NOTICES OF MEMOIRS.

I.—Notes on an Expedition to Christmas Island. By C. W. Andrews, B.A., B.Sc., F.G.S., Assistant in the British Museum (Natural History).

[Sir John Murray, having resolved to send a naturalist at his own expense to investigate the fauna and flora and the geology of Christmas Island, invited Mr. C. W. Andrews, of the Geological Department, British Museum (Natural History), to undertake the task. Having obtained the necessary leave of absence Mr. Andrews sailed from England on May 4th, 1897, and after an absence of 15 months he reached home on August 3rd, 1898. He made a considerable stay in Java on his outward passage; he also visited the Cocos-Keeling Islands on his return voyage. The expedition was most successful.

The collections made by Mr. Andrews during his stay on Christmas Island include geological specimens and many illustrating the botany and zoology. These comprise 274 mammals, birds, and reptiles; 183 mollusca; 1,419 insects; and 378 spiders, myriopods, crustacea, echinoderms, and worms. A selection of the specimens have been generously presented by Sir John Murray to the British Museum (Natural History).

The island is typically oceanic, and the mammals, land birds, and many of the insects found are peculiar to it; the geographical and geological observations made by Mr. Andrews are also of great interest.

The following abridged account communicated by the author is from a paper read by him before the Royal Geographical Society, November 28th, 1898.—H. W.]

One of the most interesting of the lonely islets of the Indian Ocean is Christmas Island, which lies about 190 miles south of Java, in lat. 10° 25′, long. 105° 42′. The seas around it are of enormous depth, and soundings of over 1,000 fathoms occur within two or three miles of its coasts. To the north and north-west is Macclear deep, in which 3,200 fathoms were found, and to the south is the more extensive Wharton deep, with upwards of 3,000 fathoms. The island, in fact, rises from the summit of the low submarine ridge which separates these two abysses, and on the westward end of which the Cocos-Keeling Islands are situated.

Seen from the south-west, the island appears as a long green ridge nearly level at the top, there being only slight elevations at the north-west and south-east ends. The ridge descends seaward in a succession of terraces, the upper ones bounded by comparatively gentle slopes, the lower by a high and nearly vertical cliff, below which there is a narrow platform sloping gently down to the sea-cliff. This is usually about 15 to 30 feet high, and is much undercut by the heavy swell that is continually breaking against its base. On approaching nearer it can be seen that the whole island is covered with a dense forest, only broken by the grey face

https://doi.org/10.1017/S0016756800141901 Published online by Cambridge University Press

of the high inland cliff which runs round the greater part of the island, rising like a wall above the tall trees growing on the shore terrace.

If the coast be examined in a boat or from the top of the sea-cliff, it will be seen that a submarine terrace in the shape of a fringing reef is being formed round the greater part of the island. It varies greatly in width, and also in its depths below the surface; in some places it is partly dry at low-water, in others some fathoms deep. Outside the edge of this reef the water deepens suddenly.

The greatest length of the island, from North-East Point to Egeria Point, is about 12 miles. The greatest width from north to south is about 9 miles; the least 3½ miles. Its area may be roughly stated at 43 square miles.

The island consists of a central plateau, highest towards the north and east, and descending to the sea on all sides by a succession of terraces, separated by slopes or cliffs. In most places the arrangement of these, from the edge of the plateau downwards, is—(1) a steep slope strewn with blocks; (2) a broad terrace, followed by a similar slope (this seems to be wanting on the south); (3) a second terrace, terminating in a cliff 200 or 300 feet high; (4) the shore terrace, sloping gently down to the sea-cliff; (5) the present fringing reef. There are, however, many local differences, the more important of which will be noticed below.

The Central Plateau.

The edge of the central plateau is roughly parallel to the coast, receding farthest from it opposite the principal headlands. It is highest along its northern and eastern borders, where there is a raised rim, the average height of which above the sea is about 800 feet. Towards the south it slopes away so that its edge is only from 400 to 450 feet high, but there are some slight elevations above this general level. On the west the upper terraces are replaced by a gentle slope, and even the first inland cliff is not well marked except towards North-West and Egeria Points.

Along the raised rim of the plateau there are a number of hills, the highest of which (Murray Hill) occurs towards North-West Point. It is a nearly flat-topped hill, divided by an oblique valley into a larger and rather higher western portion and a lower eastern one; the greatest height is about 1,170 feet. The summit is formed by masses of dolomitic limestone, and on its lower slopes there are beds of shelly limestone, and a peculiar deposit which seems to be mainly made up of tiny spherules of altered volcanic glass. The outer face is very steep, but towards the south the land first descends gently, then rises a little, finally sinking to the general level of the plateau in a long gradual slope. On the south-western side there are occasionally patches of rounded pebbles, which are of a volcanic nature, and are, perhaps, derived from the bed above mentioned. Similar nodules occur in many places on the higher parts of the island.

The next highest hill (Ross Hill) is over South Point. It also has a flat top covered with dolomitic limestone, in which traces of gastropod shells are visible. On its outer side there is a low cliff, and below this a long steep slope covered with blocks of limestone in the wildest confusion, and thickly overgrown with creepers and brushwood. Towards the plateau also the descent is rather abrupt.

Over North-East Point is another elevation (Phosphate Hill), which, though not so high (900 feet), is particularly interesting on account of the extensive deposit of phosphate of lime which is found there. This substance is strewn over the surface in blocks of all sizes, and in some places it is found to a considerable depth; in others, however, it can be seen to rest directly on an irregular surface of dolomitic limestone, occasional pinnacles of which project through it. At the northern end of the hill the phosphate is found on both outer and inner slopes, but farther south on the plateau side only, the outer being occupied by a reef of limestone, which descends to the terrace beneath in a low cliff. The area actually covered by this thick deposit of phosphate of lime is about half a mile long by a quarter broad, but an immense quantity occurs in the form of irregular nodules and blocks scattered over all the slopes and terraces of this part of the island. There are other less extensive beds over Flying Fish Cove, and also at several points along the eastern edge of the plateau. Probably, when the islands were still low and not covered with forest, they formed the homes of myriads of sea birds, and the guano thus formed, after undergoing alteration, mainly through loss of its organic matter, gave rise to the hard phosphatic rock now existing. At the same time the limestones on which it rests have often been phosphatized, and lumps of coral consisting mainly of phosphate of lime are sometimes found. The extensive accumulations of guano which must have taken place point to a time when the rainfall was much less than at the present day, a condition which may, at least in part, have been dependent on the circumstances that the islands were low and probably free from forest.

On the eastern rim, between Phosphate Hill and Ross Hill, there are several smaller elevations, all presenting similar characters, viz.: having on their seaward side a steep talus slope or low cliff, a flat top, and a moderate declivity on the inland side. Between the hills both on the north and east coasts, the rim of the plateau varies a good deal in character. As a rule, its outer edge is marked by a kind of rampart of lines of limestone pinnacles separated by channels, but sometimes it descends by a gentle slope; in either case, beneath the cliff or the slope there is always a steep talus-strewn declivity passing down to the first terrace.

The northern part of the plateau within the elevated rim is particularly characterized by the presence of numerous low hills (about 50 feet), with more or less flat tops covered with blocks and pinnacles of limestone. Further south there are several step-like ridges, running in a generally east-and-west direction; their southern face is covered with blocks of limestone, composed mainly

https://doi.org/10.1017/S0016756800141901 Published online by Cambridge University Press

of rather fresh-looking corals. In a few places similar limestones form extensive reefs, cut up into deep channels and holes. These reefs, when covered with thick bush, form almost impenetrable obstacles.

The Upper Slopes and Terraces.

As already mentioned, there is beneath the edge of the plateau a steep slope usually covered with talus, but where the rocks composing it are exposed they are found to consist of foraminiferal and coral limestones, and are often full of angular fragments of older limestones. Beneath this slope is a level terrace varying in width from a few yards to a quarter of a mile or more, and bounded on the seaward side by a second steep declivity, or in places by an actual cliff. The rocks comprising it usually show very distinct traces of coral, and sometimes seem to be entirely composed of it. This slope is absent on the southern side of the island.

The next terrace also varies considerably in width; on its outer margin there is usually a broad belt of pinnacles of limestone separated by channels. In the neighbourhood of Steep Point, it rises into a rounded hill covered with blocks of phosphate of lime. This hill must have formed a small islet at the time the foot of the second inland cliff was washed by the sea. In other places there is a channel 40 or 50 yards wide running parallel to the edge of the cliff; the inner side is formed by a cliff 30 or 40 feet high, the outer by walls and pinnacles separated by branching channels, the floor of which, like that of the main channel, is perfectly level. Towards the sea there is a steep slope covered with blocks of limestone. When the sea was 350 to 400 feet higher than at present, this channel formed a sort of canal in the reef parallel to the coast.

Beneath the terrace just described comes the first inland cliff, by far the most conspicuous feature of the island. Usually it has a vertical, or nearly vertical, face, and it is especially well-marked at the headlands. Its summit is from 250 to 300 feet above the sea. In several places about 150 feet above the shore platform there are distinct traces of wave action, the most notable being the presence of caves along this line. In some cases beneath this point, instead of a vertical face, we find a steep slope of limestone with coral in position of growth, apparently the remains of a narrow fringing reef, founded upon and partly composed of talus. That the elevation of this cliff has been of an intermittent character is further shown by the fact that where the slopes of the island are gentle and no high cliff has been formed, there is either a succession of minor cliffs separated by terraces and partly built up of coral rock, or merely a slope with ledges of coral limestone. Although these minor cliffs and ledges may be continuous for some distance in any given locality, they do not always correspond to those found a few miles off. It must also be noted that the geological structure and even the origin of this cliff are not everywhere the same, a point that will be referred to more fully below.

The shore terrace slopes gently down from the foot of the first inland cliff to the sea-cliff, which is from 15 to 30 or more feet high, and is often undercut by the waves to a remarkable extent, so that it sometimes overhangs more than 20 feet. The inland side of this terrace is often covered with pinnacles of rock similar to that of the cliff above, and once formed part of the foreshore planed down by the waves. Near the sea the terrace is clearly a raised fringing reef resting on a foundation of talus; the corals are often very fresh in appearance. In some localities this platform has been cut into the older rocks (orbitoidal limestones, basalts, etc.) which form the basis of the island, and in such places small streams may occur, the water being held up by the volcanic rocks. The point where these are best developed is on the east coast, where there are two or three muddy brooks and a small fall of excellent water, which gushes out over a bed of basalt just above high-water mark.

On the south, where the cliffs are exposed to the full force of the swell produced by the south-east trade wind, which blows most of the year, the coast scenery is very fine. The cliffs are cut into numberless narrow inlets, and their summits are often completely bare of vegetation for some distance from the sea. Blowholes are very numerous, and several columns of spray rising high above the trees may often be seen at once.

At various points round the coast there are shingle beaches. The most important of these are that in Flying Fish Cove and West White Beach, at both of which landing is fairly easy. There are also two or three others on the north coast, several on the east, and one or two towards the northern part of the west coast; most of these are small and shut in by cliff, and are covered at high-water.

The above is a brief account of the usual plan of the island, but there are several localities in which considerable divergences from this occur. One of these is Steep Point, where a deep fissure, forming a narrow valley, has cut off an angle of the first inland cliff, and the portion thus isolated has tilted forward so that the usual shore platform, if it ever existed, has been carried beneath the sea, and the headland, which is 150 to 200 feet high, is, in fact, part of the first inland cliff.

Again, on the east coast, near North-East Point, extensive slips or faults have taken place, the result being that the ordinary terraces are replaced by a single precipice 500 to 600 feet high, the foot of which is covered by talus of enormous blocks of limestone. In this case the edge of the island as far back as the second inland cliff has slipped down beneath the sea, and has helped to build up the foundation upon which the reefs now forming the shore terrace were built. Nearer North-East Point the slip was less extensive, and the slipped mass here forms the first inland cliff, on the top of which there are several step-like ridges running parallel to its edge, and marking minor dislocations. The rock comprising both this cliff and the precipice further south seems to be almost wholly a mass of orbitoidal limestone, the flat joint faces of which give it a very characteristic appearance; the cliff on the southern side of Egeria promontory is similar, and the small cliffs resulting from successive steps can be plainly seen.

At the western end of the island the upper cliffs are replaced by gentle slopes, and even the first inland cliff is ill defined, except towards North-West and Egeria Points. Another characteristic feature of this region is the occurrence of several valleys running down to the sea in a generally south-western direction. These first commence as a shallow depression at about 400 feet, but, as they are followed, deepen to a narrow gorge which cuts through the first inland and sometimes the sea cliff also. The scenery of these valleys is the most picturesque on the island, and reminds one a little of the dales in the Mountain Limestone in the Peak District. The floor of these valleys is generally formed of volcanic rock (basalt), and in the wet season is occupied by a small stream, which descends to the sea by a succession of falls and rapids; but at the time of my visit water was only found in the northernmost valley.

The last locality to be described is Flying Fish Cove, by far the most important, because it seems to supply the key to the structure of the island as a whole. In the large-scale map of this district given, it will be observed that at this point the sea-cliff is interrupted, and its place taken by a long curved stretch of white shingle beach, in front of which a broad fringing reef stretches from one end of the cove to the other. Behind the beach is a nearly level platform, composed mainly of blocks and fragments of coral mingled with talus from the cliff above. This level has been, for the most part, cleared and planted with cocoanut-palms, fruit-trees, and vegetables, and is the site of "Clunies-Ross Settlement," which consists of some nine or ten houses, workshops, and stores. The cliff joining the back of the cove is about 500 feet high in the middle, but decreases in height towards the ends, and towards the north the slope becomes less steep. For the greater part of its length it consists of alternations of low, more or less vertical cliffs, with steep talus slopes; but towards the southern end the upper part forms overhanging precipices of 200 feet or more in height, while the lower portion is covered by a talus slope of limestone blocks, often as large as a fair-sized cottage. Some of these lie far out on the reef. In this cliff and in its immediate neighbourhood we have almost the only section from which it is possible to get an idea of the nature of the foundation upon which the upper reefs have been established; almost everywhere else the central portion of the island is concealed by the investing covering of more recent limestones which have formed round the island, either as sediment derived from the higher coral masses or as reefs which have grown on the slopes of the island during its elevation. The circumstance that nearly all the rocks of the island are white limestones, often largely made up of fragments of older beds or containing fossils derived from them, renders the interpretation of the facts observed a matter of great difficulty. It will not be necessary, however, here to enter into details of the geology of the island, and only a brief

https://doi.org/10.1017/S0016756800141901 Published online by Cambridge University Press

sketch of the structure of the neighbourhood of Flying Fish Cove is given.

Round the greater part of the cove, about half-way up the cliff, there is a thick bed of yellow foraminiferal limestone, the nearly vertical face of which is from 15 to 60 feet high. Beneath this, and apparently penetrating its lower surface, are several masses of volcanic rock, mainly basaltic. Above the limestone is another bed of basalt, upon which there are thick bands of palagonite tuffs, and occasionally traces of basalt above these again; but the upper slopes are so thickly covered with soil and fallen blocks of limestone, that it is difficult to determine the exact structure of this part of the cliff. About the middle of the cove the hard limestone is found at a rather higher level, apparently the result of faulting, but its relations to the volcanic series are the same. Southward of this the bed dips downward towards the shore, and the basalt and tuffs resting upon it disappear abruptly, their edges being overlapped by hard white limestone with *Orbitoides.* This rock forms the upper 50 feet or so of the cliff throughout its length, and on the summit occurs in low cliffs, ridges, and pinnacles. At the southern end of the cove it thickens out to a cliff some 250 to 300 feet high, the lower part of which is penetrated by masses of basalt. Above the cliff to the southward this limestone is found on the eastern and western sides of a broad belt of basalt, which forms a series of rounded hills with valleys opening towards the sea. On the eastern side its base is about 500 feet above the sea; on the west, where it is largely concealed by the more recent deposits forming the cliffs and terraces representing the first inland cliff, it is only 300 to 350 feet. No doubt this limestone completely covered the basalt, but has been removed by denudation; and, in fact, further south the volcanic rock is completely concealed by limestones.

Further inland, above the orbitoidal limestones comes the steep slope of the second inland cliff, which is here largely composed of corals; shells of mollusca are also found, and there are some beds of foraminiferal limestone without *Orbitoides.* Above this cliff is a long slope with lines of limestone pinnacles parallel to its edge, and above this, again, the upper inland cliff, or rather slope. Along the foot of this there are some ridges of coral limestone; but towards the summit it rises into rounded hills of dolomitic limestone, with a great many blocks of phosphate of lime here and there. These piles are probably the remains of islets along the edge of the lagoon (now the plateau) before the first elevation of the island took place.

The history of the island, as far as it can be made out, seems to have been as follows:—At first, at no great depth, there was a submarine bank upon which numerous foraminifera, including *Orbitoides,* lived, and the shells of which formed thick beds of limestone. The foundation of this bank was volcanic, and from time to time lava was erupted through and upon the limestones: the occurrence of thick bands of palagonite tuff indicate that the eruptions were submarine. Some elevation took place, and the

https://doi.org/10.1017/S0016756800141901 Published online by Cambridge University Press

beds of tuff became consolidated by the infiltration of lime. In the next place, the whole was covered with thick beds of white limestone crowded with large *Orbitoides.* These strata seem to have overlapped the edges of the beds of tuff, and in places it can be seen that they dip away from the central mass. The deposits resting on the orbitoidal limestones are for the most part covered with recent accumulations, but they appear to have been mainly foraminiferal limestones.

Upon the foundation thus prepared extensive reefs grew up and formed an atoll-shaped group of islands, the reef flat and islands being now represented by the raised rim of the plateau and the hills rising from it, the lagoon by the central plateau itself. The rounded hills and lofty pinnacles found within the raised margin are probably the remains of knolls and masses of coral growing up in the lagoon, such as may be seen in the Cocos-Keeling Islands at the present day. The height of the hills over North-West and South Points may be accounted for by supposing either that they are points of local elevation greater than that affecting the main mass of the island, or that they represent the higher parts of the bank, upon which reefs were formed before the greater part of it was near enough to the surface for the growth of reef corals. During the formation of these higher reefs, the material derived from their wear, mingled with the remains of organisms living around the coast, formed thick deposits of limestone upon the flanks of the island.

The first important movement which took place seems to have resulted in the elevation of the northern and eastern sides of the island, the south and west probably remaining submerged. At this time the reefs forming the second inland cliff grew round the north and east coast, and probably some of the ridges of coral limestone running across the middle of the island were formed near the new shore-line on the side of the lagoon.

The next extensive elevation affected the whole area equally, and along the new shore-line the second inland cliff was cut back into the reefs just formed, or even in some places into the central foraminiferal limestones. Subsequently a series of movements of elevation led to the formation of the first inland cliff, or, on the more gentle slopes, to the succession of small cliffs and ridges of coral rock which represent it.

During these various movements much slipping and faulting took place round the island; the effects of this at Steep Point and North-East Point have already been described. As a result of this, and of the action of the waves around the coast, a submarine talus slope was formed, upon which a fringing reef was established, and at the next elevation this was converted into the shore terrace, while its margins were cut back into the present sea-cliff. Finally, as already mentioned, a reef is now growing around the coast which some day may form yet another raised terrace round the island. It is a point of some interest that Mr. Andrew Ross, during the eight or nine years he has been residing on the island, has noted the occurrence of two slight earthquakes, the more severe occurring in October, 1895; this was followed by heavy falls of rock from the cliffs.

II.—STRUCTURE OF A CORAL REEF.—Report of the Committee, consisting of Professor T. G. BONNEY (Chairman), Professor W. J. SOLLAS (Secretary), Sir ARCHIBALD GEIKIE, Professors J. W. JUDD, C. LAPWORTH, A. C. HADDON, BOYD DAWKINS, G. H. DARWIN, S. J. HICKSON, and ANDERSON STUART, Admiral Sir W. J. L. WHARTON, Dr. H. HICKS, Sir J. MURRAY, Drs. W. T. BLANFORD, C. LE NEVE FOSTER, and H. B. GUPPY, Messrs. F. DARWIN, H. O. FORBES, G. C. BOURNE, and J. W. GREGORY, Sir A. R. BINNIE, and Mr. J. C. HAWKSHAW, appointed to consider a project for investigating a Coral Reef by boring and sounding.

THE boring into the coral reef at Funa Futi, under the superintendence of Professor Edgeworth David, was carried down to a depth of 643 feet. After he had quitted the island to return to Sydney the work was continued until, owing to a breakdown of the apparatus, it finally ceased at a depth just short of 700 feet. The cores obtained during the work have been forwarded to England, and are now being worked out under the supervision of Professor Judd in the laboratory of the Royal College of Science at South Kensington. A brief summary of the results down to 643 feet was presented to the Royal Society on November 25, 1897, and will be found in their "Proceedings." According to the survey of Funa Futi and the neighbouring seas made by Captain Field, of H.M.S. "Penguin," it appears that the shape of the former is that of a cone with a rudely elliptical base rising with a gradual slope from the ocean floor at a depth of about 2,000 fathoms, and forming a kind of mural escarpment for the last 750 feet (approximate). When the whole party had returned to Sydney, Professors David and Stuart, after discussing the question of renewing the attempt to pierce the reef, the bottom of which, from the change of slope mentioned above, they thought must lie within 800 feet of the surface, prevailed on the authorities of the Department of Mines, Sydney, to lend plant and workmen in order to continue the old borehole, and, if possible, to put down another one in a shallow part of the lagoon. Application was made to the Admiralty by the Royal Society, and permission was given for the members of the expedition and the plant to be conveyed from Suva to Funa Futi and back by H.M.S. "Porpoise." The expedition has been at work during the summer, and intelligence of the result will doubtless have reached England during the autumn. Until this arrives, and the study of the materials already in this country has been completed, it would be premature to express any opinion of the theoretical bearing of the results obtained by the very successful operation undertaken in 1897.

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https://doi.org/10.1017/S0016756800141901 Published online by Cambridge University Press

III. — The Fossil Phyllopoda of the Palæozoic Ro
Fourteenth Report of the Committee, consisting of Prof. Wiltshire (Chairman), Dr. H. Woodward, and Prof. T. Rup Jones (Secretary). (Drawn up by Prof. T. Rupert Jones.)

§ I. In our First Report on the Palæozoic Phyllopoda (preser to the Association in 1883) the genus *Dithyrocaris* was included the Tabular List at p. 216 of the Reports for 1883 (1884), as be "ridged along the back (like *Apus*)," and as "being ridged sometimes prickled." It was referred to as occurring in Carbc ferous and Devonian strata.

In the Fifth Report (made in 1887), at pp. 63–66, we enumera all the known and reputed species of the genus. Thanks to obliging courtesy of friends and correspondents, we are now enab to state that we can distinguish the following species found in British Islands and elsewhere:—

		Scotland.	Ireland.	England.	Belgium.	Germany.	Canada.	[illegible]
	Carboniferous.							
Carapaces.	1. *Dithyrocaris glabra*, H. Woodward & R. Etheridge, jun.	*						
Carapaces.	2. ,, *ovalis*, W. & E. ...	*						
Carapaces.	3. ,, *granulata*, W. & E.	*						
Carapaces.	4. ,, *testudinea*, Scouler ...	*		*				
Carapaces.	5. ,, *Scouleri*, M'Coy ...	*	*					
Carapaces.	6. ,, *funiculata*, sp. nov. ...	*	*					
Carapaces.	7. ,, *Colei*, Portlock ...	*	*					
Carapaces.	8. ,, *tricornis*, Scouler ...	*		*				
Carapaces.	9. ,, *orbicularis*, Portlock		*					
Carapaces.	10. ,, *tenuistriata*, M'Coy...		*	*	*			
Carapaces.	11. ,, *Youngii*, sp. nov. ...	*						
Carapaces.	12. ,, *striata*, Woodward...	*						
Tailpieces.	13. ,, *lateralis*, M'Coy ...	*		*				
Tailpieces.	14. ,, *Neilsoni*, sp. nov. ...	*						
Tailpieces.	15. ,, *Dunnii*, sp. nov. ...	*		*				
Tailpieces.	16. ,, *carbonaria*, Meek & Worthen							*
Tailpieces.	17. *Rhachura venosa*, Scudder							*
	Devonian.							
Cara-pace.	18. *Dithyrocaris Belli*, Woodward...						*	
Tailpieces.	19. ,, *Kochi*, Ludwig... ...					*		
Tailpieces.	20. ,, *breviaculeata*, Ludwig					*		
Tailpieces.	21. ,, (?) *Jaschei*, Römer ...					*		
Tailpieces.	22. ,, *Kayseri*, Clarke ...					*		
Tailpieces.	23. *Mesothyra Oceani*, Hall & Clarke...							*
Tailpieces.	24. ,, *Neptuni*, Hall							*
	Carboniferous.							
	Gastric Teeth	*	*	*				

[1] Being a paper read before the British Association for the Advancement of Science Section C (Geology), Bristol, September, 1898.

https://doi.org/10.1017/S0016756800141901 Published online by Cambridge University Press

Dithyrocaris has a clypeiform test; at all events most of the specimens have a shield-like test, readily dividing into two moieties or valves; but some specimens seem to support the idea of having been able to fold the two sides together. The moieties are often separate, and some are too convex to have formed a quite flat shield; some have the lateral edges turned sharply downwards and inwards.

The valves, or two lateral moieties, were united along their dorsal edges simply; several specimens, however, had a dorsal rugose ridge-plate, over-riding, narrow, and longitudinal (somewhat like that described as an intervening plate in *Mesothyra* by Hall and Clark in 1888), ending in a posterior spine.

The valves are sub-oblong, straight along the middle two-thirds of the dorsal border, and elliptically curved ventrally; more or less rounded at the ends, with a median hollow or notch at their junction on the front and hind borders. The antero-dorsal region ends with a blunt angle or a short process; and the postero-ventral with a strong, sharp, trigonal spine.

The straight hinge-line is defined by two small dorsal notches. The ventral border has a striated, serrated, or fringed margin, either on its posterior moiety or throughout its extent.

The surface of each valve bears one longitudinal (*meso-lateral*) ridge, and sometimes others parallel; also short ridges (*cephalic*) over the gastric apparatus, and slighter ridges (*nuchal*) near the top of the dorsal ridge, all more or less rugose.

Scattered granulations and tubercles are often present on some parts of the valves, also lines and reticulations.

Granulation is feeble and sparse on *D. glabra* and *D. ovalis*; strong and abundant on *D. granulata*. Small prickles, rising from the meshes of a reticulation, are scattered over *D. tricornis*, *D. Colei*, and *D. orbicularis* (?). A system of oblique transverse lines characterizes *D. testudinea*. A feeble reticulation is traceable on *D. funiculata* and *D. Scouleri* (?). Longitudinal striæ mark the surface in *D. Belli* and *D. striata*; and *D. tenuistriata* and *D. Youngii* have longitudinal costulæ.

In consideration of certain differences in the carapaces, we separate Nos. 10 and 11 of the Table, at p. 28, from *Dithyrocaris*, as *Chænocaris tenuistriata* and *Ch. Youngii*, the carapace being bivalved and *gaping*. There is also an obscure Devonian form, from Saalfeld, to which we refer as *Chænocaris Richteriana*. We regard No. 12 as having a *closed* bivalved test, and therefore designate it as *Calyptocaris striata*.

We have had the opportunity of studying an old Apus-like fossil[1] labelled 'Burdiehouse.' It shows a small circular carapace (measuring 15 by 13 mm.), with strong postero-ventral angles, and distinct meso-lateral ridges leading to them; also a slightly curved depression in the middle of the front border, and a granulated margin throughout.

Mr. E. J. Garwood, F.G.S., who is a member of the British Association Committee for defining the zones in the Carboniferous

[1] *Hibbertia orbicularis.*

rocks, has just now forwarded for examination a very interesting collection of the remains of *Dithyrocaris*[1] from excavations in the shales of the Millstone-grit series at Eccup, Yorkshire.

§ II. In the "Proc. United States National Museum," vol. xix (1897), Mr. C. Schuchart has a paper "On the Fossil Phyllopod Genera *Dipeltis* [Packard *emend.*] and *Protocaris*." The latter was noticed in our Report to the Association for 1889, p. 64, and in our Ninth Report (for 1891), p. 300. The original genus *Dipeltis* was established by A. S. Packard, in the "Memoirs of the National Academy of Sciences," vol. iii (1885), Mem. xvi, p. 145, pl. v, figs. 2, 2*a*, as one of the Carboniferous Xiphosura of North America. In the December number of "Natural Science," 1897 (vol. xi, p. 401, figs. 2–5), in his paper on "Fossil Apodidæ," Mr. H. M. Bernard follows Mr. Schuchart in regarding the *Dipeltis*, as defined by the latter, as a Phyllopodous Apus-larva. Mr. C. J. Gahan, however, in "Natural Science," January, 1898, pp. 42–44, points out that it is really a larval form of the Blattarian insect *Etoblattina*, described and figured by H. Woodward in the GEOLOGICAL MAGAZINE, 1887, p. 433, Pl. XII.

§ III. With reference to the Bohemian *Estheriæ* mentioned at p. 4 of our Report for 1893 (Tenth, 1894), Dr. Anton Fritsch has informed us that they were named by him in the "Sitzungsb. k. böhm. Gesellsch. Wissen.," 1894: No. 1 being *Estheria triangularis*, Fr.; No. 2, *E. cyenea*, Fr.; No. 3 [and No. 4 ?], *E. palæoniscorum*, Fr.; and No. 5, *E. calcarea.*

IV.—THE COMPARATIVE ACTIONS OF SUBAËRIAL AND SUBMARINE AGENTS IN ROCK DECOMPOSITION. By THOMAS H. HOLLAND, A.R.C.S., F.G.S., Geological Survey of India.[2]

IN Europe nearly all crystalline and igneous rocks of any considerable age show signs of hydrous decomposition, which by the microscope can generally be traced far beyond the limits of the very evident superficial crust of weathered products: in some cases, like the peridotites, the changes due to hydration, even in rocks of Tertiary age, have resulted in a practically complete alteration of the original constituents. In working over various parts of Peninsular India, the writer has been struck by an almost constant absence of any but the most superficial traces of hydration, even in minerals like olivine and nepheline, which are so noticeably susceptible to the action of water. As in all tropical and moist climates, however, a complete and rapid superficial decomposition is shown by most of the rocks, and in some areas they are found to be changed into a ferruginous clay, which, though forty or fifty feet thick, is found to retain the characteristic macroscopic structures of the original rocks. In some districts, where the atmosphere is always warm, and during the monsoon season highly charged with moisture without great precipitation of rain, the rocks are

[1] For which we propose a new species, *D. insignis*.

[2] Read before Section C (Geology), British Association, Bristol, 1898.

similarly decomposed at the surface, but, on account of the limited amount of running water, the lime is retained in the decomposition products, and forms a concretionary 'kankar.'

In all these cases, however, although the action of the atmosphere is so striking, the results are purely superficial, and a specimen of rock taken from within a few inches of the clay products seldom shows a trace of hydrous decomposition, even in thin sections under the microscope. This is just as true for such delicate minerals as olivine and nepheline as for the commoner silicates. In many of the basic dykes, certainly pre-Cretaceous and probably Lower Palæozoic in age, the absence of serpentine is so complete that unusual precautions are often necessary for the determination of the olivine, whilst in the numerous occurrences of dunite throughout the Madras Presidency serpentine is extremely scarce. In a nepheline syenite recently discovered in the Coimbatore District, and at least of Cuddapah age, the nepheline on microscopic examination shows mere traces of alteration along the fracture cracks.

In the light of European experience, where most of our petrographical data have been established, the peculiarities of the Madras rocks call for some special consideration, and the object of this paper is to suggest that the probable explanation of the peculiarities now referred to arises from a contrast of the geological histories of the two areas. In Europe all, or nearly all, the rocks have been submerged below the sea during the later geological periods; in South India there is no evidence beyond the immediate precincts of the coastline of any depression below sea-level since Cuddapah (probably Lower Palæozoic) times. In Europe, therefore, the features generally attributed to weathering are the compound effect of submarine and subaërial action; in South India the former class of agencies has not affected the rocks now exposed, and the remarkable freedom from hydration which they show suggest that the action of the atmospheric agencies is purely superficial.

Taking into consideration the presence of lime carbonate and other salts, with a larger proportion of carbonic acid and the great pressure under which sea-water attacks a submerged rock-mass, it is theoretically to be expected that submarine agencies are more potent means of decomposition than those of the atmosphere; but these South Indian observations tend to show that serpentine and other forms of hydrated products within rock-masses are due only in a very limited degree to true weathering.

The products of atmospheric action are removed from the rock surface as fast as they are formed, and deeper portions are *pari passu* brought to the surface. It is not improbable that it is on account of this denudation, which has proceeded without known interruption for so many geological ages, that relatively deep-seated portions of the earth's crust have been brought to the surface in Madras, and that the crystalline rocks there met with at times present peculiarities for which European experience hardly prepares us.