The John Murray Expedition to the Arabian Sea

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SINCE the previous report on the work of the John Murray Expedition (NATURE, Jan. 20, 1934, p. 86), H.E.M.S. *Mabahiss* has twice traversed the width of the Arabian Sea, and in addition has cruised off the African coast between Mombasa and Zanzibar, and to the east of Pemba Island.

The *Mabahiss* sailed from Bombay on a traverse of the Arabian Sea to Mombasa on December 13. During the whole passage the weather was favourable, and good progress was made, observations being carried out at 12 stations. As we approached the African coast we encountered a strong head current that kept us back somewhat, so that we did not arrive in Mombasa until the morning of January 1, 1934. We remained at Mombasa until the morning of January 9 and then sailed for Zanzibar in order to report to the Sultan and obtain permission to work off this region of the African coast. Unfortunately, during the whole of our stay in the Zanzibar area we experienced strong winds and there was a sufficiently heavy sea running to render the *Mabahiss* most uncomfortable, while several members of the expedition contracted malaria.

One very noticeable feature of the African coast in this region round Mombasa and Zanzibar is the extent to which coastal erosion is, and has in the past, been going on; this is particularly evident on the west side of Pemba Island where most, if not all, of the bays and inlets are fringed with coral reefs on which small detached islets are to be seen, still indicating the limits to which the original land extended in times past, though now only the most resistant areas are left. This erosion is particularly clearly seen in Chumbi Island, about seven miles to the south of Zanzibar. At the request of the authorities of the British Museum, a visit was paid to this island in order to try to obtain evidence of the presence on the island of the giant robber crab, *Birgus latro*; the whole island consists of a raised 'coral rock', the upper surface of which has been weathered into holes and pinnacles by rain, while the seaward margins have been eroded and undercut by wave

action (Fig. 1). The greater part of the island is covered with a profuse growth of a species of *Euphorbia* such as to render a thorough investigation impossible; the crab, however, appeared to be well known to the resident lighthouse keepers

FIG. 1. Chumbi Island, showing coastal erosion.

and examples have been obtained on other islands in the group.

After leaving Zanzibar on our return passage across the Arabian Sea, we encountered moderate winds and seas during the first few days, but after that the weather again improved, and, after calling in at the Seychelles for extra coal, we had a comfortable voyage past the Maldive Archipelago to Colombo, though owing to a strong head current during the greater part of the journey our speed was considerably reduced. During these

three cruises we have carried out work at 45 stations, making a total of 135 stations in all up to date.

TOPOGRAPHY and BOTTOM DEPOSITS

Lieut.-Commr. Farquharson, R.N., has successfully managed to keep the echo-sounder running

bottom was very irregular. In about lat. $1^{\circ} 20' S.$, long. $60^{\circ} 30' E.$ we crossed a low ridge on which the depth of water shoaled to 1,570 fathoms (2,873 metres). To the east of this the depth of water increased to 2,600 fathoms (4,758 metres) and then the bottom rose again in a second ridge that lies between long. $66^{\circ} 00'$ and $67^{\circ} 30' E.$, and

over which there appears to be a general depth of from 1,600 to 1,200 fathoms (2,928 to 2,196 metres), though at two points depths as small as about 900 fathoms (1,737 metres) were obtained, with a deep gully having a depth of some 1,800 fathoms (3,294 metres) between them.

Having crossed the first of these shallow areas and thinking that we were in the eastern basin, we carried out a complete station and were fortunate enough to bring up in the trawl

FIG. 2. Halogen content of water between Bombay and Mombasa (Cl ‰).

metically continuously, though towards the end the apparatus required almost constant attention. We have thus been able to map more than 5,000 miles of the sea floor along lines on which there were previously few, if any, soundings. The late Prof. J. Schmidt, in his account of the voyage of the *Dana*, put forward the suggestion that there must be a deep ridge crossing the Arabian Sea from the south-east towards the north-west and connecting the Chagos Archipelago with Socotra and the entrance to the Gulf of Aden; we have now crossed this area twice and there can be no doubt that Schmidt was right. On our voyage from Bombay to Mombasa in about long. $59^{\circ} E.$, a little to the west of where the Admiralty chart shows a sounding of 1,950 fathoms, we crossed a ridge on which the depth of water was only 1,650 fathoms (3,020 metres), though to the north-east the depth fell to 2,400 fathoms (4,392 metres) and to the south-west it increased to as much as 2,910 fathoms (5,325 metres). On our return voyage from Zanzibar to Colombo we again crossed this ridge.

After leaving the Seychelles, we found that the

a number of rock fragments; one of these has been examined by Mr. J. S. Coates, mineralogist to the Ceylon Government, and he informs me that the rock consists of dolerite, a rock of the basaltic series that is frequently found associated with the Deccan Trap in India; the occurrence of this rock is of particular interest in view of the

FIG. 3. Oxygen content of water between Bombay and Mombasa.

theory, held by many geologists, that a large section of basalt-covered Gondwanaland now lies submerged to the west of India. Between this portion of the ridge and the western side of the Maldivé archipelago the depth of water again increased to some 2,300 fathoms (4,209 metres).

It thus seems clear that there are two separate

basins in the Arabian Sea, one lying to the north-east and the other to the south-west of the diagonal ridge, and it is of interest to note that a bottom sample obtained in the north-eastern basin from a depth of 2,352 fathoms (4,305 metres) is of quite a different character from those obtained to the south-west of the ridge; it was a core 62 inches long of a comparatively soft reddish-yellow ooze, in which there appears to be very few Foraminifera, and it seems probable that this is the type of deposit that Sir John Murray showed to lie between lat. 5° and 12° N. and long. 62° and 72° E., and classified by him as "red clay", though the depth is much less than would be expected for such a deposit.

HYDROGRAPHIC OBSERVATIONS

During our voyage from Bombay to Mombasa, and again during the return voyage from a point about lat. $7^{\circ} 30'$ S., long. $44^{\circ} 10'$ E., past the Seychelles to the entrance to Kardiva Channel in the Maldivé Archipelago, lines of hydrographic stations were run across the Arabian Sea. The results obtained in the first of these traverses have now been tabulated and are given in Figs. 2 and 3. In this section between Bombay and Mombasa there appear to be a series of currents and counter-currents in the upper levels. A study of the halogen content (Fig. 2) shows that, on the surface, the water is streaming towards the south-west under the influence of the north-east monsoon wind, while immediately beneath this upper stratum there is a counter-current in the opposite direction at a depth of some 136 fathoms (250 metres). At a still deeper level, approximately 400 fathoms (732 metres), the current is again moving towards the west, but in long. 68° E. this mass of water becomes deflected downwards. In this connexion it is interesting to note that in the region to the east of the Arabian Sea there are indications of a similar deep current at about the same depth and moving in the same direction*.

As already mentioned, the presence of a deep ridge separates the Arabian Sea into two basins, and it is into the south-west basin that the greater part of this descending mass of water is directed. In each basin a mass of water of low salinity was detected that is almost certainly derived from the great antarctic bottom drift. A study of the oxygen content of the water (Fig. 3) at the different levels and at different stations gives an almost identical picture of the movement of the water

masses, the descending mass of tropic water, with a low oxygen content, being clearly distinguishable from the antarctic polar water in which the oxygen content is relatively high; and in each basin there appears to be a vertical rotatory movement in progress, the water on the eastern side passing downwards towards the bottom.

Our work off Bombay has now made it possible to trace the movements of the water masses into and out of the Gulf of Oman (Fig. 4). The main interest is the flow of water of a high halogen content (20.0 and above) out of the Persian Gulf towards the south-east. At the head of the Gulf of Oman this mass of water lies at a depth of 110–160 fathoms (200–300 metres), but as it is followed out of the Gulf it can be seen to sink gradually until off Bombay it is lying at a depth of 382 fathoms (700 metres). At a series of stations off Bombay we encountered the same or a very similar type of deposit to that found in the curious azoic region in the Gulf of Oman

FIG. 4. Halogen content of water in the Gulf of Oman (Cl ‰).

referred to in the earlier report of the Expedition. The deposit from a depth of 156 fathoms was similarly, though to a rather less extent than off the Arabian coast, impregnated with sulphuretted hydrogen, and here too the result of three trawls yielded remarkably little in the way of animal life.

BIOLOGY

The region of the African coast under investigation proved to possess a very rich fauna, and good catches were made at a number of stations in water the depth of which ranged from 100 to 500 fathoms (183 to 915 metres). In shallower depths our nets were badly torn by coral, while in depths greater than 660 fathoms (1,200 metres), there seemed to be evidence of a distinct falling off in the quantity of life at the bottom. Sometimes large catches were made; thus at one station at a depth of 802 metres, an hour's haul with the Agassiz trawl resulted in our securing a hundred examples of a species of *Phormosoma*, probably *P. indicum*, and masses of a species of *Virgularia*. At another station we secured some 114 examples of fish belonging to about twenty

* Sewell, R. B. Seymour, 1932, "Geographic and Oceanographic Research in Indian Waters; Part VI. Temperature and Salinity of the deeper waters of the Bay of Bengal and Andaman Sea". *Mem. Asiatic Soc. Bengal*, 9, No. 6. See pp. 377–378.

species and nearly as many genera; together with some 58 asteroids and about 700 examples of an ophiuroid.

The general richness of the fauna provided a very marked contrast to the comparatively barren region round the Arabian coast and the azoic area of the Gulf of Oman. Until the collections

have been worked out, it is impossible to give any details of the fauna of this African region, but the general impression created is that this region round Mombasa and Zanzibar has a fauna much more nearly allied with the fauna of the southern coast of the Gulf of Aden than with that of the northern coast of the Gulf.

Chemistry and Chemists in Spain

AT the tenth meeting of the Union Internationale de Chimie held at Liege in 1930, apart from formal business, an adequate amount of time was devoted to consideration of problems connected with the constitution and properties of the simple and complex carbohydrates. Comprehensive papers previously circulated by recognised authorities prepared the way for useful discussions, and only in one or two cases was discussion rendered impossible by the tedious reading by authors of long manuscripts which either had been or should have been circulated previously. In spite of one or two drawbacks, the Liège meeting indicated how scientifically useful such international meetings may be when suitably organised.

When the invitation to hold the eleventh meeting of the Union in Madrid was accepted, it was decided by leading Spanish chemists to revive the pre-War International Congress of Chemistry at the same time, with the object of consolidating the scientific side of the meeting. The last meeting of the International Congress was held in Washington in 1912 and the meeting, postponed from 1932 to 1934, held in Madrid (April 5-11) constituted the Ninth International Congress. Some confusion may have arisen even among those attending that Congress and the eleventh meeting of the Union Internationale.

In spite of all the difficulties which have attended their work of organisation during the last two years, our Spanish colleagues have entertained their guests with lavish hospitality, both scientific and otherwise. The Congress and the meeting of the Union were opened in the ultra-modern Salle Capitol in the presence of the president of the Spanish Republic, who made what appeared to be an impressive speech in Spanish after the reading in Spanish by Prof. Fernandez of an account (previously circulated) of the developments in chemistry since the Eighth Congress. There were about 1,200 on the list of ordinary members of the Congress. This list included also the ladies who were kept busy enjoying the artistic and other treasures of Madrid, while the chemists were supposed to be busy discussing some of the 245 scientific communications, attending the four special lectures such as that of Prof. G. N. Lewis on "The Different Kinds of Water" and listening to the twenty special papers such as those given by Profs. P. Walden ("Anomale Elektrolyte in nichtwässrigen Lösungen"), G. Barger ("On the

Alkaloids of the Isochinolin Group"), R. Robinson ("Molecular Architecture of Plant Products"), R. H. Kruyt ("The Modern Development of Colloid Chemistry"), P. Karrer ("Untersuchungen über Carotinoide und Vitamine") and Miss Jordan Lloyd ("The Chemistry of the Tanning Process with Special Reference to Vegetable and Chrome Tanning"), the only lady chemist taking a leading part in the last two groups of special papers. Nearly all the communications to the Congress were circulated beforehand and intended to be the basis of discussion.

This huge scientific programme was interspersed with receptions by the president of the Republic at the National Palace and by the Mayor of Madrid at the Town Hall, visits to Toledo and Segovia and artistic entertainments terminating with a well-attended banquet. One heard also of several official or semi-official lunches and dinners and of private excursions before the dispersal of the delegates to the many places of interest in the south of Spain and even to Morocco. Everywhere, the members of the Congress were most kindly and graciously received and, apart from the somewhat adverse climatic conditions in Madrid, there was no sign anywhere of discomfort, alarm or even disquietude. The graciousness of our hosts was shown in a more permanent fashion by the conferring of honorary doctorates of the University of Madrid on seven delegates, among whom are Profs. H. E. Armstrong and R. Robinson, the election of ten foreign members of the Spanish Academy of Exact Sciences, among whom is Prof. G. Barger and, finally, the conferring of the new Order of the Spanish Republic on another eight delegates, among whom is Prof. E. Biilmann, president of the Union Internationale.

The permanent result of the Ninth International Congress is not easy to forecast. Many hope that its scientific proceedings will not be buried in a separate huge volume, but will find their way into more accessible journals devoted to the publication of contributions to chemical knowledge.

The meeting of the Union Internationale seemed to be overshadowed and was confined to two sittings of the Council and one of the Bureau, apart from those of several of the committees. In formal business, Prof. N. Parravano (Rome) was elected to succeed Prof. Biilmann in the presidency and the new members of the Bureau are Profs. M. Bodenstein (Berlin), E. Bartow (Iowa), F. Fichter (Basle), K. Matsubara (Tokyo)