discovered in our area. The outcrop of its parent-bed is about 50 miles distant in a straight line from Old North Road Station. The Boulder-clay, where it was found, is said by Professor Bonney ("Camb. Geol.," p. 49) to be 160 feet thick, as seen in the cutting and well.

From the presence in the Cambridgeshire Boulder-clay of fragments of the Red Chalk and Carstone, and from the general invasion of the outcrops of beds to the south by the materials of beds to the north or north-east, it has been inferred that the direction of movement of the agent of transportation was towards the south; and the occurrence of this boulder of Spilsby Sandstone is strongly in favour of this view. But in spite of this evidence for its support it cannot be said that this theory is completely satisfactory, for it fails to explain the reason of the extremely miscellaneous character of the majority of the non-local rocks in the Boulder-clay, and the distribution of the deposit in relation to the configuration of the country, whether we consider the transporting agent to have been land-ice, icebergs, or an ice-foot.

NOTICES OF MEMOIRS.

Facts and Arguments in favour of an Antarctic Expedition.

IN advocating "The Scientific Advantages of an Antarctic Expedition" before the Royal Society in February last,[1] Dr. John Murray, F.R.S. (now Sir John Murray, K.C.B., F.R.S.), said:—

"From a scientific point of view the advantages to be derived from a well-equipped and well-directed expedition to the Antarctic would, at the present time, be manifold. Every department of natural knowledge would be enriched by systematic observations as to the order in which phenomena coexist and follow each other, in regions of the earth's surface about which we know very little or are wholly ignorant. It is one of the great objects of science to collect observations of the kind here indicated, and it may be safely said that without them we can never arrive at a right understanding of the phenomena by which we are surrounded, even in the habitable parts of the globe.

"Before considering the various orders of phenomena concerning which fuller information is urgently desired, it may be well to point out a fundamental topographical difference between the Arctic and Antarctic. In the northern hemisphere there is a polar sea almost completely surrounded by continental land, and continental conditions for the most part prevail. In the southern hemisphere, on the other hand, there is almost certainly a continent at the South Pole, which is completely surrounded by the ocean, and, in those latitudes, the most simple and extended oceanic conditions on the surface of the globe are encountered."

The author then proceeds to discuss the Meteorology.

[1] Proceedings of the Royal Society, vol. lxii, No. 387, pp. 424–451, Feb. 24, 1898.

"One of the most remarkable features in the meteorology of the globe is the low atmospheric pressure at all seasons in the southern hemisphere south of latitute 45° S., with the accompanying strong westerly and north-westerly winds, large rain and snow fall, all round the South Polar regions. The mean pressure seems to be less than 29 inches, which is much lower than in similar latitudes in the northern hemisphere. Some meteorologists hold that this vast cyclonic system and low-pressure area continues south as far as the pole, the more southerly parts being traversed by secondary cyclones. There are, however, many indications that the extreme South Polar area is occupied by a vast anticyclone, out of which winds blow towards the girdle of low pressure outside the ice-bound region. In support of this view it is pointed out that Ross's barometric observations indicate a gradual rise in the pressure south of the latitude of 75° S., and all Antarctic voyagers agree that when near the ice the majority of the winds are from the south and south-east, and bring clear weather with fall of temperature, while northerly winds bring thick fogs with rise of temperature.

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"There would appear, then, to be good reasons for believing that the region of the South Pole is covered by what may be regarded practically as a great permanent anticyclone with a much wider extension in winter than in summer. It is most likely that the prevailing winds blow out from the pole all the year round towards the surrounding sea, as in the case of Greenland, but, unlike Greenland, this area is probably seldom traversed by cyclonic disturbances.

"But what has been stated only shows how little real knowledge we possess concerning the atmospheric conditions of high southern latitudes. It is certain, however, that even two years' systematic observations within these regions would be of the utmost value for the future of meteorological science."

Referring to the Antarctic ice, Dr. Murray said :—

"From many points of view it would be important to learn something about the condition and distribution of Antarctic sea-ice during the winter months, and especially about the position and motion of the huge table-shaped icebergs at this and other seasons of the year. These flat-topped icebergs, with a thickness of 1,200 or 1,500 feet, with their stratification and their perpendicular cliffs, which rise 150 or 200 feet above and sink 1,100 or 1,400 feet below the level of the sea, form the most striking peculiarity of the Antarctic Ocean. Their form and structure seem clearly to indicate that they were formed on an extended land surface, and have been pushed out over low-lying coasts into the sea.

"Ross sailed for 300 miles along the face of a great ice-barrier from 150 to 200 feet in height, off which he obtained depths of 1,800 and 2,400 feet. This was evidently the sea-front of a great creeping glacier or ice-cap just then in the condition to give birth to the table-shaped icebergs, miles in length, which have been described by every Antarctic voyager.

"All Antarctic land is not, however, surrounded by such inaccessible cliffs of ice, for along the seaward faces of the great mountain ranges of Victoria Land the ice and snow which descend to the sea apparently form cliffs not higher than 10 to 20 feet, and in 1895 Kristensen and Borchgrevink landed at Cape Adare on a pebbly beach, occupied by a penguin rookery, without encountering any land-ice descending to the sea. Where a penguin rookery is situated, we may be quite sure that there is occasionally open water for a considerable portion of the year, and that consequently landing might be effected without much difficulty or delay, and further that a party, once landed, might with safety winter at such a spot, where the penguins would furnish an abundant supply of food and fuel. A properly equipped party of observers situated at a point like this on the Antarctic continent for one or two winters might carry out a most valuable series of scientific observations, make successful excursions towards the interior and bring back valuable information as to the probable thickness of the ice-cap, its temperature at different levels, its rate of accumulation, and its motions, concerning all which points there is much difference of opinion among scientific men."

We come then to the question—"Is there an Antarctic continent? It has already been stated that the form and structure of the Antarctic icebergs indicate that they were built up on, and had flowed over, an extended land surface. As these bergs are floated to the north and broken up in warmer latitudes they distribute over the floor of the ocean a large quantity of glaciated rock fragments and land detritus. These materials were dredged up by the 'Challenger' in considerable quantity, and they show that the rocks over which the Antarctic land-ice moved were gneisses, granites, mica-schists, quartziferous diorites, grained quartzites, sandstones, limestones, and shales. These lithological types are distinctly indicative of continental land, and there can be no doubt about their having been transported from land situated towards the South Pole. D'Urville describes rocky islets off Adélie Land composed of granite and gneiss. Wilkes found on an iceberg, near the same place, boulders of red sandstone and basalt. Borchgrevink and Bull have brought back fragments of mica-schists and other continental rocks from Cape Adare. Dr. Donald brought back from Joinville Island a piece of red jasper or chert containing Radiolaria and sponge spicules. Captain Larsen brought from Seymour Island pieces of fossil coniferous wood, and also fossil shells of *Cucullæa, Cytherea, Cyprina, Teredo,* and *Natica*, having a close resemblance to species known to occur in Lower Tertiary beds in Britain and Patagonia. These fossil remains indicate in these areas a much warmer climate in past times. We are thus in possession of abundant indications that there is a wide extent of continental land within the ice-bound regions of the southern hemisphere.

"It is not likely that any living land-fauna will be discovered on the Antarctic continent away from the penguin rookeries. Still, an Antarctic expedition will certainly throw much light on many

geological problems. Fossil finds in high latitudes are always of special importance. The pieces of fossil wood from Seymour Island can hardly be the only relics of plant life that are likely to be met with in Tertiary and even older systems within the Antarctic. Tertiary, Mesozoic, and Palæozoic forms are tolerably well developed in the Arctic regions, and the occurrence of like forms in the Antarctic regions might be expected to suggest much as to former geographical changes, such as the extension of Antarctica towards the north, and its connection with, or isolation from, the northern continents, and also as to former climatic changes, such as the presence in Pre-Tertiary times of a uniform temperature in the waters of the ocean all over the surface of the globe."

After pointing out the importance of magnetic and pendulum observations, geodetic measurements, tides, and currents, the author referred to the depth of the Antarctic Ocean.

"In regard to the depth of the ocean immediately surrounding the Antarctic continent we have at present very meagre information, and one of the objects of an Antarctic expedition would be to supplement our knowledge by an extensive series of soundings in all directions throughout the Antarctic and Southern Oceans. It would in this way be possible, after a careful consideration of the depths and marine deposits, to trace out approximately the outlines of the Antarctic continent. At the present time we know that Ross obtained depths of 100 to 500 fathoms all over the great bank extending to the east of Victoria Land, and somewhat similar depths have been obtained extending for some distance to the east of Joinville Island. Wilkes sounded in depths of 500 and 800 fathoms about 20 or 30 miles off Adélie Land. The depths found by the 'Challenger' in the neighbourhood of the Antarctic circle were from 1,300 to 1,800 fathoms, and further north the 'Challenger' soundings ranged from 1,260 to 2,600 fathoms. To the south-west of South Georgia, Ross paid out 4,000 fathoms of line without reaching bottom. In the charts of depth which I have constructed I have always placed a deep sea in this position, for it appears to me that Ross, who knew very well how to take soundings, was not likely to have been mistaken in work of this kind.

"The few indications which we thus possess of the depth of the ocean in this part of the world seem to show that there is a gradual shoaling of the ocean from very deep water towards the Antarctic continent, and, so far as we yet know, either from soundings or temperature observations, there are no basins cut off from general oceanic circulation by barriers or ridges, similar to those found towards the Arctic."

Dr. Murray next spoke of the deposits of the Antarctic Ocean.

"The deposits which have been obtained close to the Antarctic continent consist of blue mud, containing glauconite, made up for the most part of detrital matters brought down from the land, but containing a considerable admixture of the remains of pelagic and other organisms. Further to the north there is a very pure diatom ooze, containing a considerable quantity of detrital matter from

icebergs, and a few pelagic foraminifera. This deposit appears to form a zone right round the earth in these latitudes. Still further to the north the deposits pass in deep water, either into a Globigerina ooze, or into a red clay with manganese nodules, sharks' teeth, ear-bones of whales, and the other materials characteristic of that deep-sea deposit. Since these views, however, as to the distribution of deep-sea deposits throughout these high southern latitudes, are founded upon relatively few samples, it cannot be doubted that further samples from different depths in the unexplored regions would yield most interesting information."

The subject of temperature of the Antarctic Ocean was then discussed.

"The mean daily temperature of the surface waters of the Antarctic, as recorded by Ross, to the south of latitude 63° S. in the summer months, varies from 27·3° to 33·6°, and the mean of all his observations is 29·85°. As already stated, his mean for the air during the same period is somewhat lower, being 28·74°. In fact, all observations seem to show that the surface water is warmer than the air during the summer months.

"The 'Challenger' observations of temperature beneath the surface indicate the presence of a stratum of colder water wedged between warmer water at the surface and warm water at the bottom. This wedge-shaped stratum of cold water extends through about 12° of latitude, the thin end terminating about latitude 53° S., its temperature varying from 28° at the southern thick end to 32·5° at the northern thin end, while the temperature of the overlying water ranges from 29° in the south to 38° in the north, and that of the underlying water from 32° to 35°. This must be regarded as the distribution of temperature only during the summer, for it is improbable that during the winter months there is a warmer surface layer.

"In the greater depths of the Antarctic, as far south as the Antarctic circle, the temperature of the water varies between 32° and 35° F., and is not, therefore, very different from the temperature of the deepest bottom water of the tropical regions of the ocean. The presence of this relatively warm water in the deeper parts of the Antarctic Ocean may be explained by a consideration of general oceanic circulation. The warm tropical waters which are driven southwards along the eastern coasts of South America, Africa, and Australia, into the great all-encircling Southern Ocean, there become cooled as they are driven to the east by the strong westerly winds. These waters, on account of their high salinity, can suffer much dilution with Antarctic water, and still be denser than water from these higher latitudes at the same temperature. Here the density observations and the sea-water gases indicate that the cold water found at the greater depths of the ocean probably leaves the surface and sinks towards the bottom in the Southern Ocean, between the latitudes of 45° and 56° S. These deeper, but not necessarily bottom, layers are then drawn slowly northwards towards the tropics, to supply the deficiencies there

produced by evaporation and southward-flowing surface-currents, and these deeper layers of relatively warm water appear likewise to be slowly drawn southwards to the Antarctic area to supply the place of the ice-cold currents of surface water drifted to the north. This warm underlying water is evidently a potent factor in the melting and destruction of the huge table-topped icebergs of the southern hemisphere. While these views as to circulation appear to be well established, still a fuller examination of these waters is most desirable at different seasons of the year, with improved thermometers and sounding machines. Indeed, all deep-sea apparatus has been so much improved as a result of the 'Challenger' explorations, that the labour of taking specific gravity and all other oceanographical observations has been very much lessened."

In speaking of the pelagic life of the Antarctic Ocean, the author mentioned that "In the surface waters of the Antarctic there is a great abundance of diatoms and other marine algæ. These floating banks or meadows form primarily not only the food of pelagic animals, but also the food of the abundant deep-sea life which covers the floor of the ocean in these South Polar regions. Pelagic animals, such as copepods, amphipods, molluscs, and other marine organisms, are also very abundant, although species are fewer than in tropical waters. Some of these animals seem to be nearly, if not quite, identical with those found in high northern latitudes, and they have not been met with in the intervening tropical zones. The numerous species of shelled Pteropods, Foraminifera, Coccoliths, and Rhabdoliths, which exist in the tropical surface waters, gradually disappear as we approach the Antarctic circle, where the shelled Pteropods are represented by a small *Limacina*, and the Foraminifera by only two species of *Globigerina*, which are apparently identical with those in the Arctic Ocean. A peculiarity of the tow-net gatherings made by the 'Challenger' Expedition in high southern latitudes, is the great rarity or absence of the pelagic larvæ of benthonic organisms, and in this respect they agree with similar collections from the cold waters of the Arctic seas. The absence of these larvæ from polar waters may be accounted for by the mode of development of benthonic organisms to be referred to presently. It must be remembered that many of these pelagic organisms pass most of their lives in water of a temperature below 32° F., and it would be most interesting to learn more about their reproduction and general life-history."

As to the benthos life of the Antarctic Ocean, Dr. Murray said:—

"At present we have no information as to the shallow-water fauna of the Antarctic continent; but, judging from what we do know of the off-lying Antarctic islands, there are relatively few species in the shallow waters in depths less than 25 fathoms. On the other hand, life in the deeper waters appears to be exceptionally abundant. The total number of species of Metazoa collected by the 'Challenger' at Kerguelen in depths less than 50 fathoms was about 130, and the number of additional species known from other sources from the shallow waters of the same island is 112, making altogether 242

species, or thirty species less than the number obtained in eight deep hauls with the trawl and dredge in the Kerguelen region of the Southern Ocean, in depths exceeding 1,260 fathoms, in which eight hauls 272 species were obtained. Observations in other regions of the Great Southern Ocean, where there is a low mean annual temperature, also show that the marine fauna around the land in high southern latitudes appears to be very poor in species down to a depth of 25 fathoms, when compared with the number of species present at the mud-line about 100 fathoms, or even at depths of about two miles.

"In 1841 Sir James Clark Ross dredged off the Antarctic continent species which he recognized as the same as he had been in the habit of taking in equally high Northern latitudes, and he suggested that they might have passed from one pole to the other by way of the cold water of the deep sea. Subsequent researches show that, as with pelagic organisms, many of the bottom-living species are identical with, or closely allied to, those of the Arctic regions, and are not represented in the intermediate tropical areas. For instance, the most striking character of the shore-fish fauna of the Southern Ocean is the reappearance of types inhabiting the corresponding latitudes of the northern hemisphere, and not found in the intervening tropical zone. This interruption of continuity in the distribution of shore-fishes is exemplified by species as well as genera, and Dr. Günther enumerates eleven species and twenty-nine genera as illustrating this method of distribution. The genus by which the family Berycidæ is represented in the Southern Temperate Zone (*Trachichthys*) is much more nearly allied to the northern than to the tropical genera. 'As in the Northern Temperate Zone, so in the Southern . . . . the variety of forms is much less than between the tropics. This is especially apparent on comparing the number of species constituting a genus. In this zone, genera composed of more than ten species are the exception, the majority having only from one to five.' . . . . '*Polyprion* is one of those extraordinary instances in which a very specialized form occurs at almost opposite points of the globe, without having left a trace of its previous existence in, or of its passage through, the intermediate space.'

"Speaking of the shore-fishes of the Antarctic Ocean, Günther says: 'The general character of the fauna of Magelhæn's Straits and Kerguelen's Land is extremely similar to that of Iceland and Greenland. As in the Arctic fauna, Chondropterygians are scarce, and represented by *Acanthias vulgaris* and species of *Raja* . . . . As to Acanthopterygians, Cataphracti and Scorpænidæ are represented as in the Arctic fauna, two of the genera (*Sebastes* and *Agonus*) being identical. The Cottidæ are replaced by six genera of Trachinidæ, remarkably similar in form to Arctic types . . . . Gadoid fishes reappear, but are less developed; as usual, they are accompanied by *Myxine*. The reappearance of so specialized a genus as *Lycodes* is most remarkable.'[1]

[1] Günther, "Study of Fishes," pp. 282–290; Edinburgh, 1880.

"These statements with reference to shore-fishes might, with some modifications, be repeated concerning the distribution and character of all classes of marine invertebrates in high northern and high southern latitudes. The 'Challenger' researches show that nearly 250 species taken in high southern latitudes occur also in the northern hemisphere, but are not recorded from the tropical zone. Fifty-four species of seaweeds have also been recorded as showing a similar distribution.[1] Bipolarity in the distribution of marine organisms is a fact, however much naturalists may differ as to its extent and the way in which it has originated.

"All those animals which secrete large quantities of carbonate of lime greatly predominate in the tropics, such as Corals, Decapod Crustacea, Lamellibranchs, and Gasteropods. On the other hand, those animals in which there is a feeble development of carbonate of lime structures predominate in cold polar waters, such as Hydroida, Holothurioidea, Annelida, Amphipoda, Isopoda, and Tunicata. This difference is in direct relation with the temperature of the water in which these organisms live, a much more rapid and abundant precipitate of carbonate of lime being thrown down in warm than in cold water by ammonium carbonate, one of the waste products of organic activity.

"In the Southern and Sub-Antarctic Ocean a large proportion of the Echinoderms develop their young after a fashion which precludes the possibility of a pelagic larval stage. The young are reared within or upon the body of the parent, and have a kind of commensal connection with her till they are large enough to take care of themselves. A similar method of direct development has been observed in eight or nine species of Echinoderms from the cold waters of the northern hemisphere. On the other hand, in temperate and tropical regions the development of a free-swimming larva is so entirely the rule that it is usually described as the normal habit of the Echinodermata. This similarity in the mode of development between Arctic and Antarctic Echinoderms (and the contrast to what takes place in the tropics) holds good also in other classes of Invertebrates, and probably accounts for the absence of free-swimming larvæ of benthonic animals in the surface gatherings in Arctic and Antarctic waters.

"What is urgently required with reference to the biological problems here indicated is a fuller knowledge of the facts, and it cannot be doubted that an Antarctic expedition would bring back collections and observations of the greatest interest to all naturalists and physiologists, and without such information it is impossible to discuss with success the present distribution of organisms over the surface of the globe, or to form a true conception of the antecedent conditions by which that distribution has been brought about."

Dr. Murray concluded his paper as follows:—

"There are many directions in which an Antarctic Expedition would carry out important observations besides those already touched

[1] Murray and Barton, "Phycological Memoirs of the British Museum," part iii; London, 1895.

on in the foregoing statement. From the purely exploratory point of view much might be urged in favour of an Antarctic Expedition at an early date; for the further progress of scientific geography it is essential to have a more exact knowledge of the topography of the Antarctic regions. This would enable a more just conception of the volume relations of land and sea to be formed, and in connection with pendulum observations some hints as to the density of the sub-oceanic crust and the depth of ice and snow on the Antarctic continent might be obtained. In case the above sketch may possibly have created the impression that we really know a great deal about the Antarctic regions, it is necessary to restate that all the general conclusions that have been indicated are largely hypothetical, and to again urge the necessity for a wider and more solid base for generalizations. The results of a successful Antarctic Expedition would mark a great advance in the philosophy—apart from the mere facts—of terrestrial science.

"No thinking person doubts that the Antarctic will be explored. The only questions are: when? and by whom? I should like to see the work undertaken at once, and by the British Navy. I should like to see a sum of £150,000 inserted in the estimates for the purpose. The Government may have sufficient grounds for declining to send forth such an expedition at the present time, but that is no reason why the scientific men of the country should not urge that the exploration of the Antarctic would lead to important additions to knowledge, and that, in the interests of science among English-speaking peoples, the United Kingdom should take not only a large but a leading part in any such exploration."

The Duke of Argyll, Sir J. D. Hooker, Dr. Nansen, Dr. G. Neumayer, Sir Clements Markham, Dr. Alexander Buchan, Sir A. Geikie, Dr. Sclater, Professor D'Arcy Thompson, Admiral Sir W. J. L. Wharton, and others, took part in the discussion which followed.

REVIEWS.

Wachsmuth and Springer's Monograph on Crinoids.

The North American Crinoidea Camerata. By Charles Wachsmuth and Frank Springer. Mem. Mus. Comp. Zool. Harvard, vols. xx and xxi, containing 838 pp. and 83 plates. (Cambridge, U.S.A., May, 1897).

First Notice.

In the last letter that he wrote me, Charles Wachsmuth repeated a wish already expressed by word of mouth, namely, that in some English publication I should review this grand monograph, then in active preparation. Although, through the kindness of Mr. Alexander Agassiz and Mr. Frank Springer, a copy has been in my hands for a twelvemonth, yet the wish of my departed friend is still unfulfilled. The reasons for delay have been two. The first is the size and importance of the work, coupled with my desire to do it justice. What has taken twenty years to write cannot be digested