

(15) A slight subsidence of the coast-line, now going on, with an accumulation of extensive deposits of blown sand at Mogador.

(16) The formation of a tufaceous surface-crust over almost the entire plain of Morocco, due to the drawing up to the surface, by rapid evaporation, of water from the subjacent calcareous strata, depositing, layer by layer, laminated carbonate of lime.

### EXPLANATION OF PLATE III.

Fig. 1. Sketch section across the plain of Morocco to the watershed of the Great Atlas.

2. Cliff-section at Saffé.
3. Section of the Tufa-crust covering the plain of Morocco.
4. Surface of ditto.
5. Section of boulder-mounds skirting the escarpment of the Atlas plateau.
6. Front view of the escarpment and boulder-mounds.

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APPENDIX to MR. MAW'S PAPER on the GEOLOGY of MOROCCO, being a DESCRIPTION of a NEW GENUS of FOSSIL SCUTELLOID ECHINODERM from SAFFÉ, N. AFRICA. By R. ETHERIDGE, Esq., F.R.S., F.G.S.

AMONGST the specimens brought by Dr. Hooker and Mr. G. Maw, from Morocco, in North Africa, and submitted to me for examination, were some Urchins of the family *Scutellidæ*, of peculiar form, differing from any I had previously seen or examined, and certainly not referable to any described Tertiary species. Comparison with known forms, recent and fossil, failed to elucidate their true history more than to show that they evidently belonged to the Rotuline group of *Scutellidæ* amongst the Clypeasteroidea, nevertheless differing considerably from the genus *Rotula* (Klein) the only form to which they can be referred.

*Rotula* now inhabits the sea and coast of Senegal, West Africa, from which two, if not three, species are known:—*R. Rumphii*, Klein; *R. Augusti*, Klein; and *R. Gaulteri*, Ag. There is, however, a marked difference between the characters of our new genus and that of *Rotula*, especially in the more elongated and oval form of the test, the extreme rounding or truncation of the fimbriation, or crenulation, upon the posterior margin, more acute anterior and less tumid lateral margins,—so much so, that a line drawn round the circumference of the test of *Rotula*, including the digitations, would describe a complete circle touching the periphery of the Urchin, whereas the form of *Rotuloidea* is an oval or ellipse—*Rotula* being circular, *Rotuloidea* oval; these, with other differences to be hereafter noticed, justify the establishment of a new genus for the reception of these North-African, fossil forms. The resemblance to and affinities with *Rotula* suggest the name *Rotuloidea*.

It is of no small interest thus to obtain from the Great Morocco plain south of Saffé, at "Jew's cliff" &c., what appears to be a less-developed or lower type of Clypeasteroid, which must have been an abundant species in the Miocene sea of that area, then extending far

to the north of the habitat or range of its present representative. *Moulinisia*, Ag., which also has some affinity, is now a denizen of the seas around Martinique; this and the extinct genus *Runa* (Ag.) from the Tertiary beds of Bordeaux and Palermo (noticed under the affinities) seem to be, in some respects, allied genera.

This genus is established to receive Scutelloid forms with lobed instead of digitate expansions upon the posterior margin, and otherwise differing from known *Scutella*.

*Rotuloidea fimbriata*, Etheridge.

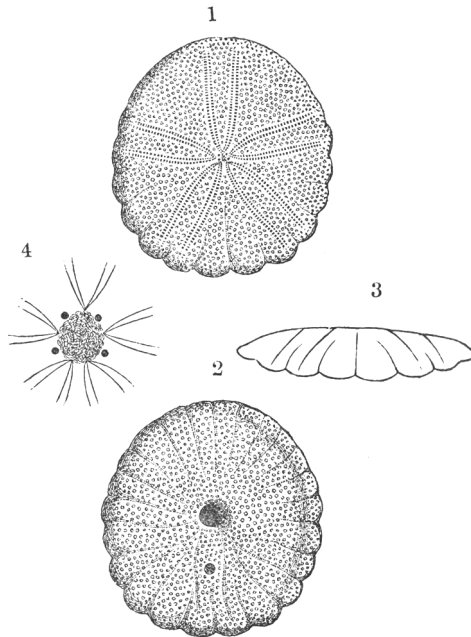


Fig. 1. Dorsal aspect, showing the twelve fimbriations, subpetaloid ambulacra and central madreporic tubercle.  
2. Ventral aspect, showing mouth, position of vent, and ramifying furrows.  
3. Posterior border and height of test.  
4. Apical disk, with the Madreporic tubercle, the four genital pores, and place of the five oculars.

Class ECHINODERMATA.

Order ECHINIDA.

Group Clypeasteroidea.

Fam. SCUTELLIDÆ.

Genus ROTULOIDEA (Etheridge, 1872).

*Gen. char.*—General form depressed, broadly ovate, longer than

broad; base slightly concave. Dorsal and ventral surfaces densely covered with equal-sized, apparently imperforate, tubercles\*. Anterior margin smooth and slightly acute; posterior margin broader than anterior and possessing in the middle six tumid lobes or fimbriations; three others, less tumid, occupy the right and left postero-lateral margins (twelve in all). Ambulacra subpetaloid and equal. Apical disk small, central, round, and covered by the madreporiform plate and tubercle. Mouth central. Vent placed nearly halfway between the mouth and posterior border, nearer the mouth. Tubercles of one order.

*ROTULOIDEA FIMBRIATA*, sp. nov.

*Specific char.*—Test thick, elongated, depressed; upper and under surfaces densely and equally covered with small, nearly equal-sized, imperforate tubercles, all of which are surrounded by ring-like areolæ. Base slightly concave and covered by anastomosing, slightly impressed, bifurcating avenues, meeting at the mouth; these carry the “interrupted” pores of the ambulacra. Ambulacra subpetaloid, slightly narrowing on approaching the margin; the right and left postero-lateral pair sharply, or suddenly, diverge on leaving the apical disk, and pass to the margin over two of the posterior crenulations, ceasing to appear in pairs of “hole and slit” about two-thirds down the posterior area. The lateral pair of ambulacra do not diverge so much as the postero-laterals, and occupy, with the odd ambulacrum, the anterior half of the test. The odd or single ambulacrum is straight, occupying the anterior margin. All traces of the pores in the ambulacra are apparently lost at the margin and base, save near the mouth; but on the ventral surface they are represented by five slightly depressed, smooth-looking furrows, possessing numerous small pores; these furrows divide or ramify about halfway between the mouth and margin. The inner row of pores in the poriferous zones are small and round; the outer slit-like, well-developed, and nearly horizontal. Near the margin of the test the subpetaloid condition of the ambulacra ceases, and the pores become unigeminal in single file, a few in scattered pairs passing the margin over definite fimbriations, after leaving which, all direct traces of them are lost amidst the ramifying and anastomosing furrows at the base; but they appear to be trigeminal near the peristome. The posterior and lateral pairs of ambulacra bear peculiar relation to the twelve crenulations occupying the posterior half of the test: four lobes or fimbriations occupy the space between the two extremities of the posterior ambulacra; one branch of each ambulacral zone (consisting of a single pair of pores) passes over the two lobes next the centre pair, thus occupying four and enclosing two. On the lateral margins two lobes occur between the posterior and lateral ambulacra, which latter pass over (also in single file) the two antero-lateral lobes, thus completing the twelve

\* In the living *Rotula Rumphii* the puncta of the tubercles are so minute as almost to defy detection microscopically; it would be quite impossible that they could escape destruction under fossilization and mineralization. The term “imperforate,” therefore, must be received with this reservation.

fimbriations. The anterior margin is smooth and is occupied by the single ambulacrum. The interambulacral areas are all equal at the margin, owing to the ambulacra being there equidistant.

*Apical disk* central, small, round, or slightly pentagonal, the whole covered by the madreporic body, which occupies the centre. Ocular plates five, perforated; pores small. Genital plates four, perforated; pores large.

*Mouth* ventral, lodged in a slight depression in the centre of the base. Peristome subpentagonal, and margin slightly thickened.

*Vent* subcentral, small, situated between the mouth and posterior border, nearer the former by one third the distance from anal aperture to margin at base of centre fimbriations.

*Tubercles* all of one order, apparently imperforate, Microscopical investigation failed to detect any puncta; but so delicate must they have been in the living state, that all evidence would be obliterated during the process of fossilization; in the living *Rotula* the tubercular pore is hair-like. The tubercles are surrounded by shallow areolæ, the peripheries of which nearly touch each other; and there are no scattered secondary tubercles as in *Rotula*.

*Affinities and differences.*—In the gently arcuated form of the dorsal surface, general characters of the ambulacra, as well as in the position of the mouth and anal aperture, *Rotuloidea fimbriata* closely resembles *Rotula Rumphii*, Klein; the test, however, differs considerably in many points from that of any known *Rotula*. *R. Rumphii* is quite circular, including the digitations, which nearly equal one fourth the diameter of the test and are deeply segmented; whereas the form of *Rotuloidea* is oval, broader posteriorly than anteriorly, and the fimbriations on the posterior border are tumid, scarcely projecting beyond the general margin, being little more than mere crenulations; these marginal undulations are faintly traceable up the anal or posterior half of the dorsal surface of the test to near the apical disk, and most pronounced between the right and left postero-lateral ambulacra. A difference, also of chief importance, exists in the arrangement of the poriferous zones in our genus compared with those of *Rotula*: in *Rotula Rumphii* the outer slit-like ambulacral pores are inclined at a greater angle than in *Rotuloidea*, in which they are nearly horizontal; in *R. Gaulteri* and *R. Augusti* also the slits lie at a considerable angle. The connecting fissures cannot be traced in *Rotuloidea*, owing to the mineralized condition of the test. The pore-slits cease at one third from the margin. The ambulacra of the living *Rotula* are narrower and slightly more petaloid than in *Rotuloidea*; and in this important character the species of *Rotula* differ much from each other, especially as regards the outer zone of elongated pores.

The chief tubercles upon the test of *Rotula* are also much smaller and more closely packed than in *Rotuloidea*; and the living type, *Rotula Rumphii*, possesses secondary tubercles somewhat irregularly placed among the primary ones; none, however, occur upon the test of *Rotuloidea*, all being of one order; again, in *R. Gaulteri* and *R. Augusti* the tubercles are so delicate and close as scarcely to be detected microscopically.

In the slight development of the posterior and lateral fimbriations and in the position of the mouth and vent, *Rotuloidea* has affinity with the Martinican genus *Moulinsia*, Ag. ; but the entire margin, as well as the dorsal and ventral surfaces, of *Moulinsia* is crenulated ; the elements of the apical disk, also, at once remove it from that genus. The same comparison may apply to the genus *Runa*, Ag., from the Tertiary beds of Bordeaux and Palermo, in whose crenulated or fimbriated margin, as well as the position of the mouth and vent, there is much resemblance to the new form ; but the affinity disappears upon comparing the ambulacra of the dorsal surface with those of *Rotuloidea* : both nevertheless belong to one group of Urchins. But for the depression of the test, the position of the anal aperture, the grooved avenues on the base carrying the ambulacra, and the lobed peristome, this genus might almost be referred to *Pygurus* (amongst the *Echinolampidæ*) of the Oolites and Cretaceous rocks of Europe ; for the margin of many forms of that genus is broadly and strongly lobed (notably so in *P. Blumenbachii*). Again, the apical disk and dorsal aspect have strong resemblance to those of *Pygurus*, and also of *Clypeus Plottii* ; and the wandering ambulacra at the base of *Rotuloidea* give it an affinity to the digitate *Pyguri* of the Oolitic rocks.

The Urchins of this singular group in their recent state seem to be confined to the western coast of Africa, near Senegal ; and I believe the specimens brought by Mr. Maw are the first of the true Rotuline type ever found fossil.

*Geological position.*—In assigning to *Rotuloidea* its horizon in time, I believe it to be Miocene, and an extinct genus ; it is associated with Miocene species, and would seem to be the earliest known form of the Rotuline group.

#### DISCUSSION.

Mr. BALL, as an Alpine traveller who had also visited the Atlas in company with Dr. Hooker and Mr. Maw, offered a few remarks. The plain of Morocco was not, in his opinion, a level, but an inclined plane, rising gradually in height up to the foot of the mountain, so that the base of the boulder ridges was at some height above the level of the plain near Morocco. He did not think that the boulder deposits could be safely attributed to glaciers, but thought rather that they had been carried into and deposited in a shallow sea. He thought also that Mr. Maw had somewhat overestimated the thickness of some of the boulder deposits ; and though there was one instance of an undoubted moraine in one of the higher valleys of the Atlas, yet he could not agree in the view that the glaciation of the Atlas was general. He could not accept such a great thickness of beds as that represented by the vertical shales in Mr. Maw's section.

Prof. RAMSAY was pleased that the author, though giving so many interesting details, had not assigned any definite age to many of the beds. He agreed with him as to the cause assigned for the great tufaceous coating of the country. He had already assigned the same cause for the existence of certain saline beds, and would attribute the existence of the great coating of gypsum at a slight depth

below the surface of the Sahara to the same cause. As to the existence of moraines, he was not surprised to find them in the Atlas, as they were already known in the mountains of Granada. As to the escarpments, it was now well known that, as a rule, they assumed a direction approximately at right angles to the dip of the strata; and he felt inclined to consider that the bulk of the mounds at the foot of the escarpment of the Atlas were rather the remains of a long series of landslips from the face of the cliffs than due to an accumulation of moraine matter.

Mr. D. FORBES commented on the similarity of the rocks to those of the Andes in South America. In the Andes the porphyritic tuffs appeared to belong to the Oolitic age; and the igneous rocks associated with them were of the same date. He thought that, so far as the author's observations had gone, the structure of the Atlas was much the same as that of the Andes.

Mr. W. W. SMYTH mentioned that in the district to the east of the Sierra Nevada, in the south part of Spain, where there was great summer heat, and also heavy occasional rainfall, the same tufaceous coating as that observed in Morocco was to be found. He had been led to much the same conclusion as to its origin as that arrived at by Mr. Maw. The upper part was frequently brecciated, and the fragments recemented by carbonate of lime.

Mr. SEELEY, though accepting Mr. Etheridge's determination as to the Cretaceous age of the fossils if found in England, could not accept it as conclusive in the case of fossils from Morocco. The genus *Exogyra*, for instance, which ranges through the secondary and up to existing seas, might well belong to some other age; and even the fossils presumably Miocene might, after all, date from some other period.

Mr. MAW, in reply, stated that he agreed with Mr. Ball as to the rise in the Morocco plain as it approached the Atlas, and pointed out that his section actually represented a rise of 400 feet from the city of Morocco to the foot of the boulder mounds; but in addition to this gradual rise there was a range of altitude of 2000 feet from the foot to the summit of the boulder beds.

He also pointed out the resemblance between the interrupted occurrence of the boulder mounds in the Atlas and the distribution of glacial moraines in the Rhone valley, and in the valley of the Esk, in Forfarshire. As a proof that the boulder mounds on the flanks of the Atlas consisted of transported blocks, he mentioned the fact that the red sandstone rock of which they were composed did not occur in the adjacent escarpments, and was not to be found within four or five miles. There was, moreover, a mixture of different materials in the mounds.

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JANUARY 24, 1872.

Henry Ludlam, Esq., of 174, Piccadilly, W., and Charles Whitehead, Esq., J.P., F.L.S., F.S.A., of Barming House, Maidstone, were elected Fellows of the Society.

The following communications were read:—