHEMISTRY

AT the Bristol meeting of the British Association, a joint session between Sections D (Zoology), B (Chemistry) and C (Geology) was devoted to papers on the topic of "Marine Organisms and Biogeochemistry". Dr. C. F. A. Pantin, who was in the chair, stressed the value of joint meetings. It is in these borderline fields, he said, that many complex and interesting problems are found, which for a variety of reasons are generally more difficult to solve than those of the traditional scientific disciplines.

The first paper, by Dr. J. D. H. Wiseman, of the British Museum (Natural History), was on the rates of accumulation of nitrogen and calcium carbonate on the equatorial Atlantic floor. The rate of accumulation of nitrogen is, under ideal conditions, a measure of biological activity, and similarly the rate of accumulation of calcium carbonate is a measure of the productivity of those organisms which secrete calcium carbonate, provided there has been no solution subsequent to deposition. Dr. Wiseman said that geochemically it is significant to determine these rates, and to discover whether a change can be correlated with an alteration in some fundamental property in the upper layer of the sea. The investigation has been carried out on sixty sections each approximately $\frac{1}{2}$ cm. thick. These were taken continuously down an equatorial Atlantic core, collected by the Swedish Deep-sea Expedition of 1947-48. Sedimentation in this core had apparently been continuous, and there was no evidence of disturbance by benthonic organisms, or through other causes.

In order to compute, from the percentages of nitrogen and calcium carbonate, rates of accumulation, it was necessary to determine the weight of dried salt-free sediment in a column of unit area through each section in its original moist condition (hereafter called weight of sediment in the section), as well as the number of years (the age) required to deposit each section. The weight of sediment in a section of known thickness can be computed from its chlorinity. The reason for this is because in highly calcareous deep-sea sediments, composed for the most part of planktonic foraminifera and a clay component, there is a relation between the weight of salt-free sediment in 1 c.c. of the moist sediment and its salt content. Age computations are, therefore, made from the weight in each section of selected elements, the rates of sedimentation of which have been shown to remain constant with time. Dr. Wiseman said that to understand the method it is necessary to appreciate the origin of the non-biological components of deep-sea sediments. The components may be divided into two classes: the hydrogenous components, and the unweathered high-temperature minerals derived from the lithosphere. Included in the hydrogenous components are the secondary minerals formed by ionic reactions in the continental hydrosphere. There are also substances precipitated in the marine hydrosphere—for example, as hydroxides—and some probably in the form of alumino-silicate sols. In addition, there are elements chemically scavenged from sea water. The high-temperature lithogenous minerals are derived from the land, as well as from submarine rocks and vol-

canoes. Minerals from this source are fortunately very rare in this core.

If the rate of sedimentation of any one of the components of either class changed, this would in general be reflected in a change of chemical composition. For example, if there were a sudden addition of the lithogenous mineral ilmenite, this would be shown by a change in the titanium percentage when expressed on a carbonate-free basis, as well as in the iron/titanium ratio. Dr. Wiseman then gave the theoretical reasons for constancy in the rate of sedimentation of the hydrogenous components in those areas of the deep-sea floor where there had been no superimposed complications. Changes in the rate of sedimentation of the non-biological components were found in terrigenous sediments (derived largely from the land), and in some deep-sea sediments, especially those from volcanic regions, or where there had been sediment transportation by turbidity currents. It was therefore essential, before computing age, to check from the chemical composition of each section that the rates of accumulation of the selected elements had remained constant with time, and that there had been no post-depositional chemical movement.

The percentages of iron and titanium, expressed on a carbonate-free basis, as well as the iron/titanium ratios, showed in this core no appreciable variations. From this it was concluded that there were no significant changes in the rates of accumulation or post-depositional movement of these two elements. The age of each section was computed from the iron and titanium percentages, and where there were notable percentage differences between the two results (the greatest was 12 per cent), it was possible to make an objective choice.

A graph of the rates of accumulation of calcium carbonate for each section shows that the annual rate varies between 0.9 and 1.1 mgm./cm.² during the past 7,000 years; then there is a rapid fall, and at approximately 15000 B.C. the rate is 0.28 mgm./cm.². Similarly, the annual rate of accumulation of nitrogen varies between 2.4 and 3.6×10^{-4} mgm./cm.² during the past 7,000 years, followed by a rapid fall to 1.1×10^{-4} mgm./cm.² at approximately 16000 B.C.

Biological examination has demonstrated that when the foraminiferal assemblage was of a warmer type, the rates of accumulation of both calcium carbonate and nitrogen were higher. This conclusion is strongly supported by the temperatures (Table 1) at which the shells of planktonic foraminifera were deposited. These temperatures are based on oxygen-18 measurements, carried out by Dr. C. Emiliani.

Dr. Wiseman concluded that, in the equatorial Atlantic Ocean about 15000 B.C., when the upper layer of the sea was about 5 deg. C. cooler, the rates of accumulation of both nitrogen and calcium carbonate were approximately a third of their present-day values.

The second paper, by Mr. M. V. Strong, of the British Petroleum Research Station, was on iron bacteria as rock-forming organisms. Mr. Strong said

Table 1

Section No.	P3	P46	P48
<i>Globigerinoides sacculifera</i>	24.3° C.	21.2° C.	20.1° C.
<i>Pulleniatina obliquiloculata</i>	21.0	17.9	17.1
<i>Globigerina dubia</i>	19.7	15.0	13.6
<i>Globorotalia menardii</i>	18.7	16.8	—
<i>Globorotalia tumida</i>	15.3	13.6	13.8
Annual rate of accumulation of calcium carbonate	1.00 mgm./cm. ²	0.46 mgm./cm. ²	0.34 mgm./cm. ²
Date of mid-point of section	A.D. 1200	11750 B.C.	12800 B.C.

that the object of his paper was to bring to the attention of microbiologists organic remains, apparently bacterial, preserved in Permian rock salts. Most of the material investigated is from a deep bore-hole at Eskdale. Some of the forms described by Mr. Strong are identical with those in lower Palaeozoic rock salts of Saskatchewan. It is of considerable interest that this organic material has so far been found only in red rock salts, in which the iron is present in minute haematite crystals, or possibly goethite.

The organisms occur as bright red discrete aggregates, which float upwards on dissolving the salt; the most common forms being needles up to $\frac{1}{2}$ mm. in length. They may be sinuous or straight, and are apparently without branches; the threads may form a network, or may be set in a fine membrane of yellowish material. Rarely the threads show a swollen termination, either cylindrical or spindle-shaped with a grooved point. They are highly resistant to heat and acids, and no internal structure has been seen.

Another common form includes fragments of membranous tissue, sometimes apparently structureless, and at other times enclosing a close mesh of threads. A third form is a cyst-like, lozenge-shaped sac of permeable membrane, enclosing liquid. The length is $\frac{1}{2}$ –1 mm. and the width slightly smaller. Twisted threads recalling *Gallionella* occur in the form of ribbons. Mr. Strong suggested that the deposits of haematite found on certain islands in the Persian Gulf may be due to the solution of salt plugs in sea water.

The third paper, on the biogeochemistry of strontium, was by Dr. H. J. H. Bowen, of the Atomic Energy Research Establishment, Harwell. Since the advent of nuclear fission, there has been considerable interest in the biological fate of strontium, as two of its isotopes are among the longer-lived fission products of uranium-235. In particular, strontium-90 constitutes the major hazard, since its half-life is approximately twenty years. The element is readily taken up by plants, and in consequence may be concentrated in the bones of animals feeding on contaminated fodder. Although strontium is widely distributed in Nature, little is known about its behaviour in living organisms, apart from the fact that it tends to follow calcium. Limited knowledge about the biological behaviour of strontium is due in part to the lack of sufficiently sensitive analytical techniques for determining small amounts of the element, as well as to chemical interference of calcium, which in biological material is always present in large amounts. Spectro-

metric determinations are never very precise, and can seldom determine less than 10^{-5} gm./ml. of the element. The method of activation analysis, developed at Harwell, is sufficiently precise to determine 10^{-7} gm./ml. of strontium and is a major advance in the study of the inactive element. The method is used for investigating the occurrence of strontium in rocks, plants, marine organisms and sea water.

In view of the similarity of strontium to calcium, the calcium/strontium ratio is a better index of concentration by an organism than its absolute content. For example, the ratio is 50/1 in sea water, whereas in marine algae (*Laminaria*) it is about 10/1, and in molluscan shells about 200/1. Dr. Bowen concluded from these figures that *Laminaria* prefer strontium to calcium by a factor of five, whereas molluscs reject strontium from their shells by a factor of four. The calcium/strontium ratio in sea water is remarkably small compared with the ratio in most igneous and sedimentary rocks, where it ranges from 100/1 to 1,000/1. Strontium is, therefore, an element which accumulates in the sea, whereas calcium is removed by marine organisms and, to a small extent, by chemical precipitation.

In contrast to its behaviour in marine algae, strontium is neither rejected nor accumulated by the majority of land plants. The calcium/strontium ratio in the plant is generally similar to the available ratio in the soil on which the plant grows. However, in the Bristol district, where there are deposits of celestine, the strontium content of the soil is very high, and plants from this soil reject strontium in favour of calcium. In the Avon Gorge, a locality rich in strontium, one of the rare plants, the Bristol rock cress (*Arabis stricta*), may accumulate strontium. Further work is, however, required, because the low calcium/strontium ratio may in part be due to strontium contamination on its leaves.

J. D. H. WISEMAN

SURFACE RHEOLOGY

ANNUAL CONFERENCE OF THE BRITISH SOCIETY OF RHEOLOGY

THE annual conference of the British Society of Rheology was held in the Washington Singer Laboratories of the University College of the South West, Exeter, during September 22–24. Dr. S. Gregg (University College, Exeter) opened the conference with a paper on the effect of adsorption on the strength of brittle solids. After summarizing the general theory of the subject, he described his recent experimental work, assisted by Dr. D. Dollimore and Dr. A. Desai, on the strength of compacted disks of compressed powders, broken *in vacuo* and in controlled atmospheres. Adsorption isotherms were prepared. The density of elastic energy located between two planes at distance a apart is $\frac{1}{2} \cdot \frac{\sigma^2}{E} \cdot a$,

where σ is the stress and E Young's modulus. Although, in the case of glass at the rupture point the value of $\sigma_{\max}$ is calculated to be 10^{11} dyne cm.⁻², the experimentally measured value is about one-hundredth of this amount. The discrepancy is attributable to the weakening effect of the adsorption of water molecules on the surfaces of incipient cracks. The reduction in surface energy on exposure to vapour, ($\gamma_{\text{vac.}} - \gamma_{\text{vap.}}$), in relation to the amount