In conclusion, it ought to be stated that this brief review of the Charleston earthquake must be regarded only as an attempt to place some of the leading facts upon record, for the benefit of the readers of the *Monthly Weather Review*. It is in no way intended to anticipate the investigations now in progress by the United States Geological Survey, a full report from which, based upon all attainable information, will be looked for with great interest.

THE SIMILARITIES IN THE PHYSICAL GEOGRAPHY OF THE GREAT OCEANS[1]

AT the outset Mr. Buchanan reminded the audience of the similarities observed in the eastern and western continents, especially in their southern extremities. Such similarities in corresponding localities had been called homologous geographical features, in imitation of the homologies of comparative anatomy, and they had received much attention from students of geography. A remarkable group of similarities of this kind is to be found in the arrangement of inclosed seas lying to the northward of the three southern continents. To the northward of South America there are the Gulf of Mexico and the different basins of the Caribbean Sea; to the northward of Africa there are the Mediterranean with its different basins, and on the north-east the Red Sea; and to the northward of Australia there are the well-known seas of the Eastern Archipelago. These seas are bounded on all sides by islands and insular groups, and they are in continuous connection with two oceans, the Pacific and the Indian. The African seas are bounded entirely by continental land and communicate directly with two oceans; but in the limited sense that one sea, the Red Sea, communicates with the Indian Ocean by a single channel, and the Mediterranean Sea with the Atlantic, likewise by a single channel. Finally, the American seas are all in continuous communication with only one ocean, the Atlantic, the continental barrier towards the Pacific being continuous.

It is not unworthy of remark that the great depths (over 4000 fathoms) of the Atlantic and the Pacific Oceans occur immediately to the northward of these groups of seas, and in the western sinus of the northern portions of both oceans; while the greatest depression of the continental land, the region of the Dead Sea, is found similarly situated with regard to Africa. The analogy here, however, does not hold good all through, because it is a mere accident of climate that this area does not form a large and not excessively deep fresh-water lake.

The seas of the Malay Archipelago and those of the West Indies have important functions in the physical geography of the oceans, as they receive the warm dense water of the westerly-running equatorial currents of the Pacific and the Atlantic Oceans. The Pacific current finds no obstacle in the chains of islands which bound the Malayan seas, and is able to pass freely through into the Indian Ocean; while the Atlantic current is stopped by the continuous continental barrier of South America, and the head of water thus produced is relieved by the overflow of the Gulf Stream all the year round. Although there is no static barrier, in the shape of continuous land, to the westerly Pacific current, there is, during one season of the year, a kinetic one, furnished by the prevalence of the south-west winds during the monsoon season. These furnish the intermittent *kuro siwo*. The main cause of the westerly equatorial current is the propulsive action of the trade winds.

These winds have also great evaporating power; and, by making the surface water salter, they furnish the mechanical means of propagating the surface heat into the deeper layers of the ocean. Hence the leading characteristic of the westward or leeward regions of the intertropical oceans is water of considerable density and of high average temperature in the sub-surface layers. This characteristic is seen most clearly in the Atlantic, where there is no communication with another ocean. In the Pacific the non-continuous boundary neutralises to some extent this effect, and gives to the eastern parts of the Indian Ocean a borrowed leeward character, independent of its own climate. A secondary consequence of a leeward position in the ocean, and due to the above-mentioned characteristics of the temperature and density of such water, is the prevalence of coral formations in the western regions of the Atlantic and Pacific, and, owing to the mixture of conditions, in both eastern and western regions of the Indian Ocean.

Continental homologies, or similar features in corresponding localities, are found on the western as well as on the eastern sides of the continents. One of the most striking is the resemblance of the Gulf of Guinea on the African coast with the great Central American bight stretching from Cape St. Lucas at the extremity of the Californian Peninsula, by Panama, to the mouth of the Guayaquil River, and with the unnamed bight in the Indian ocean bounded continentally by the north-west coast of Australia and insularly by the chain of islands stretching from the Peninsula of Malacca to Australia. Oceanically these bights are homologous. It is in them that the beginnings of the westerly-running equatorial currents are to be found, and perhaps more important still, it is in them that the easterly-running counter equatorial currents end. They are to be found in each of the three oceans, and generally on the northward side of the axis of the westerly-running current. In the Atlantic it is best known by its eastern portion, the Guinea current.

The observations here recorded of the Guinea current, a hitherto unexplored region of the ocean, were made on board the steamship *Buccaneer*, at the invitation of the owners, the India-rubber, Gutta-percha, and Telegraph Works Company, of Silvertown, and were carried out during a survey for a telegraph cable from Sierra Leone to St. Paul de Loanda. From a diagram showing the variation of salinity of the surface water of the Guinea current, with distance from the coast, it appeared that for a considerable distance along the Guinea coast the salinity of the surface water was an almost accurate test of the proximity of the land. The Guinea current starts in mid-ocean, but it is most constant near the African coast. The density of the water is low, its temperature high, and its velocity, especially in-shore, is sometimes as great as three miles an hour. It varies somewhat with the season.

Bottle experiments showed an average rate of fifteen miles per day in the months of January and February, for a thousand miles along the coast. In March, the *Buccaneer* experienced no easterly current, and in connection with this absence of easterly currents off the coast may be taken the very remarkable under-current which is found setting in a south-easterly direction with a velocity of over a mile per hour at three stations almost on the equator, and to the northward of the Island of Ascension. For the double purpose of examining the currents and of obtaining a large specimen of the bottom, the *Buccaneer* was anchored in 1800 fathoms of water by means of an ordinary light anchor fitted with a canvas bag to receive the mud which would otherwise fall off the flukes on its being weighed. While the ship was lying thus at anchor, the surface water was found to have a very slight westerly set. At a depth of 15 fathoms there was a difference, and at 30 fathoms the water was running so strongly to the south-east, that it was impossible to make observations of temperature, as the lines, heavily loaded, drifted straight out, and could not be sunk by any weight the strain of which they could bear. In the Pacific the counter equatorial current in the open ocean was well observed by the

[1] Abstract, by the Author, of a Paper read at the meeting of the Royal Geographical Society on Monday, November 8, by Mr. J. Y. Buchanan.

Challenger on her voyage from Hawaii to Tahiti. Her observations were illustrated by two diagrams, one showing the direction of the current, and the other the distribution of temperature and density in the upper layers of the water traversed. The easterly current was found between the parallels of 5° N. and 10° N., there being two streaks of maximum velocity, one between 7° and 8° N., and the other between 9° and 10°. In the former the mean daily set was 54 miles; in the latter it was probably quite as high, but it could not be accurately determined, as the ship passed from westerly to easterly current in the course of the 24 hours, and the observed current of 20 miles represented the difference of the two. The streaks or axes of strong easterly current are sharply defined by areas of abnormally low surface density. The whole of the area of easterly-running water has a comparatively low density, but where there is a sudden acceleration of its velocity, there is a correspondingly sudden drop in its density, so that the existence of a strong easterly current in equatorial regions may be guessed with great probability by the use of the hydrometer. The diagram showed also in a very marked way the protective action of the fresh surface water in preventing the penetration of heat into the lower layers of the water. A temperature of 60° Fahrenheit is found here at a depth of 50 fathoms from the surface, while in the westerly-running current, a little further south, the same temperature occurs at a depth of over 100 fathoms. In this region there are great inequalities in the density of layers of water at the same depth and within a short distance of each other. Thus, if the column of water between 20 fathoms and 70 fathoms from the surface be considered, its weight at the station where the westerly-running equatorial current prevails is only 88 per cent. of its weight under the counter equatorial current, the distance between them being not more than 200 miles. This disturbance of statical equilibrium must be balanced by circulation of water between the localities, and hence the violent and conflicting currents observed in these regions. The study of the currents of equatorial regions would well repay the trouble of the investigation. The counter equatorial current is particularly interesting, and its dynamics obscure. Its range is very superficial, and its physical conditions can be studied without the elaborate and costly equipment required for the research of oceanic depths.

To the north and to the south of the equatorial bights of the western shores of Africa and America we have a remarkable similarity in the distribution of temperature in the coast waters. The transition from equatorial heat to extratropical cold is very marked: on the North American shore, at Cape St. Lucas, the southern extremity of the Californian peninsula; on the North African, at Cape Verd; on the South American shore, at Cape Blanco; and on the South African, at Cape Frio. In rounding Cape St. Lucas the temperature was observed to fall from 75° to 65° F. in less than an hour; and a similar difference of temperature was found in rounding Cape Blanco between Payta and the Guayaquil river. On the Morocco coast the water is found to have a temperature quite 10° lower than is found twenty miles to sea. These sharp transitions are found only close inshore, and they have usually been attributed to surface currents from higher latitudes. This explanation is at variance with the observations of navigators on the coasts, who do not notice any currents which would be strong enough to bring water many hundreds of miles under a burning sun without sensible rise in temperature. The occurrence of these coast areas of abnormally cold water is explained when we recognise that they are the windward shores of the oceans. The trade winds blow from them towards the equator, and in doing so mechanically remove water, which has to be supplied from the readiest source. This source is the deep water lying off the continental coasts, which is supplied by a gradual drift of cold water from high latitudes. Hence, though the low temperature of the coast waters referred to is due to the cold of high latitudes, it is not supplied by a long coast Polar current, but by a short vertical one. This view was very strongly supported not only by the temperature of the water, but by its other characteristics, especially colour. The outside ocean water is of an intense ultramarine blue; the coast water off Mogador had the clear olive-green colour met with constantly in Antarctic seas. The same is observed on the west coast of North and South America, and it would be of the highest interest to have these waters investigated from a biological point of view. No waters in the ocean so teem with life as those on the west coast of South America. A bucket of water collected over the side is turbid with living organisms, the food of countless shoals of fish, who, in their turn, afford prey for innumerable schools of porpoises. One remarkable school which accompanied the ship for some time consisted entirely of females, each accompanied by a calf following in her wake and mimicking her every movement. Along with abundance of life this coast unites facilities for investigating it. At every port there are plenty of shore boats anxious for a fare, and with a tow-net and a few bottles a naturalist might make a rich collection of the shore-water fauna of the coast in one trip from Valparaiso to Panama.

The most remarkable confirmation of the view that the cold water on the windward shores is due to a submarine source has been quite recently supplied by the observations of Capt. Hoffmann, of the German man-of-war *Möwe*, on a voyage from Zanzibar to Aden. He kept close to the coast as far as possible, and observed a very uniform surface temperature of 78° to 80° F. from Zanzibar to Cape Warschek, when it began to fall, and remained at a temperature of from 60° to 65° F., until Cape Guardafui was reached, when the temperature went up rapidly to 86°. The minimum temperature observed was 59° F., and Capt. Hoffmann calls particular attention to the dark-green colour of the water, and in speaking of its low temperature he recognises that its source can only be the deep water in the neighbourhood, as the surface water on both sides has a temperature bordering on 80° F. The *Möwe* passed through these seas in the month of July, when the south-west monsoon is blowing most strongly, and at this season the Somali coast is a pronounced windward shore, and exhibits the same characteristics as the windward shores of Morocco or South America. The coral growths, too, which are so abundant north and south of it are here quite absent, thus accentuating the eastern or windward character of the shore.

NOTES

THE following is the list of selected names to be submitted to the Fellows of the Royal Society at the forthcoming anniversary meeting (November 30) for election into the Council for the ensuing session:—President: Prof. George Gabriel Stokes, M.A., D.C.L., LL.D.; Treasurer: John Evans, D.C.L., LL.D.; Secretaries: Prof. Michael Foster, M.A., M.D., Lord Rayleigh, M.A., D.C.L.; Foreign Secretary: Prof. Alexander William Williamson, LL.D.; other Members of the Council: Prof. Robert B. Clifton, M.A., Prof. George Howard Darwin, M.A., LL.D., W. T. Thiselton Dyer, M.A., Prof. David Ferrier, M.A., Edward Frankland, D.C.L., Arthur Gamgee, M.D., Archibald Geikie, LL.D., Prof. Joseph Henry Gilbert, M.A., John Hopkinson, M.A., D.Sc., J. Norman Lockyer, F.R.A.S., Sir Lyon Playfair, K.C.B., LL.D., Prof. Bartholomew Price, M.A., Prof. Pritchard, M.A., Admiral Sir George Henry Richards, K.C.B., Prof. Arthur Schuster, Ph.D., Philip Lutley Sclater, M.A., Ph.D.

IN the third volume of Ray's "Historia Plantarum" there is a list of plants collected in the Island of Luzon by George Joseph