

fact, for $H = 10,000$ gauss, the emission is grouped round 1.1 cm.

These relations have indeed not yet been verified in emission, but in some ingenious absorption experiments by Rabi and his co-workers for Na^{23} , Li^6 , Li^7 , Cs^{133} , K^{41} ; but there seems to be no reason why it should not be possible to design emission experiments, for example, by putting a sodium lamp in a strong magnetic field, which is then crossed by a feeble oscillating magnetic field at right angles. Such sodium lamp ought to give out strong radio-waves of both metre and centimetre range. It is desirable to carry out such experiments in view of the prospect which they hold out of throwing light on the all-important question of stimulation of transitions.

What we have said with respect to Na^{23} will also apply to the nuclei H , Li^6 and Li^7 , B^{10} , B^{11} , N^{14} , Na^{23} , Al^{27} , and other nuclei which possess spin and magnetic moment, and therefore when forming part of an atom or molecule can exist in several well-defined quantized states produced by the electron cloud. The details of calculations will, however, widely differ, and cannot be given in this short communication; but as in the case of Na^{23} , they will give rise to both metre and centimetre waves.

The most important part in the sun and the stars will, however, be played, not by Na, but by hydrogen, because this forms, according to well-verified astrophysical arguments, 95 per cent of total number of atoms in the atmosphere of the sun; in the stars, also, hydrogen forms in the majority of cases more than 90 per cent of the atmosphere. Na was chosen simply to illustrate the phenomenon. In the spots, on account of lower temperature, the hydrides CH , MgH and SiH (and possibly H_2) are formed in great abundance, and their spectra form characteristic features of spots, but the greater proportion remains in the atomic state. For the H-atom, $\Delta\nu$ cannot be obtained from hyperfine structure experiments, but it has been calculated to have the value of $0.0163 \mu\mu = 0.0474 \text{ cm.}^{-1}$, $\lambda = 21 \text{ cm.}$, $x = H/500$, and calculation shows that both centimetre and metre waves can be emitted by the H-atom, corresponding to $\Delta f = 0$, $\Delta f = 1$. But in the case of hydrides, N_2 , CN , no experimental data or theoretical calculations are yet available; but it can be surmised that the characteristic radio-frequency waves would be much longer.

In addition to waves arising out of nuclear transitions, the rotational states of the molecules have also been shown by Rabi and his pupils to be capable of radio-frequency transitions in magnetic fields.

We consider next the possibility of nuclear emission of radio-waves of both centimetre and metre range from the sun and the stars. It now appears extremely probable that the radio-waves observed can be emitted only from the sunspots. The spots show in the centre of the umbra large magnetic fields which vary with the size of the spot², and may reach values as high as 4,500 gauss. The direction of the field is axial (that is, perpendicular to the surface of the sun) in the centre of the umbra, but it becomes inclined to the solar radius as we proceed towards the penumbra, and also diminishes in value. The values of the fields are exactly such as will promote the emission of centimetre and metre waves according to the schemes given above, and the intensity of emission will be large enough if we can postulate the existence of a small cross-field, having frequencies of the same magnitude as those of the radio-waves. It is not improbable from what we know of the

physical nature of sunspots that such variable fields do actually exist, and may partly be provided by the fields of the 'ordinary'-waves, and the 'extraordinary'-waves corresponding to the condition $f(f - f_h) > \frac{4\pi Ne^2}{m}$ coming from below, which may,

however, find it impossible to penetrate the electron barrier above (see ref. 1).

These speculations, though far from being established on a sure basis, are given on account of their promise of being able to throw light on a series of extremely interesting phenomena, the origin of which has so far appeared to be wrapped in mystery; the moment is also opportune because experiments on the subject are being undertaken all over the world. If the speculations are on the right lines, it appears that sunspots would also strongly emit radio-waves of the centimetre range. I am not aware if any such observation has yet been made. Further, the emission of centimetre waves by the stars of the Milky Way probably indicates the development of spots in these stars, which should belong to the *G*, *K* and *M* classes. But no spectroscopic observation in verification of such a hypothesis is known to me, and from the nature of things it appears extremely unlikely that any such observation is possible, unless the spots in these stars possess gigantic proportions.

¹ *Nature*, 153, 549 (1946).

² Heney and Keenan, *Astrophys. J.*, 91, 265 (1940).

³ Pawsey, Payne-Scott and McCready, *Nature*, 157, 158 (1946).

⁴ Greenstein, Heney and Keenan, *Nature*, 157, 806 (1946).

⁵ See, for example, Kusch, Millman and Rabi, "Radio-frequency Spectra of Atoms and Molecules", *Phys. Rev.*, 57, 765.

⁶ *Phys. Rev.*, 53, 441.

⁷ Nicholson, *Pub. Astro. Soc. Pacific*, 45, 51 (1933).

SOME AMERICAN FOSSIL FORAMINIFERA AND CORALS

UNDER the general title "American Old and Middle Tertiary Larger Foraminifera and Corals" (*Geol. Soc. Amer., Mem.* 9; 1945), Dr. Thomas Wayland Vaughan and Dr. John West Wells have produced a notable contribution to science. Part 1, "American Paleocene and Eocene Larger Foraminifera" (pp. x+175+46 plates) is by Dr. Vaughan; Part 2, "West Indian Eocene and Miocene Corals" (pp. iii+25+3 plates), is by Dr. Wells. It is a far cry from the brief list of foraminiferal and coral species published by Matley in 1932 (*Geol. Mag.*, 69) from the Scotland Beds of Barbados to this splendid double monograph by two well-known specialists on their respective groups.

Part I

Morley Davies's two species of foraminifera (in Matley) have entirely disappeared, to be replaced by twenty-two species and varieties, most of which are new. Study of the handsome plates with which the paper is illustrated is sufficient to convince those familiar with the groups concerned that most, if not all, of the new forms are so distinct as to be worthy of separation.

The portion of the work devoted to the foraminifera is itself divided into two parts; the first is entitled "Paleocene and Eocene Larger Foraminifera from Barbados", and is concerned to describe the material collected by Dr. Alfred Senn during his mapping of the Scotland formation in detail. The age of this has

long been established as Eocene; but the new data presented permit a more precise correlation:

Scotland Formation	{ Upper	.. Middle Eocene
Boulders from the Joes River mudflows	{ Lower	.. Low Middle or Lower Eocene
 Palaeocene.

In the systematic section of this part occurs a considerable discussion of the genus *Miscellanea* Pfender, in the synonymy of which is placed Caudri's genus *Ranikothalia*; the reviewer holds the opinion that *Ranikothalia* is valid and distinct from *Miscellanea*; that *Pellatispirella* Hanzawa 1936 is closely related to, if not identical with, *Elphidium* (*Polystomella*); and that *Sulcoperculina* Thalmann 1938 is, as Vaughan is inclined to recognize, a valid genus: however, these opinions cannot yet be substantiated, and the task of elucidating the distinctions between these five genera will probably have to await the discovery of 'hollow' material of each of the generic types, suitable for the elaboration of the 'gelatin preparations' of Dr. Earl H. Myers, a new method which is briefly described in Part 2 of this memoir.

Six years ago, the old genus *Discocyclina* (*Orthophragmina* auctt.) was raised to family status as the Discocyclinidae Vaughan and Cole (Cushman, 1940). Here, in the second part, under the title "Catalogue of American Discocyclinidae", Vaughan provides a complete review—almost a text-book—of the family. Almost twenty pages are allotted to a general account embracing structure, classification and ecology; while after thirty pages of species descriptions (including six new species and two new varieties), there is a final chapter of twelve pages on "Stratigraphic Zonation and Geographic Distribution of the Species".

The presence of intra-mural canals in the genus *Discocyclina sensu stricto* is now fully established both by means of Canada balsam preparations—decalcified—and by the novel method of 'gelatin reimpregnation' already referred to. The reviewer considers that the absence of similar canals from *Pseudophragmina* (*Proporocyclina*) is equally certain, since the most careful preparations (Canada balsam decalcified) by Vaughan, by Wright Barker, and by himself have failed equally to expose the faintest trace of this feature either in *Proporocyclina perpusilla* (Vaughan), or in *P. cushmani* (Vaughan), both of which species occur in perfect preservation in eastern Mexico. Further attempts will undoubtedly be made, and this question settled. Should the absence of canals in *Pseudophragmina* (*Proporocyclina*) be proved beyond all reasonable doubt, the homogeneity of the Discocyclinidae at once becomes suspect.

A further point bearing upon this latter theme is the early co-occurrence of the two genera *Discocyclina* and *Pseudophragmina* in the Chicontepec formation of eastern Mexico. Vaughan's stratigraphy of the Chicontepec, based upon Muir's, cannot be compared satisfactorily with that known to the reviewer, but this cannot be entered into here. The deepest (oldest) occurrences of Discocyclinids known to the reviewer have included both *Discocyclina* (*Discocyclina*) spp. and *Pseudophragmina* (*Atheocyclina*) sp.; they lie at about 1,800 ft. below the top of the series containing *Rzehakina epigona*, *Globorotalia velascoensis*, etc. (the Velasco fauna of Cushman), and about an equal distance (thickness) above the Velasco base, where it rests upon the Mendez, in the country south of the Chumatlan River. This clear distinction between the genera at so deep a level in the Palaeocene is not suggestive of a monophyletic origin for the family; but at present it is difficult to suggest even one

possible source from which this remarkable group might have evolved, and this provides a fascinating object for future research. Certain characters in *Vaughanina* D. K. Palmer 1934 recall the equatorial chambers of a Discocyclinid; but this is mere speculation.

The foregoing remarks embody a few minor points of difference between the author and the reviewer. Their mention must not be allowed to overshadow the enormous value and importance of this work for all palaeontologists and stratigraphers studying the American Older Tertiary rock succession. With by far the greater portion of the information and opinion contained therein the reviewer desires to express his full agreement; for the author's achievement he has the deepest admiration and respect.

LIST OF NEW FORAMINIFERAL SPECIES IN PART 1

- Orbitolinidae
Orbitolinoides senni gen. et sp. nov.
 Discocyclinidae
Discocyclina (*Discocyclina*) *harrisoni* sp. nov.
 " " *mestieri* sp. nov.
 " " *turnerensis* sp. nov.
 " (*Asterocyclina*) *barbadensis* sp. nov.
 " *franki* sp. nov.
Pseudophragmina (*Proporocyclina*) *schomburgki* sp. nov.
 " (*Atheocyclina*) *soldadensis* Vaughan and Cole, var.
 " *calbardensis* var. nov.
Pseudophragmina (*Atheocyclina*) *jukes-brownei* sp. nov.
 Asterigerinidae
Amphistegina senni Cushman sp. nov.
 Orbitolididae
Lepidocyclina (*Polylepidina*) *barbadensis* sp. nov.

IN PART 2

- Discocyclinidae
Discocyclina (*Discocyclina*) *caudriæ* sp. nov.
 " " *fonslacertensis* sp. nov.
 " (*Asterocyclina*) *rutteni* sp. nov.
Pseudophragmina (*Pseudophragmina*) *bainbridgensis* (Vaughan), var.
 " *angusta* var. nov.
 " (*Pseudophragmina*) *bainbridgensis* (Vaughan), var.
 " *obsoleta* var. nov.
 " (*Pseudophragmina*) *novitasensis* sp. nov.
 " (*Proporocyclina*) *palmeræ* sp. nov.
 " (*Atheocyclina*) *macglameriæ* sp. nov.

T. F. GRIMSDALE

Part 2

In Part 2 of the work, Dr. John W. Wells describes the corals, which include eighteen named species and one variety, one comparable species, and seven indeterminate species from the Upper Scotland formation of Barbados, and two species from the Miocene of Martinique. The collection extends very much our knowledge of the Scotland formation corals. Previously only one had been figured by Trechmann in 1925 and five other species (only one named) mentioned by Matley and described by Wells himself in 1934; but their revision in the light of the present suite might be useful now that more is known of the age of the Scotland formation.

The new corals are mostly from the Chalky Mount member, but one form, a new species of *Madracis*, occurs lower down in the Murphys member as well (and, according to Vaughan, p. 20, in the Mount All member also). They are distributed among twenty-two genera and sub-genera, of which two are new. The eighteen named species are new with the exception of two, but as the corals fortunately occur with foraminifera, their Eocene age can be fixed. The sixteen new species are, however, related to Eocene (mainly Middle Eocene) corals of the United States and the West Indies. *Endopachys maclurii* (Lea), one of the previously existing species, and *Balanophyllia irrorata* (Conrad), with which one species is compared, are well known in the American Middle and Upper Eocene, while *Trochocyathus* (*Aplocyathus*) *obesus* (Michelotti) ranges from Eocene to Recent. Of the two new genera, *Sideroseris* is remarkable in being

structurally like *Siderastraea*, but simple. The other, *Barbadiastraea*, is probably a faviid.

Wells discusses the probable temperature and depth conditions under which the coral fauna lived. He rightly concludes that the evidence favours "a tropical shallow-water, but not littoral, environment", and suggests "a depth at or beyond the minimum temperature (21° C.) necessary for vigorous growth of reef corals, which is now approximately 75 metres in the Windward Islands, with a maximum of nearly 200 metres elsewhere in the West Indies".

The two species of Miocene corals from Martinique are interesting. One belongs to *Eusthenotrochus*, a peculiar sub-genus of *Sphenotrochus*, hitherto known only from a Recent South African species and from an Eocene species from the Paris Basin. Wells notes an undescribed specimen, probably identical with his new species, from the Miocene Bowden marl of Jamaica. The other species, *Dominicotrochus dominicensis* (Vaughan), occurs in numbers enabling its range of variation to be determined. It also suggests that Vaughan's original, ill-localized specimen from the Dominican Republic is also of Miocene age.

H. DIGHTON THOMAS

FOOD AND AGRICULTURE ORGANISATION

THE report of the special meeting on urgent food problems summoned by the Food and Agricultural Organisation of the United Nations at Washington during May 20-27, 1946, as a sequel to a resolution of the General Assembly on February 11, includes an appraisal of the world food situation during 1946-47, issued on May 14, 1946 (Washington: Food and Agricultural Organisation). This emphasizes that a critical world food shortage will continue at least until crops are harvested in 1947, even assuming average or somewhat better than average weather for the rest of 1946 and 1947. In spite of some prospective increases compared with 1945 in both Continental Europe and the Far East, production in 1946 in continental Europe generally as well as rice production in the Far East will still be well below the pre-war level. World stocks of food have been seriously depleted to meet the current crisis, and the incidence of any widespread drought in the months immediately ahead might well be even more disastrous than the effects of the droughts which developed in 1945 and early in 1946.

As regards Continental Europe, the report points out that, even if the production estimates are realized, imports equivalent to about 16 million metric tons of wheat would be required to bring the average consumption to about 90 per cent and of French North Africa to about 95 per cent of the pre-war level. Assuming that sufficient meats, fats and oils, and sugar were available to bring consumption for these commodities to about 80 per cent of the pre-war a head level, some 12.5 million metric tons or 450 million bushels of wheat would be required. Moreover, even with imports at this volume and average consumption at a level ranging from 2,250 calories a head daily in the European-Mediterranean area to 2,550 calories or more in Western Europe, non-farm consumption in some countries would still be under the emergency subsistence level. The urban food situation over wide areas in Continental Europe will thus again be disastrous in the spring of 1947

unless livestock feeding is held to a minimum and supplies are evened out as between different consumer classes and over the year.

The situation in the Far East is equally serious. With average yields the production of paddy (unhusked) rice may be 7 per cent higher than in 1945, but the bulk of this rice will not be harvested until November onwards, and estimates are still 10 per cent short of the pre-war level. Even under favourable conditions, not more than 2.5 million metric tons of paddy is expected to be available for shipment, as against 10 million metric tons in the pre-war period 1935-39. Current reports indicate that the wheat and other grains crops harvested in India are short; and so far as can be estimated, some 25 million tons (wheat equivalent) of cereals or other staple foods would be required to raise Far Eastern diets even to their full pre-war level in 1947—diets which themselves were usually too low for promoting health and working efficiency.

Discussing the export situation, the report notes that supplies are unlikely to be greater in 1946-47 than the amounts actually moved in 1945-46 unless effective measures are taken to reduce the amounts used in the exporting countries. Supplies of wheat are likely to be smaller, and of fats and oils no greater than in 1945-46. Supplies of cane-sugar available for shipment should be about 20 per cent greater, but supplies of meat and manufactured dairy products from the Americas, Australia and New Zealand are unlikely to be any greater. On the other hand, it is anticipated that fish production in 1946-47 will be substantially greater than in 1945-46. Fertilizer supplies are likely to be short in every major producing area, and in very large areas agricultural rehabilitation is necessary to achieve production possibilities.

The survey is completed by a summarized report from the Nutrition Committee which puts the emergency calorie intake requirements at about 2,200 a head daily at the retail level to prevent sections of the population from falling below the danger point. This level may be somewhat lower in eastern and tropical countries generally.

This appraisal provides the basis on which the special meeting during May 20-27 of the Food and Agriculture Organisation framed its recommendations. Those of its first committee related to the establishment of a Research and Information Service to provide the Organisation with further appraisals, to help keep the situation under review, and assist the International Emergency Food Council with information in the same way. Detailed recommendations from the Second Committee, on the Conservation and Expansion of Supplies, include extraction-rates of at least 85 per cent for wheat and rye in all countries for the consumption year 1946-47, and further curtailment of the use of wheat and other grains for feeding animals, as well as proposals for increasing the supplies of food products from the 1947 harvest, covering fertilizers, seeds and equipment. A further section of this report deals with principles and policy to be adopted by individual countries and by the International Emergency Food Council in regard to the production, collection, procurement, allocation and distribution of food-stuffs; if the measures recommended are adopted forthwith and applied consistently throughout 1946-47, a repetition of the hardship and privation of 1945-46 can largely be avoided. The report of yet a third committee is concerned with future machinery;