

of water of 25° C. with a salinity of 39 ‰, or more, such as does not occur in the other oceans.

The writer describes the sections individually and then discusses the origin of the various layers, attaching considerable importance to the winds. The circulation of the various layers is not easy to disentangle, since they pass over into one another at vertical convergence surfaces.

The upper layer of high salinity and temperature, generally a few hundred metres thick, is fed from surface water which sinks in the counter current and southern tropical convergences and spreads in all directions. Along its southern boundary this under-current meets cold, light, polar waters, chiefly between 200 and 600 m., in the subpolar convergence which lies in about 42° S. lat. in the West and 52° S. lat. in 120° E. long. The mixed waters flow northwards with a salinity of 34.7 to 34.0 ‰ and a temperature of 8° to 2.5° C. with a thickness of about 1000 m. and an axis of minimum salinity and temperature in about 1200 m. At the end of their journey they rise to mix with the waters that feed the northern deep current. Their course is not due North: at first it is North-west then North and North-east, and finally North-west again.

The northern deep current arises where the antarctic current meets the northern subtropical waters in about 5° S. lat. The mixed waters have their density so raised by evaporation that they sink below the antarctic intermediate current with a salinity over 34.75 ‰ and flow southwards until they near the south polar continent, where they rise, mix with the thaw water along the edge of the land, and sink again as the bottom current with a salinity of 34.5 to 34.6 ‰ and a temperature of 0° to 1.5° C. This creeps slowly northwards, losing its characteristics on the way, so that under the equator it can scarcely be distinguished from the water above it.

DONALD J. MATTHEWS.

J. W. GREGORY. *The Geological History of the Atlantic Ocean* — being the Presidential Address to the Geological Society of London at its Anniversary Meeting on 15th February, 1929. Q. J. G. S. vol. LXXXV pt. 2, pp. LXVIII—CXXII. London, 1929.

This very fully documented and important paper cannot fail to be of great interest to many who are not primarily geologists. Workers upon problems of Marine Biology whereto a knowledge of the past distributions of land and water could profitably be applied, will find the requisite information concerning the palæogeography of what is now the Atlantic area, authoritatively set down here.

Professor GREGORY treats his subject under twenty heads in the space of some fifty-five closely printed pages, and a very useful summary is appended. Three small charts showing the land and water distribution in Mid. Devonian, Mid. Cretaceous, and Upper Carboniferous to Rhaetic times are given, whilst a fourth one depicts "Features in later History". In marshalling the arguments for and against former land connections and marine transgressions, the author discusses the petrological affinities, the resemblances in geological structures, and the faunal and floral sequences as displayed in the formations of opposite parts of the Old and New Worlds.

It is almost impossible to give any useful summary, even of the author's summary, in a brief space. One matter in particular will interest readers of the Journal — the remarks made upon the spawning of the eel. The congregation of the eels of Europe and Northern Africa to breed where they do in the Atlantic, is, as Professor GREGORY says, "regarded as one of the most surprising freaks in the life history of fishes". It seems possible to state that there was a more recent land connection across the North Atlantic than across the tropical zone. Arguments supported by a consideration of the nature of the sea floor some 600 miles North of the Azores, point to the recent sinking of the Atlantic in these latitudes.

The genus *Anguilla* is known from the Swiss Upper Miocene, and indubitable fossil eels have been collected by Sir ARTHUR SMITH WOODWARD from the Upper Cretaceous of the Lebanon. "If the present spawning area had been the early home of the European eel", says Professor GREGORY, "it may have continued to resort thither to breed, and the larvae have adapted themselves to the new conditions as the sea floor sank".

Major questions such as the permanence of ocean basins, the implications of isostatic compensation, and the nowadays much discussed conceptions of continent drift largely associated with the name of WEGENER — receive their full meed of attention.

It appears certain that there was land where now are the North and South Atlantic, in the Lower Palæozoic Era in both Cambrian and Ordovician times. In post-Ordovician times, a North Atlantic sea existed as the result of Caledonian earth-movements. In Devonian times, an Old Red Sandstone land joined Canada and Britain; at the same time the present South Atlantic area was also land (SCHWARZ's "Flabellitesland").

In the Upper Palæozoic and Mesozoic Eras, Gondwanaland long occupied the site of the present tropical and southern Atlantic. It is demonstrable that a continuous land occupied the tropical Atlantic throughout most of the Palæozoic and all the Mesozoic Era; according to many authorities this lasted until at least the end of the Oligocene Period. Its survival until the Middle Kainozoic can be confirmed, but there seems to be need to assume a temporary land bridge in the Upper Miocene to account for the appearance of a Floridan Hipparion in Southern Europe. In the Jurassic Period, the sea lying North of Gondwanaland from the Mediterranean to the West Indies, spread northward over the eastern part of the North Atlantic and was temporarily united with the Arctic Sea. This sea was the western part of the Tethys and was SCHUCHERT's Poseidon. The Tethys was the main sea on the course of the present Atlantic until late Cretaceous times, when southwards stretching gulfs projected from it. In the lower, and in part of the Middle Kainozoic, Brazil and Africa were still united. The Oligocene Alpine folding resulted in meridional fractures which increased the northwards and southwards stretching gulfs from the Tethys, resulting ultimately in a continuous longitudinal sea from Arctic to Antarctic. The last transatlantic land-connection, the Icelandic, was probably not severed until the Upper Palæolithic, whilst evidence exists to show that the Falklands were not separated from South America until about the same time.

The combined evidence of all kinds proves that no ocean entitled to

rank as the Atlantic existed during the Palæozoic and Mesozoic Eras. Its formation began at the end of the Cretaceous, and was effected mainly after the widespread mountain-forming movements of the Oligocene Period.

J. N. CARRUTHERS.

JOHAN T. RUUD. On the Biology of Copepods off Möre 1925—1927. Cons. Perm. Intern. pour l'Exploration de la Mer. Rapp. et Proc.-Verb., Vol. LVI, Copenhagen 1929.

In this paper Mr. RUUD gives an account of the Copepoda taken during the plankton investigations carried on off Möre, on the West coast of Norway, in 1925—27, tracing their development from the small winter stock to the enormous shoals which characterise the spring and summer months. He deals separately with the three areas in which investigations were carried on, viz.: the fjords, the bank, which extends seawards from Möre for 40—50 miles with a depth of about 80—200 metres, and the open sea outside the bank, up to 200 miles or more from shore.

The bank, across which lines of stations were made during three years from March to July, is treated of at greatest length and affords the most consistent picture of the annual course of development. In this area the total volume of the copepod plankton, starting from a minimum in March, rapidly reaches a maximum some time during April, the date probably varying with the year and locality. A decrease occurring earlier or later during May is followed by a secondary maximum in June, both of which were clearly marked in the two years in which the observations covered the months in question, and in July the decrease is resumed. The two most important species of Copepod, *Calanus finmarchicus* and *Pseudocalanus minutus* (*P. elongatus*), both show this second maximum, and the author suggests that the first maximum may be connected with the early flowering of diatoms and the second with the later development of peridineans which follows after an interval in these waters.

The most important species, and the one which occupies the largest space both in nature and in the paper, is naturally *Calanus finmarchicus*. A counting of the numbers of the successive developmental stages in the townettings shows that the two maxima correspond to two spawning periods, one in February—March the other in May—June, the specimens which make up the second maximum being the offspring, not of those actually making up the first, but of others developed under similar conditions further to the South and drifted into the area by the slow passing of the coastal water to the North-east.

Reproduction of *C. finmarchicus* is seen to start from the shore and to extend outwards across the bank, the nauplii appearing first on the innermost station, but by the time it has extended across the bank there has appeared on the outermost station a large stock in a later stage of development, indicating that an invasion from a second and earlier centre, probably oceanic, has contributed to the numbers on that station.

The longer cruises made in summer across the Norwegian Sea showed the smallest numbers of *C. finmarchicus* where they crossed the line of the Gulf Stream, which follows a well defined course parallel to the coast, the greatest numbers occurring in the water-masses bordering it.