

1.—On the Fossil Sponge Spicules in a Rock from the Deep Lead (?) at Princess Royal Township, Norseman District, Western Australia.

BY

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Some months since Mr. A. Gibb Maitland, F.G.S., Government Geologist of Western Australia, forwarded to me for examination a sample of an earthy siliceous rock [8131] from the Deep Lead (?), known as the "Princess Royal," situated on the townsite of the same name at the eastern margin of Lake Cowan. Brief references to this deep lead (?) are given in Bulletin No. 21 (1906), of the Geological Survey of Western Australia, where it is stated that it was discovered in February, 1901, in carrying out alluvial workings for gold, mostly in the main street. The depth was 88ft. in kaolin.

Above the "wash" there is a white pug showing the usual slickensides and crush faces and above this ironstone gravel patches. The wash itself is mullocky, with concretions of a magnesian nature, and with quartz particles, etc. This wash is said to have been 30 to 40 feet wide, and about 6ft. in thickness on the west side, and below it there is a gritty brown material, evidently decomposed hornblendic rock.

At the Princess Royal townsite there is a strip of kaolinized ground about a mile long and a quarter of a mile wide, which may be either a remnant of a wider covering or be due to the felsite dykes in this locality being very susceptible to decomposition. At the south end of this patch the deep lead was found. No particular age can be assigned to this kaolin; it is probably mostly decomposed rock *in situ* and has been increasing in depth as long as this has been dry land (pp. 20, 36).

The reports from the Bulletin quoted above respecting the character of the deposits in this deep lead (?) do not make mention of any rock at all comparable with the sample which has been sent to me, and it may be hoped that further investigation will furnish some detailed information as to the thickness of the deposit from which the sample was taken, its position in the series exposed in the lead, and the character of the beds above and below it.

GENERAL CHARACTERISTICS OF THE ROCK.

The sample of rock examined consists of three small irregular lumps of a very light, whitish, finely granular, and powdery material, which is so incoherent, tender, and friable that it readily breaks up into dusty powder between the fingers, and when treated in water with a soft brush it passes into a greyish mud. It may be said to be an aggregation of fine particles without any cementing material to bind them together. There is no indication of bedding to be seen in the lumps. Treated with dilute hydrochloric acid, the rock shows no reaction whatever.

When the powdered rock is examined dry with a strong lens or by reflected light under a microscope, it is seen to be composed mainly of minute glassy rods and granules, and occasionally of entire sponge spicules. In addition to these remains of organic origin there are some minute grains of a dark mineral, and also more numerous clear granules, mostly of quartz. The larger part of the latter are angular or sub-angular, some are rounded, and others seem to be small crystals. †

The spicules of siliceous sponges are the only fossils recognised so far, in the rock sample, no remains of other siliceous organisms, usually associated in marine deposits of this character, such as radiolaria and diatoms, have been met with.

CONDITION OF PRESERVATION OF THE SPONGE SPICULES.

The chemical constitution of the spicules of which this rock is mainly composed is closely similar to that of recent siliceous sponges. The silica is in the colloid condition and presents the same clear glassy aspect so characteristic of recent spicules and, as in these latter, it is negative in polarized light between crossed Nicols.

Exceptionally some of the spicules are of a milky tint with a porcellaneous appearance, similar to spicules in the Lower and Upper Greensand of the South of England (1) and in the Cretaceous Sponge-beds of Westphalia, and in a few cases also the spicular walls are traversed in all directions by very minute curved lines as in fossil spicules from Wiltshire (2). But the change from the normal glassy condition does not seem to have reached any further stage, and in no instance have I seen a spicule of chalcidonic silica in the material.

† "In my report on the Norseman material I mentioned that some of the quartz grains probably were partially formed in the rock, but I have since had an opportunity of showing these grains to Dr. J. S. Flett of the Geological Survey of Great Britain, and he considers that they have not been enlarged by a secondary deposition of silica, and that they have rather the appearance of having been derived from vein quartz. He further thinks that some of the fine portions of the rock in which the sponge spicules are embedded may be kaolin." G. J. H., 10th September, 1909.

(1.) Hinde. *Sponge Remains in the Lower and Upper Greensand of the South of England*. Phil. Trans. Roy. Soc., Vol. CLXXV. (1885), p. 426.

(2.) *Ibid* pl. XL, fig. 8.

The axial canals in these fossil spicules are considerably enlarged, and they contrast strongly with the very fine, oftentimes scarcely visible, axial canals in the spicules of recent sponges. In some instances the silica of the interior of the spicules has been dissolved away to such an extent that only a thin outer sheath of the original wall remains. The enlarged canals have usually smooth and even walls, but not infrequently they are eroded irregularly and have a nodose appearance. The outer surface of the spicules is very commonly covered with small circular pittings and their walls are bored at right angles with neat cylindrical holes which often penetrate to the axial canal of the spicule. Similar borings and enlarged canals are found in detached sponge spicules dredged up from considerable depths and they have been attributed to the action of boring algæ (1).

Comparatively few of the larger spicules in this soft rock are preserved intact; a large proportion are broken up into small fragments. The larger and more robust monaxon spicules, together with the trifids and calthrops have suffered most from fracture, and uninjured specimens are difficult to find, whilst many of the smaller fusiform, cylindrical, pinshaped, and styliform spicules and the delicate dermal spicules of lithistid sponges, remain in a perfect condition. The skeletal spicules of lithistids have, as a rule, lost their distal ends, by which they are interlocked together. The robust meshwork of dictyonine hexactinellids, which might have been supposed strong enough to resist fracture, is in the material, now reduced to microscopic fragments.

On the whole the preservation of the sponge spicules in this Norseman material is very similar to that of other fossil sponge deposits of Tertiary Age, and it does not markedly differ from that of the detached spicules found at the present time of the sea floor.

DESCRIPTION OF THE SPONGE SPICULES.

With the view of correlating the spicules in this Norseman material with these in similar fossil deposits in other regions, and also with those of recent siliceous sponges, the various forms commingled together in the rock sample are described and figured below. The similar forms of Monaxonid spicules are first considered and afterwards those of Tetractinellid, Lithistid and Hexactinellid Sponges.

MONAXONID SPICULES.

The fusiform acerate, cylindrical, styliform, dumb-bell or tibiella and pin-shaped spicules with a single axis are very numerous. With the exception that a few of the larger acerate spicules belong to the Tetractinellida, the rest are the skeleton spicules of the Monaxonida. The very minute so-called flesh spicules are poorly

(1.) Duncan, Journ. Roy. Micros. Soc., ser. 2, Vol. I. (1881), p. 557, pls. VII., VIII.

represented in the deposit by a few forms of chessman or sceptrella spicules belonging to the genus *Latrunculia*.

No anchorate flesh spicules have been observed in the deposit.

Acerate Skeleton Spicules of various genera.

Pl. I., fig. 1.—Fusiform acerate, robust, smooth, slightly curved, greatest thickness in the centre; tapering gradually to each end. Length 1.5 mm., thickness (1) 0.07. Probably belongs to a species of *Geodia*.

Pl. I., fig. 2.—Fusiform acerate with tapering drawn out ends, smooth. Length 0.43 by 0.05. Common. An axial canal is not shown in these spicules. A spicule very similar in form and proportions occurs in *Desmacidon* (*Homæodictya*) *grandis*, from Simon's Bay, Cape of Good Hope. Ridley and Dendy (Chall. Rep., vol. 20, p. iii, pl. XXIX., fig. 7).

Pl. I., fig. 3.—Fusiform acerate, slightly curved, gradually tapering to both ends which are acutely pointed. It is very similar to the spicules of a variety of *Petrosia variabilis*, Ridley. (Chall. Rep., vol. XX., p. 13, pl. II., fig. 12). Length 0.43 by 0.03.

Pl. I., fig. 4.—Fusiform acerate, very evenly curved, the ends blunted, smooth. An axial canal is not recognizable in the specimen figured. Length 0.38 by 0.03. Common.

Pl. I., fig. 5.—Robust fusiform acerate, bent near the centre, tapering towards the ends, which are slightly blunted, smooth. Length 0.33 by 0.035.

Pl. I., fig. 6.—Robust vermiculate spicule, curved and undulating; surface smooth. The axial canal opens at both ends, which are blunted. Length 0.68, thickness 0.064. Rare.

Pl. I., fig. 7.—Acerate, straight or slightly curved, tapering near the ends, which are blunted; the surface is covered with minute conical spines. Length 0.22 by 0.03. Smaller but similarly spined spicules are present in the sponge deposits at Oamaru, New Zealand (Linn. Soc. Jour. Zool., vol. XXIV., p. 184, pl. VII., fig. 15), and in the recent *Halichondria infrequens*. Carter, from the Gulf of Manaar (Ann. and Mag. Nat. His. s. 5, vol. VII., 1881, p. 369, pl. XVIII., fig. 9a.)

Cylindrical Spicules of various genera.

Pl. I., figs. 8, 9.—Slightly curved cylindrical spicules, smooth, with ends evenly rounded. As a rule no axial canals are shown in these forms; they vary greatly in size, the larger range to 0.46 by 0.06, the smaller are nearly reniform and about 0.08 by 0.03. The specimens are numerous and well preserved. Similar spicules are present in the Oamaru deposit (*op. cit.*, p. 184, pl. VII., figs. 31, 36), and also in the material dredged by the "Egeria" from a depth

(1.) The dimensions of the spicules are in all cases given in millimeters and decimal parts thereof, it is proposed therefore to omit "mm." after each measurement.

of 3,001 fathoms off the South-West coast of Australia. *Strongylophora durissima*, Dendy, from the Gulf of Manaar, is built up of similar spicules of various sizes. (Supp. Rep. Pearl Oyster Fisheries, Gulf of Manaar, p. 141, pl. IX., fig. 1.)

Pl. I., fig. 10.—Curved cylindrical spicule, with evenly rounded non-inflated ends, the surface with slightly raised whorls or rings with the edges minutely spined. Length 0.29 by 0.025. Smaller spicules similarly spined occur in the Oamaru material (*op. cit.*, pl. VII., figs. 29, 30), and Mr. Carter has figured a detached spicule of the same kind from the Gulf of Manaar (Ann. and Mag. N.H., ser. 5, vol. VI., 1880, pl. V., fig. 29). The sponge to which these belong is unknown.

Pl. I., fig. 11.—Robust, straight, cylindrical, spicule with round, spined ends, the lateral surface with stout blunt spines disposed in whorls. Length 0.25 by 0.085. Approximately similar spicules, but with the spines not so regularly arranged, are present in the Oamaru material (*op. cit.*, p. 187, pl. VII., figs. 42, 43).

Pl. I., fig. 12.—Subcylindrical spicule with a prominent acute spine at each end, and the lateral surfaces armed with whorls of alternate larger and smaller spines. Length 0.2 by 0.09 in width, spines included. Similar spicules are present in material dredged by the "Egeria," lat. $36^{\circ} 53'$ S., long. $115^{\circ} 48'$ E., depth 3,001 fathoms. Sponge unknown.

Pl. I., fig. 13.—Subcylindrical, slightly curved, with a prominent spine at each end, lateral surface with whorls of subequal spines. Length 0.28 by 0.08.

Tibiella or Dumb-bell Spicules.

Pl. I., fig. 14.—Slightly curved tibiella, shaft fusiform with sub-spherical ends, smooth. Length 0.17 by 0.015.

Pl. I., fig. 15.—Tibiella nearly straight, the shaft cylindrical with a round knob at each end, smooth. Length 0.37, thickness of shaft 0.02, of terminals 0.03. Similar but somewhat smaller spicules are described by Carter in *Forcepia crassanchorata* from Port Elliot, South Australia (Ann. & Mag. N.H., s. 5, vol. XV., 1885, p. 111, pl. IV., fig. 3b).

Pl. I., fig. 16.—Tibiella, slender, curved, shaft cylindrical with spherical ends, smooth. Length 0.1 by 0.005, terminals 0.007. Rare.

Sceptrella or Chessman Flesh Spicules of LATRUNCULIA, Bocage.

Pl. I., fig. 17.—Sceptrella with a relatively stout axis, the base expanded with small divergent spines, a median disc armed with short spines and a cupolar summit, also spined. Height, 0.07, thickness of shaft 0.017, width of median disc 0.05. Rare.

Pl. I., fig. 18.—Sceptrella small, with stout axis, base expanded with a thin spined edge supported on a fringe of acute spines

extending obliquely downwards; a thin median disc with sharp edge; the summit convex, smooth, with a sharp margin. Height 0.055, breadth of base and summit 0.045.

Pl. I., fig. 19.—Sceptrella with a slightly expanded and arched base with downward projecting spines; in the middle of the shaft a whorl of horizontal spines; the summit with a marginal fringe of spines and a prominent vertical spine. Height 0.066, width of axis 0.066; of the central whorl 0.026. Rare.

Pl. I., fig. 20.—Sceptrella with a stout axis and an arched and spined base, a medium sharp edged disc; the summit convex with vertical spines. Height 0.063, width of shaft 0.02, of the median disc and summit 0.036. Rare.

Pl. I., fig. 21.—Sceptrella relatively small, the basal portion and median disc similar to the preceding in form, the summit like truncated cone with minute spines. Height 0.04, width of shaft 0.011, of median disc 0.026. Rare.

Pl. I., fig. 22.—Sceptrella with slender cylindrical shaft and a small median disc with smooth margin, the summit slightly expanded with the margin notched. Length 0.05, width of shaft 0.006, of median disc 0.02.

Four of the forms of Sceptrella described above (pl. I., figs. 17, 18, 20, 21) are modifications of a common type which has an expanded base with divergent spines, a median disc and a convex summit: in fig. 19 there is a median whorl of spines and at the summit a prominent spike, whilst in fig. 22, there is no distinctive base, a small median disc and a notched summit. Each of these forms may represent a distinct species of *Latrunculia*. Similar variations of form-details are shown in the Sceptrella spicules of the Oamaru deposit (op. cit. p. 215, pl. XI., figs. 15-39).

Style or Acuate Spicules.

Pl. I., fig. 23.—Part of an elongated tapering spicule, probably a style similar to those in the genus *Tethya*, Lam. The part preserved is 1.64 in length by 0.04 in thickness at the fractured end.

Pl. I., fig. 24.—Style, robust, smooth, slightly curved at the proximal end, and tapering in the lower third of the spicule. Length 0.72 by 0.04. Similar skeleton spicules are present in the recent *Myxilla hastata*, Ridley and Dendy, from off the mouth of the Rio de la Plata at 600 fathoms. (Chall. Rep. vol. 20, p. 134, pl. XXVII., fig. 1). Common.

Pl. I., fig. 25.—Style slender, slightly curved, nearly of an even thickness throughout. Imperfect at the distal end. Length 0.73 by 0.02. Rare.

Pl. I., fig. 26.—Style slender, elongate, smooth, the summit evenly rounded and curved nearly at right angles to the straight,

gradually tapering shaft. Length 0.37 by 0.017. A similar but somewhat more robust spicule occurs in the Oamaru material (*op. cit.*, p. 191, pl. VIII., fig. 30).

Pl. I., fig. 29.—Nearly straight, robust style, the upper third stout, then somewhat rapidly tapering to the apex. The upper portion of the spicule is covered with minute conical spines, the lower two-thirds is quite smooth. Length 0.39, maximum thickness 0.06. Rare.

Spinulate or Pin-shaped Spicules.

Pl. I., fig. 27.—Robust spinulate slightly curved, head spherical, constricted at the neck, shaft slightly increasing in thickness towards the middle, the lower portion of the spicule is wanting. Length (incomplete) 0.57 by 0.05.

Pl. I., fig. 28.—Straight, smooth spinulate, head spherical, neck slightly constricted, very gradually tapering to the apex. Axial canal normal. Length 0.42 by 0.02. A similar spicule is present in the Oamaru material (*op. cit.*, p. 193, pl. IX., fig. 6).

SPINES OF TETRACTINELLID SPONGES.

Calthrops Spicules.

Pl. I., fig. 30.—Robust calthrops, the rays sub-equal, smooth, gradually tapering. Length 0.28 by 0.06.

Calthrops spicules of various sizes are fairly common in the Norseman deposit, some are larger, others smaller than the specimen figured. They have in all cases, smooth, simple rays. Similar spicules are present in the Oamaru deposit (*op. cit.*, p. 231, pl. XIII., figs. 35–40) and in fossil sponge deposits generally.

Trifid Spicules of Geodia and other genera.

Pl. I., fig. 31.—Trifid with straight tapering shaft and simple head rays directed obliquely forwards. Length of shaft (incomplete) 0.34 by 0.05; head rays 0.16 by 0.04. It may be compared with the smaller trifid spicules of the Oamaru material (*op. cit.*, p. 234, pl. XIII., figs. 14, 15).

Pl. I., fig. 32.—Trifid with simple slightly curved and nearly horizontal head rays. The shaft is broken away just below the head, it is 0.035 in thickness: the rays are 0.08 in length. This spicule corresponds in form and size with the zone spicules of the recent *Stelletta reticulata*, Carter, from off the South coast of Australia (Ann. & Mag. N.H., ser. 5, vol. XI., 1883, p. 352, pl. XIV., fig. 46).

Pl. I., fig. 32.—Trifid, with simple, strongly curved head rays. Shaft (imperfect) 0.03 in thickness, head rays about 0.1 in length. It probably belongs to a species of *Geodia*. Similar spicules are found in the Oamaru material (*op. cit.*, p. 235, pl. XII., fig. 24),

and in deposit brought up by the "Egeria" off S.W. of Australia, lat. $36^{\circ}08' S.$, long. $117^{\circ}10' E.$, from a depth of 2,479 fathoms.

Pl. II., fig. 1.—Spicule with a tapering shaft and a single, slightly recurved head ray; the base of a second ray is shown, but there is no indication of a third. The shaft is 0.23 by 0.02, the head ray 0.037 in length. It appears to be an abnormal development of a trifid spicule.

Pl. II., fig. 2.—Trifid with straight elongate shaft and with each of the head rays bifurcated and horizontally extended. The tips of the rays are broken away, and the axial canal in the shaft is considerably enlarged. Shaft 0.36 by 0.03: width across the head rays 0.13. Similar spicules are present in the genus *Erylus*. Gray.

Pl. II., fig. 3.—Trifid with simple head rays directed upwards. The shaft (imperfect) is 0.04 in thickness, the head rays 0.12 by 0.02. Similar spicules occur in the recent genus *Craniella*, O. Schmidt and in *Stelletta* they are also present detached in the Oamaru material (op. cit. p. 234, pl. XIII., figs. 16, 17).

Pl. II., fig. 4.—Trifid spicule with a stout, straight shaft, and bifurcated head rays. The shaft is 0.05 in length. It may belong to *Erylus*. Gray. A form nearly similar is figured from Oamaru (op. cit. p. 234, pl. XIII., fig. 12).

Pl. II., fig. 5.—Trifid with curved tapering shaft and trifurcate head rays directed obliquely forwards. The head rays are partly broken, but in one the trifurcate character is distinctly shown by the axial canals. Shaft 0.37 by 0.05. The head rays are 0.14 in length.

Pl. II., fig. 6.—Trifid with slender shaft and simple head rays directed backwards. The shaft is 0.006 in thickness, the head rays are 0.05 in length and about the same thickness as the shaft. It may be compared with the grapnel spicules of *Cydonium Mülleri*, Fleming—*Geodia Zetlandica*, Johnston (see Bowerbank, Mon. Brit. Spong. vol. III., pl. VII., fig. 7). Similar forms are common in the Oamaru material (op. cit., p. 235, pl. XII., figs. 18–24).

LITHISTID SPICULES.

Body Spicules of RAGADINIA, Zittel, and DISCODERMIA, Bocage.

Pl. II., figs. 7, 8.—Spicules with four arms or rays; one is frequently truncated or reduced to a rounded knob; the fully developed arms have a prominent ring-like inflation a short distance from the spicular centre; beyond the ring the arms bifurcate and terminate in twig-like extensions which interlock with those of adjoining spicules. The delicate twig-like extremities are broken off the detached spicules. In one specimen (fig. 7), the axial canal is seen as a delicate straight line extending from the centre to about two-thirds the length of each arm; in the other (fig. 8), the canals are widened and reach to the ends of the arms, which are, however,

incomplete. The arms are about 0.17 in length, and 0.04 thick near the centre. The spicules belong to *Ragadinia*, Zitt. of which several species are known from the upper Cretaceous (*Bel. mucronata* Zone) of Germany and the South-West of England. Detached spicules closely resembling those from Norseman are known from Coesfeld in Westphalia, the Upper Chalk of Norfolk (1): also in the Upper Greensand near Warminster, Wiltshire, and in the Lower Greensand of Haslemere and Tilburstow Hill, Surrey (2).

Pl. II., figs. 9, 10.—Both the spicules figured are imperfect: in one (figure 9) an arm is wanting, and in the other (fig. 10) two are broken away, so that their original tetractadine character can hardly be recognised. Small extensions are given off from the arms; their ends are frequently furcate and they are covered with tubercles. In one (fig. 9), a delicate straight line in the principal arm may represent an axial canal whilst in the other (fig. 10), two short canals are shown near the broken margin. These spicules may belong to *Discodermia*, Bocage. Fragments of similar spicules are very common in the Norseman material.

Reniform and Globostellate Spicules of Tetractinellid Sponges.

Pl. II., figs. 12, 13.—Reniform spicules, similar to those forming the dermal crust of *Geodia* sponges, are very numerous in the deposit. Generally the hilum can be distinguished, but the minute rods with prominent heads of recent forms are not shown in these fossil specimens. Not infrequently they are perforated by boring algæ (?) as in the specimen figured (fig. 13). Small specimens measure 0.07 by 0.037, the larger 0.09 by 0.062.

Pl. II., fig. 14.—Globostellate spicules, apparently solid, their surfaces covered with short, stout, conical spines, which in some cases seem to be regularly disposed in lines. Diameter 0.1. Fairly numerous.

Pl. II., fig. 15.—Globostellate similar to the preceding, but much smaller. Diameter 0.04—0.05. Very common. Similar forms are present in the recent genus *Cydonium*, Muller.

Pl. II., figs. 16, 17.—Globostellate spicules with solid centra from which extend a number of stout cylindrical rays with expanded lobate summits. No canals are visible either in the rays or in the centra. Diameter 0.1. Similar spicules are present in the recent *Cydonium Müllerii* Fleming. They occur detached at Oamaru (op. cit. p. 237, pl. XIV., figs. 28, 29, 30, and also in the dredgings by the "Egeria" off the S.W. of Australia, from a depth of 2.479 fathoms.

Globostellate Spicules of TETHYA, Lamarck.

Pl. II., fig. 18.—Globostellate with numerous rays which originate in the centre of the spicule and for about one-third their length

(1.) Hinde. Fossil Sponge Spicules from the Upper Chalk of Horstead, 1880, p. 58, pl. 5, figs. 1-4.

(2.) Phil. Trans. Roy. Soc., vol. CLXXV., part II., 1885, p. 444, pl. XLV., figs. 5, 5a, 5b.

extend beyond the centrum. The rays are straight and the free portions gradually taper. In each there is a well-marked, now enlarged, canal, which begins at the origin of the ray and opens at its free distal end. The figured specimen is 0.13 in diameter: smaller forms are about 0.08, including the rays. These spicules are closely related to those of *Tethya robusta*, Bowerbank (Proc. Zool. Soc. Lond., 1873, p. 10. pl. II., fig. 15) now living in Australian seas. They are very common in the Norseman material, but as a rule the free portions of the rays are broken off. Similar detached forms are present in the Upper Cretaceous (Zone of *Bel. mucronata*) of Westphalia, and in the same zone of the Chalk of Norfolk.

Pl. II., fig. 19.—Small globostellate with 12–14 acutely pointed rays extending for about half their length beyond the centrum. No canals visible. Diameter, including rays, 0.05. This form may be one of the smaller stellates of the crust of a species of *Tethya*.

DERMAL SPICULES OF LITHISTID SPONGES,

Pl. II., figs. 20, 21.—Spicules consisting of a thin, flattened siliceous plate with very irregular lobate margins. In the centre of the plate is a short, acutely pointed shaft which projects at right angles from the inner or lower surface. Three short canals radiate from the junction of the shaft with the plate and in the central point is a small circle representing the axial canal of the shaft. The shaft in these spicules is usually broken off the horizontal plate. The plate or head of these spicules is about 0.3 in breadth. The sponge to which they belonged cannot be known with certainty; they may have formed the dermal layer of a species of *Ragadinia* whose skeleton spicules have been described above.

Dermal Spicules of DISCODERMIA, Bocage.

Pl. II., fig. 22.—The spicule figured has the margins rounded, but in other specimens of the same form they are irregularly lobate. The outer surface has numerous minute spines or papillæ, as Carter terms them, and these are connected with each other by delicate raised lines which give the appearance under the microscope of a fine network with polygonal meshes. Three short axial canals are shown in the centre of the spicule. The spicular heads are 0.3–0.38 in breadth. The shafts are wanting. The late Mr. Carter has described dermal spicules with a similar surface network in the recent *Discodermia aspera* from the Gulf of Manaar (Ann. & Mag. N.H., ser. 5, vol. VI., 1880, p. 501, pl. VIII., fig. 49g), but in a microscopic slide of the spicules of this sponge, mounted by himself and presented to me, there is no net-work shown on the dermal spicules, nor does Prof. Sollas mention this character in describing *D. aspera* though he studied the spicules in a slide also supplied to him by Mr. Carter (Chall. Rep. vol. XXV., p. 327). It is probable therefore that the dermal spicules with this peculiar and distinctly marked surface ornamentation may belong to some other species than

D. aspera. The detached forms in the Norseman material are very common, and well preserved as a rule.

Pl. II., figs. 26–26.—Dermal spicules with an elongate slender shaft and a saucer-shaped or vasiform expansion at its summit. The expanded head is approximately circular in outline, the margins are smooth, even and slightly elevated (fig. 25); in the centre is a small boss or knob which in some cases may project above the level of the margins (fig. 23), in others it is hardly perceptible (fig. 24). Viewed from below, the under surface of the spicule shows one or more concentric growth lines and faint traces of radiating folds reaching a short distance above the edge; the fractured summit of the shaft and its axial canal are shown in the centre (fig. 26). The axial canal of the shaft is closed at or just below the junction of the shaft and the head, it extends the length of the shaft and opens at its distal apex. There is no indication of canals radiating from the centre in any of these spicular heads. In one specimen the shaft is embraced by a portion of a skeleton spicule of the sponge to which the dermal spicule belonged. The shaft is about 0.2 in length: the expanded heads are 0.075–0.11 in breadth. They belong to a species of *Discodermia* not improbably to the same form as the skeleton spicules described above (pl. II., figs. 9, 10).

Nearly similar dermal spicules are figured by O. Schmidt (1) in *D. dissoluta* from off Barbados at a depth of 56 fathoms: by Carter (2) in *D. levidiscus* from the Gulf of Manaar, and by Sollas (3) in *D. ornata* a recent sponge of unknown locality. As the Norseman spicules differ in smaller details from those in the species just mentioned, it is probable that they belong to a sponge yet undescribed.

Dermal Spicules of CORALLISTES, O. Schmidt, and other genera.

Pl. III., fig. 1.—Dermal spicule with a short shaft and at its summit six horizontally extended rays. The rays are sub-equal when complete and they are traversed by axial canals which extend to the distal ends of the rays. The rays are about 0.18 in length by 0.05 wide. The head of the specimen is 0.39 across. These spicules are common in the Norseman material but generally in fragments. Similar detached spicules are found in the Oamaru deposit, also in the material dredged by the “Egeria” off the S.W. of Australia from a depth of 2,479 fathoms. They also form the dermal layer in several genera of Megamarine and Tetracladine Sponges from the Upper Cretaceous of the South of England and of Germany, and in the recent genus *Corallistes*, O. Schmidt.

Pl. III., fig. 2.—Dermal spicule with a short shaft and five horizontally extended rays at its summit. In this form one of the head rays of the normal trifold remains simple, and the other two

(1.) Die Spongien des Meerbusen von Mexico, Heft. II., 1880, p. 87, pl. V., fig. 2c.

(2.) Ann. & Mag., N. H., ser. 5, vol. VI., 1880, p. 503, pl. VIII., figs. 51c, d.

(3.) Chall. Rep. vol. XXV., p. 297, pl. XXXI., figs. 5, 5a, 5d.

are bifurcate. The rays are nearly straight, slender, and they terminate distally with a small foot-like expansion. The axial canals extend but a short distance from the centre of the spicule. The rays are 0.13-0.22 in length by 0.02 in thickness. In the character of the rays this form resembles the dermal spicules of *Theonella Swinhoei* Gray, as figured by Sollas (Chall. Rep., vol. XXV., p. 284, pl. XXIX., figs. 4, 4a, 4b).

Pl. III., fig. 3.—Dermal spicule in which one of the head rays is larger and inequally developed in comparison with the others. The axial canals are short and nearly equal in size. Diameter of the head rays 0.4. Rare.

Skeleton Spicule of VETULINA, O. Schmidt.

Pl. II., fig. 11.—Spicule with four or five rays extending in different directions from a definitely thickened centre. Some of the rays are single, others furcate, their distal ends are slightly expanded where they have been attached to adjoining spicules. In the centre of the spicule is a shield shaped prominence. Axial canals are not present. The spicule is 0.14 in breadth. Similar spicules are present at Oamaru, they have been referred to the recent genus *Vetulina* (op. cit., p. 240, pl. XIII., figs. 31-33). Rare.

Spicules of unknown Sponge.

Pl. III., figs. 6, 7.—Minute spicules, with a short central axis or shaft from either end of which three or four acutely pointed rays extend obliquely. Each ray has two whorls of small spines. Canals are not visible. Diameter of the spicule, including the rays, 0.15: length of the terminal rays 0.075. I have not met with any description of this form in connection with either fossil or recent sponges.

Dermal (?) Spicules, DACTYLOCALYCITES, Carter: PLACOLITHIS, pars. EHRENBURG.

Pl. III., figs. 4, 5.—Thin siliceous plates of oval elliptical outlines with smooth surfaces and a series of straight or slightly curved canals radiating from the central area to the circumference. The margins in all the specimens in this deposit are imperfect, either from having been worn away or from not having reached full development: they now show the free distal ends of the radiating canals, with tongue-like extensions and deep alternating large and small notches between... In the centre of the spicules the canals are disposed so as to form a double arch, with their apices nearly meeting, from this point the canals radiate fan-like towards each end. When the spicules are complete their margins are even and continuous all round, the distal ends of the canals are closed, and the notches now form oval or hour-glass shaped apertures ranged round and just within the margins of the plate. The canals vary

in number in different specimens from 17 to 24. The spicules are 0.25-0.3 in length, by 0.12-0.18 in breadth.

These detached spicules are widely distributed. As fossils they have been found in the Jurassic radiolarian marls of Hanover (1), in the Upper Greensand of (2) Devonshire, and (3) Wiltshire, the Upper Cretaceous of (4) Westphalia (zone of *Bel. mucronata*) and in the same zone at (5) Horstead, Norfolk: in the Tertiary radiolarin deposits of (6) Barbados, and in similar deposits at (7) Oamaru, New Zealand. They have also been dredged up from a depth of over 13,000 feet in the (8) Indian Ocean and from off the S.W. coast of Australia at a depth of 3,000 fathoms. In the Norseman material they are fairly common. They are supposed to be the dermal spicules of a sponge, which is as yet, unknown.

SPICULES OF HEXACTINELLIDA.

Pl. III., fig. 8.—A small fragment of the skeleton of a dictyo-nine hexactinellid. The spicular frame is robust, its surface smooth, the nodes are simple, *i.e.*, not octahedral, and the axial canals are considerably enlarged. The spicular framework is 0.035 in thickness and the distance from node to node 0.11. Minute fragments of a similar character are common in the Norseman material.

Pl. III., fig. 9.—A detached five-rayed spicule, the rays robust, tapering, and blunt at their distal ends. The axial canals are enlarged and open at the end of the rays. Length of rays, 0.14: thickness 0.045.

Pl. III., fig. 10.—Spicule similar to the preceding, the rays are short and tapering slightly, with rounded ends; the canals are well shown, and in this specimen they terminate within the rays. Length of rays 0.085: thickness 0.04.

Pl. III., fig. 11.—A detached five-rayed spicule with smooth, slightly tapering rays; the axial canals are much enlarged and open at the ends of the rays. Length 0.14 by 0.025.

Dermal Spicules of ROSSELLA, Carter.

Pl. III., figs. 12, 13, 14.—Spicules consisting of an elongate straight shaft, with four straight or slightly curved rays extending at right angles from its summit. They have been compared to a

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- (1) Palæontographica, Bd. XXXI., pl. XX., fig. 42.
 - (2) Carter. On Fossil Sponge Spicules of the Greensand, etc., Ann. & Mag., N. H., S. 4, vol. VII., p. 123, pl. IX., fig. 40.
 - (3) Hinde. Sponge Remains in the Lower and Upper Greensand. Phil. Trans. Roy. Soc., vol. CLXXV., part II., 1885, p. 442, pl. XLIII., fig. 3.
 - (4) V. Zittel. Ueber Coeloptychium. Abh. d. k. Akad. d. Wiss. XII., Bd. III., Abth., p. 47, pl. V., figs. 32-35.
 - (5) Hinde. Fossil Sponge Spicules from the Upper Chalk., 1880, p. 40, pl. I., fig. 23.
 - (6) Bury. Polycystines in the Barbados Chalk deposit, 1862, pl. VII., figs. 1, 2.
 - (7) Hinde & Holmes. Sponge Remains in the Lower Tertiary Strata of Oamaru, New Zealand. Linn. Soc. Journ. Zool., vol. XXIV., 1892, p. 236, pl. XIV., figs. 35, 36, 37.
 - (8) Ehrenberg. Microgeol. Studien, 1873, p. 147, pl. 36, fig. 9.

section of an umbrella, the shaft representing the handle, and the four rays as so many ribs. For a short distance from the shaft the horizontal rays are connected together by a siliceous membrane, beyond this the rays are quite independent of each other. The angle included by the four rays varies in different specimens from 105° to 120° . Canals, now considerably enlarged are shown both in the shaft and in the rays. These spicules are fairly common in the Norseman material, but they are all very imperfect so that it is not possible to ascertain their dimensions when complete. The longest fragment of a shaft (fig. 12) is 0.27 in length by 0.035 in thickness, and of a ray 0.25 by 0.02. This form of spicule detached was first noticed in the *Upper Chalk of the North of Ireland, and it was considered by the late Dr. Bowerbank to belong to the dermal system of a siliceo-fibrous sponge. Afterwards it was found on the same horizon (Zone of *Bel. mucronata*) in (1) Westphalia, (2) Norfolk, and in siliceous rock occurring as an erratic in the Boulder Clay of the Roode Klif, Friesland. In (3), a paper on this rock, the resemblance of these forms to the spicules of the surface of the recent hexactinellid, *Rossella antarctica*, Carter, is pointed out. The Norseman specimens are considerably smaller than those in the (4), recent sponge from South of the Kerguelen Islands and from the South Atlantic, east of Buenos Ayres, and they further differ in having a siliceous membrane or patagium connecting the rays near their junction with the shaft, and in the absence of spines on the rays. In both these features the Norseman umbrella spicules correspond with the fossil forms in the Upper Cretaceous rocks of Germany, the East of England, and the North of Ireland.

SUMMARY.

The sample of soft, white siliceous rock from the Deep Lead (?) at Princess Royal, in the Norseman District, was found, on microscopic examination, to consist almost entirely of the spicular remains of siliceous sponges; a large proportion of the spicules are now reduced to minute fragments and detritus, but here and there some fairly perfect or but slightly injured forms have been preserved, and the various kinds of these have been described and figured in the report. No other organic remains beyond those of siliceous sponges have been found in the rock sample, and not a single specimen of radiolaria or diatoms, which are usually associated with sponge spicules in deposits of a similar character has been noticed. There is but a small proportion of inorganic constituents in the rock; these consist of minute dark grains which have not been

* J. Wright. Proc. Belfast Nat. Field Club, 1873-4, ser. 2, vol. I., p. 138, pl. III., fig. 1.

(1.) Zittel. op. cit., p. 46, pl. V., figs. 47-50.

(2.) Hinde. op. cit., 1880, p. 62, pl. I., figs. 29, 30.

(3.) Hinde. Bull. Soc. Belge de Geol. Paléon., etc., vol. III., 1889, p. 257, pl. VIII., figs. 105, 106.

(4.) See Chall. Rep. Zool., vol. XXI., p. 139, pl. LV., figs. 9, 13.

determined, microscopic particles of quartz, and a few larger granules of the same mineral which appear to have been partly formed in the rock.

The silica of the spicules is in the same colloidal condition as in recent sponges; in only a few instances are there indications of incipient change. The spicules are all detached and the various kinds are indiscriminately mingled together in the rock. They are nearly all skeleton spicules: very few of the smaller flesh spicules have been found. With hardly an exception they are well known forms, belonging to Monaxonid, Tetractinellid, Lithistid, and Hexactinellid sponges: the three first mentioned groups appear to be represented in about equal proportions, but the spicules of hexactinellid sponges in the material are comparatively few.

Besides spicules which resemble those of existing sponges, there are many in the deposit closely similar to detached spicules in material dredged from a depth of 3,000 fathoms off the South-West coast of Australia, and also to the spicules in the fossil sponge deposit at Oamaru, New Zealand, which is considered to be Upper Eocene in age.

Some of the spicules of the Norseman material are also present in the Cretaceous rocks of England, Ireland, and Germany. Amongst these are three characteristic and somewhat rare forms: the skeleton spicules of a lithistid sponge (1) *Ragadimia*, sp.: the (2) dermal spicules of a sponge as yet unknown, but probably a Tetractinellid: and the umbrella spicules of the Hexactinellid genus (3), *Rossella*, sp. I found and (4) described these three kinds of spicules many years since in the siliceous material enclosed within a single hollow flint nodule from the Upper Chalk of Horstead, Norfolk. It is worthy of note that the three species of sponge to which these spicules belong should have existed together in the Cretaceous seas of the Northern hemisphere, and should have been found again associated together in Tertiary or Post-Tertiary deposits in the Southern hemisphere.

It seems to me that this Norseman sponge-rock is not a merely local deposit, but that it was formed in the open ocean, at some distance from a coast-line, so as to be away from sediment-bearing currents, and probably at a considerable depth. The sponges which furnished the materials of the deposit may have lived, died, and been disintegrated in the same area. As regards the geological age of the rock, I should judge that it is newer than the Cretaceous, but there are no data to indicate the particular periods of the Tertiary or Post-Tertiary in which it may have been formed.

(1.) Pl. II., figs. 7, 8.

(2.) Pl. III., figs. 4, 5.

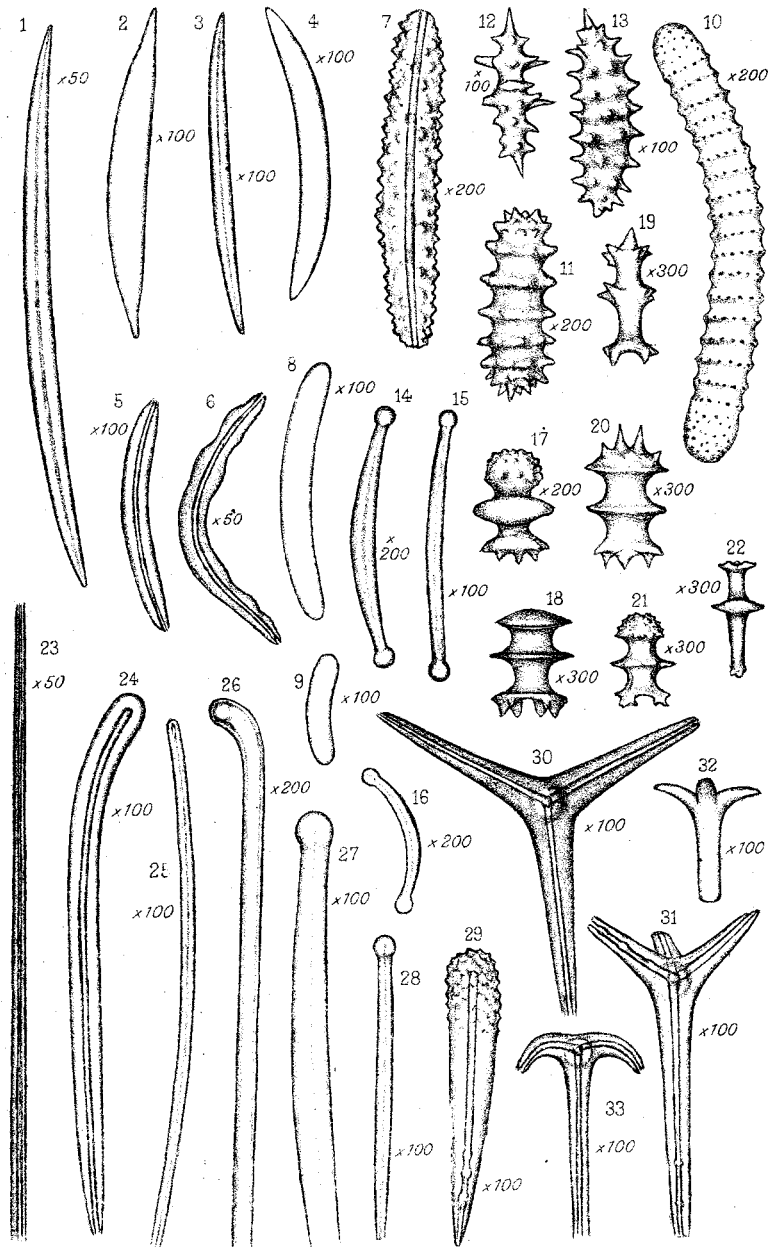
(3.) Pl. IV., figs. 12, 13, 14.

(4.) Fossil Sponge Spicules from the Upper Chalk of Horstead, 1880, p. 58, pl. V., figs. 1-4; p. 40, pl. I., fig. 23; p. 62, pl. I., figs. 29, 30.

EXPLANATION OF PLATES.

PLATE I.

- Fig. 1.—Acerate spicule. Probably of *Geodia*— $\times 50$.
 „ 2.—Acerate spicule of *Desmacidon* (?)— $\times 100$.
 „ 3.—Acerate spicule of *Petrosia* (?)— $\times 100$.
 Figs. 4, 5.—Fusiform acerate spicules— $\times 100$.
 Fig. 6.—Vermiculate spicule— $\times 50$.
 „ 7.—Spined acerate of *Halichondria* (?) $\times 200$.
 Figs 8, 9.—Smooth cylindrical spicules of *Strongylophora* (?)— $\times 100$.
 Fig. 10.—Curved cylindrical spicule with spined whorls— $\times 200$.
 „ 11.—Straight cylindrical spicule with whorls of spines— $\times 200$.
 „ 12.—Subcylindrical spicule with whorls of spines— $\times 100$.
 „ 13.—Curved cylindrical spicule with whorls of spines— $\times 100$.
 „ 14.—Curved tibiella or dumb-bell spicule— $\times 200$.
 „ 15.—Straight tibiella of *Forcepia* (?)— $\times 100$.
 „ 16.—Curved tibiella spicule— $\times 200$.
 „ 17.—Sceptrella spicule of *Latrunculia* sp.— $\times 200$.
 „ 18.—Sceptrella spicule with smooth convex summit, *Latrunculia*— $\times 300$.
 „ 19.—Sceptrella spicule with median whorl of spines, *Latrunculia* sp.— $\times 300$.
 „ 20.—Sceptrella spicule with convex spined summit, *Latrunculia* sp.— $\times 300$.
 „ 21.—Sceptrella spicule of *Latrunculia* sp.— $\times 300$.
 „ 22.—Sceptrella spicule with cylindrical axis, *Latrunculia* sp.— $\times 300$.
 „ 23.—Style spicule of *Tethya* (?) distal portion— $\times 50$.
 „ 24.—Style spicule of *Myrilla* (?) sp.— $\times 100$.
 „ 25.—Style spicule (imperfect)— $\times 100$.
 „ 26.—Style spicule with curved summit— $\times 200$.
 „ 27.—Spinulate spicule (imperfect at the distal end)— $\times 100$.
 „ 28.—Pin-shaped spicule— $\times 100$.
 „ 29.—Style with the upper portion spined, the lower smooth— $\times 100$.
 „ 30.—Calthrops spicule with subequal rays— $\times 100$.
 „ 31.—Trifid spicule with simple head-rays— $\times 100$.
 „ 32.—Trifid spicule (upper portion) of *Stelletta* sp.— $\times 100$.
 „ 33.—Trifid spicule of *Geodia* (?) with recurved head-rays— $\times 100$.



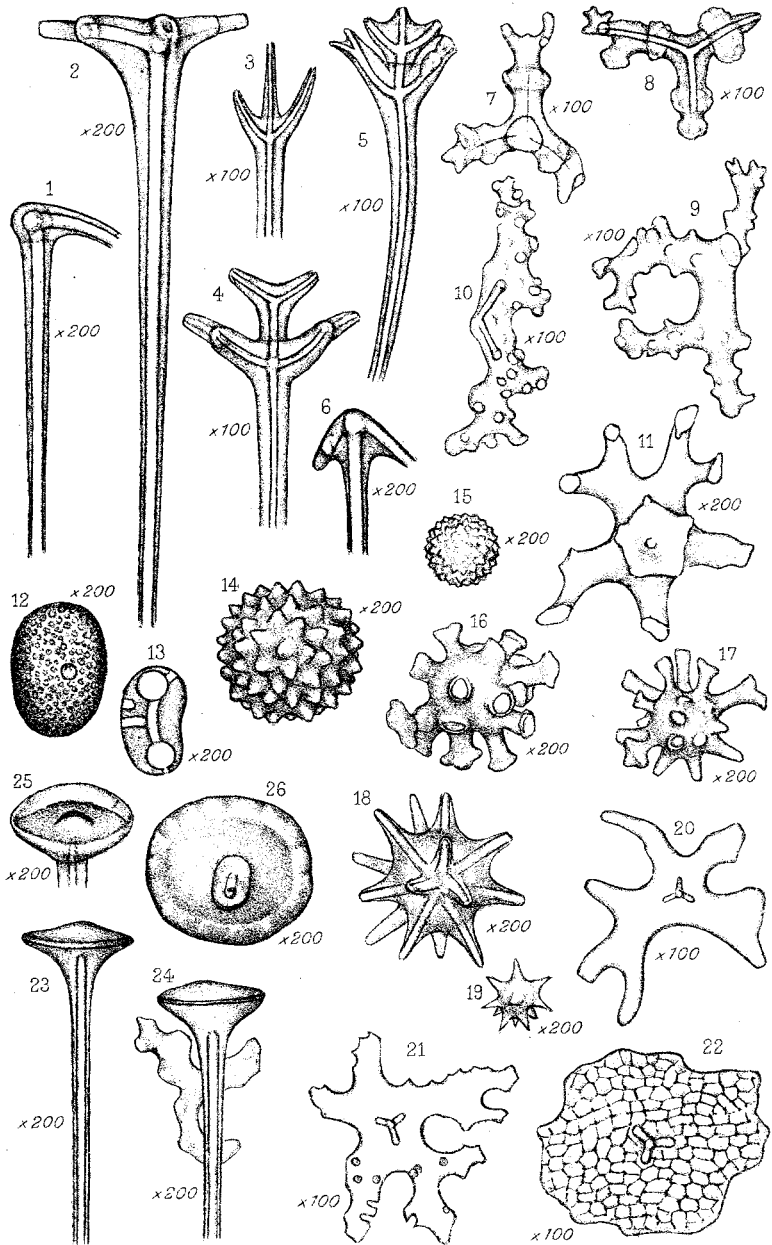
G. J. Hande del.
G. M. Woodward lith.

West, Newman imp.

FOSSIL SPONGE SPICULES. NORSEMAN, W. AUSTRALIA.

PLATE II.

- Fig. 1.—Trifid spicule, abnormal, with only two head-rays— $\times 200$.
 „ 2.—Trifid spicule with bifurcated head-rays— $\times 200$.
 „ 3.—Trifid spicule of *Craniella* (?) sp. (upper portion)— $\times 100$.
 „ 4.—Trifid spicule of *Erylus* (?) sp. (shaft imperfect)— $\times 100$.
 „ 5.—Trifid spicule with head rays trifurcate— $\times 100$.
 „ 6.—Trifid spicule of *Cydonium* (?)— $\times 200$.
 Figs. 7, 8.—Skeleton spicules of *Ragadinia* sp.— $\times 100$.
 „ 9, 10.—Skeleton spicules, imperfect, of *Discodermia* sp.— $\times 100$.
 Fig. 11.—Skeleton spicules of *Vetulina* sp.— $\times 200$.
 Figs. 12, 13.—Reniform spicules of *Geodia*. Fig. 13 shows perforations of boring alga— $\times 200$.
 Fig. 14.—Globostellate spicule— $\times 200$.
 „ 15.—Globostellate spicule of *Cydonium*— $\times 200$.
 Figs. 16, 17.—Globostellate spicule of *Cydonium* sp.— $\times 200$.
 Fig. 18.—Globostellate spicule of *Tethya* sp.— $\times 200$.
 „ 19.—Globostellate spicule of *Tethya* sp.— $\times 200$.
 Figs. 20, 21.—Dermal spicules of *Ragadinia* sp.— $\times 100$.
 Fig. 22.—Dermal spicules of *Discodermia* showing surface network.— $\times 100$.
 Figs. 23–26.—Dermal spicules of *Discodermia* sp. Fig. 23 is a lateral view, showing the shaft and a prominent boss in the centre of the head plate. Fig. 24 is a specimen with a portion of a skeleton spicule entangled round the shaft. Fig. 25 shows the upper surface of the head plate, and Fig. 26 shows the under surface with the broken stump of the shaft—all $\times 200$.



G. J. Hinde del.
G. M. Woodward lith.

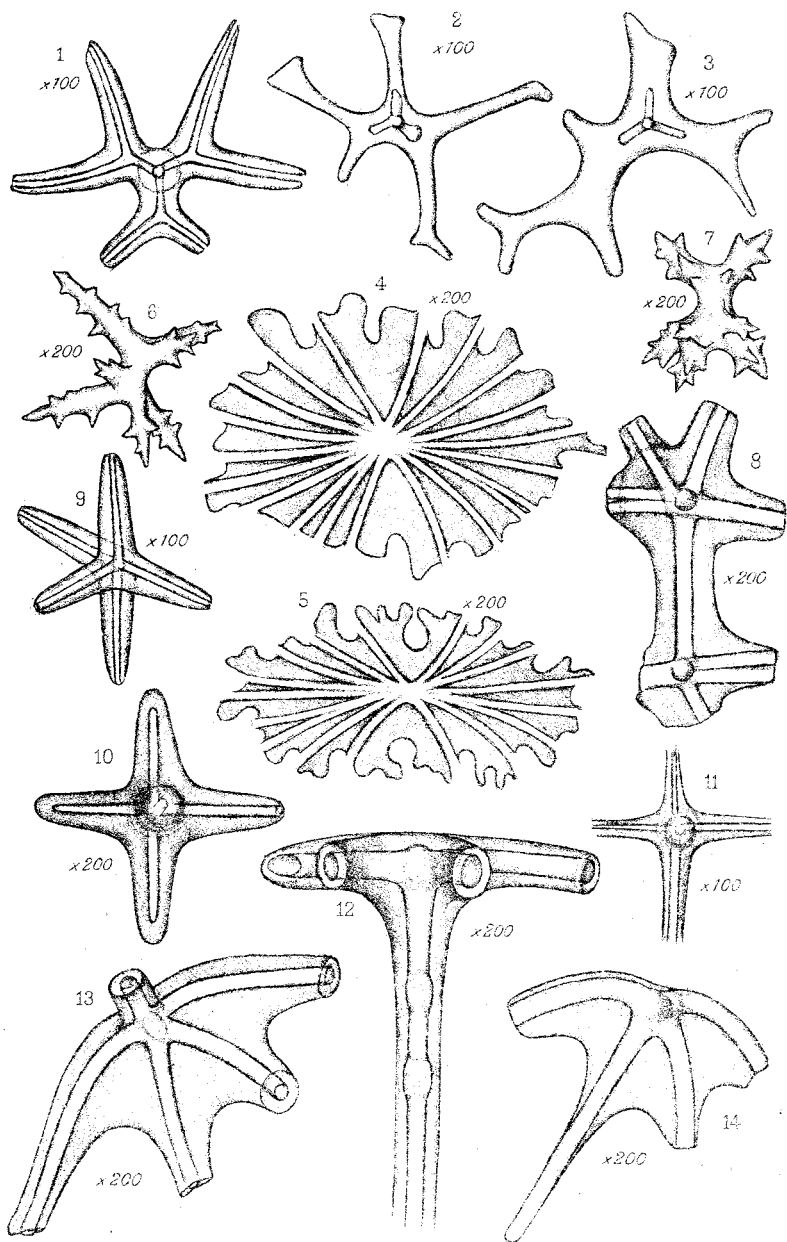
West, Newman imp.

FOSSIL SPONGE SPICULES. NORSEMAN, W AUSTRALIA.

PLATE III.

- Fig. 1.—Dermal spicule of *Corallistes* (?)— $\times 100$.
 „ 2.—Dermal spicule showing the head-rays (?) *Theonella*— $\times 100$.
 „ 3.—Dermal spicule with the head-rays unequally developed— $\times 100$.
 Figs. 4, 5.—Dermal (?) spicules of unknown sponge. *Dactylocalycites* Carter.
 The lower margin of Fig. 4 is partly broken away— $\times 200$.
 „ 6, 7.—Spicules with spinous rays. Sponge unknown— $\times 200$.
 Fig. 8.—Fragment of spicular framework of dictyonine hexactinellid— $\times 200$.
 Figs. 9, 10, 11.—Detached five-rayed spicules of hexactinellid sponges.
 Figs. 9 and 11— $\times 100$; Fig. 10— $\times 200$.
 „ 12, 13, 14.—Umbrella spicules of the dermal surface of *Rossella* sp. all fragmentary. Fig. 12 gives a lateral view of the upper portion of the vertical shaft and of the basal portion of the four horizontal rays which radiate from its summit. Figs. 13 and 14 represent the proximal portion of the four horizontal rays with their canals and the patagium connecting the rays; also the broken summit of the vertical shaft— $\times 200$.

The spicules figured on the plates were all derived from a specimen of siliceous rock from the Deep Lead (?) at Princess Royal, Norseman District, Western Australia.



G. J. Hinde del.
G. M. Woodward lith.

West, Newman imp.

FOSSIL SPONGE SPICULES. NORSEMAN, W. AUSTRALIA.