THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VII.

No. XI.—NOVEMBER, 1890.

ORIGINAL ARTICLES.

I.—SOME ADDITIONS TO THE AUSTRALIAN TERTIARY ECHINOIDEA.

By J. WALTER GREGORY, F.G.S., F.Z.S.,
of the British Museum (Nat. Hist.).

(PLATES XIII. AND XIV.)

THE Tertiary Echinoid fauna from the South-east of Australia is well known from the work of Duncan,¹ Laube,² R. Etheridge, jun.,³ and M'Coy.⁴ A collection made by H. P. Woodward, Esq., F.G.S., from the Tertiary beds of Willunga near Adelaide, enables several additions to be made. These are of interest as they considerably strengthen the Cretaceous facies which the fauna owes to the presence of such genera as *Holaster* and *Micraster*, and as they throw some additional light upon a genus the stability of which has long been questioned. The collection has been presented to the British Museum (Nat. Hist.) by H. Y. L. Brown, Esq., F.G.S., the Government Geologist for South Australia.

Dr. J. E. Taylor, during a visit to the cliffs of the Murray River at Morgan, South Australia, made a collection of fossils which is now in the Ipswich Museum. This includes two new species of Echinoids, and a description of these may be conveniently included in the present paper. For the loan of the specimens I must express my thanks to Dr. Taylor.

L.—Mr. H. P. Woodward's Collection, from Willunga.

Fam. CIDARIDÆ.

Gen. *Cidaris*, Leske, 1778.

Cidaris (*Leiocidaris*) sp. Duncan, Q.J.G.S. xliii. p. 412 (B.M. E 197), 1887.

There is a fragment (B.M. E 3377) of a *Cidaris* which, as it contains ambulacral and interambulacral plates, admits of identifica-

¹ P. M. Duncan, "A Description of some Fossil Corals and Echinoderms from the South Australian Tertiaries," Ann. Mag. Nat. Hist. (3) vol. xiv. pp. 161-8, pls. v. and vi. "On the Echinodermata of the Australian Cainozoic (Tertiary) Deposits," Q.J.G.S. xxxiii. 1877, pp. 42-73, pl. iii. and iv. "A Revision of the Echinoidea from the Australian Tertiaries," Q.J.G.S. xliii. 1887, pp. 411-430.

² G. C. Laube, "Ueber einige fossile Echiniden von den Murray Cliffs in Süd-Australien," Sitz. k. Ak. Wiss. Wien. lix. Abth. i. 1869, pp. 183-98.

³ R. Etheridge, jun., "Description of a New Species of the Genus *Hemipatagus*, Desor, from Tertiary Rocks of Victoria, Australia; with Notes on some previously described Species from S. Australia," Q.J.G.S. 1875, pp. 444-50, pl. xxi.

⁴ F. M'Coy, Prod. Pal. Victoria, dec. vi. 1879, vii. 1882.

tion. Its characters agree with those of the specimen from Bairnsdale described but not named by Dr. Duncan. This species differs from *L. australiæ* mainly by the very deeply impressed areolæ which occur in the latter.

SPINES.

The collection includes a considerable number of spines which closely resemble those of *Goniocidaris*, *Phyllacanthus* and possibly also of *Heterocentrotus*. The only plates to which the spines of the *Glyphostomata* might be referred are too imperfect for description (B.M. E 3378-9).

Fam. CASSIDULIDÆ.

Gen. *Cassidulus*, Lam. 1801.

Cassidulus longianus, sp. nov. Pl. XIII. Figs. 1-3.

Outline from above elliptical, somewhat pointed anteriorly. Abacinally it is evenly rounded; the vertex slightly precentral. Actinal surface slightly concave with the mouth in the centre of the depression. A wide median bare band runs backward from the mouth.

Apical system at vertex. Five radial and four basal pores. Madreporite large, occupying whole of centre of the system.

Ambulacra. — Petals sublanceolate; flush; open below; pores yoked. The single pores of the extrapetaloid plates are on the adoral margin. Petals nearly equal: the posterior laterals are slightly narrower and less lanceolate than the anterolateral.

Peristome anterior: at deepest part of the slight actinal depression. Floscelle very prominent. Phyllodes very narrow at oral end, but expanding into wide areas with five pores in the outer row of each side. Bourrelets very prominent. Mouth pentagonal.

Anus long, narrow and oval; situated at upper end of a long narrow groove, which however barely influences the posterior margin.

DIMENSIONS.			Largest specimen. Type, Fig. 1. Type, Fig. 2.		
Length	...	...	65 mm.	45 mm.	43 mm.
Width	...	...	56 "	42 "	40 "
Height	...	...	30 "	22 "	20 "
Distance of apex from anterior edge	...	...	27 "	19 "	...
Distance of mouth	...	...	26 "	...	17 "
Maximum width of poriferous zone:					
antero-lateral ambulacrum			2.5 "	1.5 "	
Maximum width of poriferous zone:					
postero-lateral ambulacrum			2.0 "	1.2 "	
Length of antero-lateral ambulacrum	...	...	20 "	11 "	
Length of postero- " "	...	...	22 "	12 "	

Cassidulus has not previously been described from the Australian Tertiaries. The genus is mainly Cretaceous, but a few species occur in the Eocene. *Cassidulus longianus* is a well-marked species: the bare median band, one of the features of the subgenus *Pygorhynchus*, the long anus and short petals form a series of characters to be met with in no other species of the genus. It most resembles some of the United States Cretaceous forms such as *C. subquadratus*, Conrad.¹

¹ T. A. Conrad, Journ. Ac. Nat. Sci. Phil. [2] iv. p. 291, pl. xlvii. fig. 19.

Gen. *Echinolampas*, Gray, 1825.*Echinolampas ovulum*, Laube.

Sitz. k. Ak. Wiss. Wien. lix. Abth. i. 1869, pp. 191-2.

Laube in 1869 briefly described a specimen from the Murray Cliffs, which he temporarily named *E. ovulum* as it was too imperfect for formal diagnosis. Prof. Duncan subsequently referred a specimen from Bairnsdale (B.M. E1107) to this species. Laube's type is in the Palæontological Collection of the Hof Museum in Vienna, and owing to the kindness of the Director, Dr. Fuchs, I recently had the opportunity of examining it; there can be no doubt of the correctness of Prof. Duncan's identification. As the species has hitherto been neither figured nor described, this opportunity may as well be taken for doing so: in the following diagnosis both specimens have been used.

Echinolampas ovulum, Laube. Pl. XIII. Figs. 7-8.

Laube, Sitz. k. Ak. Wiss. Wien. Bd. lix. Abth. i. 1869, pp. 191-2.

Duncan, Q.J.G.S. 1877, xxxiii. p. 66; 1887, xliii. p. 420.

Outline seen from below an elongated pentagon with rounded angles; sides tumid, rounding off into the concave actinal surface: tapering posteriorly to a slight rostrum, at the end of which is the anus: well rounded in front.

In elevation it is high, with the vertex behind the apical disc.

Vertex blunt, at the posterior third of the test.

Apical system anterior: details unknown.

Ambulacra with lanceolate petals, open below. The posterior pair the larger. Pores yoked. The petals extend more than two-thirds to the ambitus. In the posterior ambulacra the pore areas are equal (as in *Palæolampas*); in the anterior unequal (as in *Echinolampas*).

Peristome: mouth rounded pentagonal: broader than long: slightly anterior: at deepest part of the actual concavity.

Floscelle rudimentary, formed by slight bourrelets.

Anus elliptical, transverse: situated at the end of a slight rostrum.

Tuberculation: of close-set, uniform granules with impressed areolæ.

	DIMENSIONS.	Laube's type.	B.M. E1107.
Length		64 mm.	57 mm.
Width: at posterior third		56 "	48 "
" anterior third		52 "	43 "
Height		36.5 "	33.5 "
Apical disc: distance from anterior end		25 "	23 "

Echinolampas posterocrassus, sp. nov. Pl. XIII. Figs. 4-6.

Form a depressed rounded pentagon: sides tumid. Apex a little behind the calycinal system; anterior slope gentle.

Apical system precentral; basal pores large: those of the posterior pair the further apart.

Ambulacra long, narrow: slightly petaloid but almost parallel:

open below. The pore pairs of the anterior pair slightly unequal. Those of the posterior pair markedly so.

Mouth anterior: in the highest part of the actinal depression: pentagonal: phyllodes very rudimentary.

Anus triangular: infra-marginal.

DIMENSIONS.

Length	...	...	...	...	...	...	...	...	...	43	mm.
Width: at $\frac{1}{3}$ of length from anterior end	...	...	...	...	...	...	...	...	...	36	"
" " " " " " " " " " " "	...	...	...	...	...	...	...	...	...	36.5	"
Height	...	...	...	...	...	...	...	...	...	21	"
Distance of apical disc from anterior end	...	...	...	...	...	...	...	...	...	17	"
Length of petaloid portion of anterior ambulacrum	...	...	...	...	...	...	...	...	...	10	"
Max. width of " " " " " " " " " " " "	...	...	...	...	...	...	...	...	...	3	"
Length of petaloid portion of posterior ambulacrum	...	...	...	...	...	...	...	...	...	17	"
ambulacrum	...	...	...	...	...	...	...	...	...	12	"
Max. width of " " " " " " " " " " " "	...	...	...	...	...	...	...	...	...	3.5	"

This species belongs to the group of *Echinolampads* of which *E. similis*, Ag., may be taken as the type. It differs from this by its greater proportional breadth, and the greater inequality of the poriferous zones in each of the posterior petals. It can be easily distinguished from other Australian species of this genus by its depressed form and the marked inequality in the length of the poriferous zones of the petaloid portions of the posterior ambulacra. Its general form reminds one of *Echinolampas dispar*, Fritsch,¹ from the Eocene of Borneo; from this it differs in that the mouth is more excentric in position, the anus is triangular (instead of round as in the Malaysian species), and in the latter the posterior part of the test is much wider than the anterior.

Fam. ANANCHYTIDÆ.

Genus *Cardiaster*, Forbes, 1852.

Cardiaster tertiarius, sp. nov. Pl. XIV. Figs. 2 & 3. B.M. E3382.

Outline seen from above cordate: the test tapering gently posteriorly; the anterior end is broad, well rounded, and marked by the deep anterior groove. In elevation it is seen to be sloping steeply in front and very high behind; the posterior interradius is elevated into a slight keel. Vertex at a quarter of the length of the test from the anterior end. Posterior margin truncate and vertical, with the anus high upon this area. In this position the actinal surface appears straight.

Apical system central; elongate; only the right half is known.

Ambulacra flush: the pores of the posterior poriferous zones of each of the paired ambulacra larger than the anterior. Pores of unpaired anterior ambulacrum minute.

Tubercles crenulate and perforate.

DIMENSIONS.

Length	...	...	...	...	...	...	...	...	...	42	mm.
Width at $\frac{1}{3}$ length from anterior end of test	...	...	...	...	...	...	...	...	...	21	"
" " " " " " " " " " " "	...	...	...	...	...	...	...	...	...	18	"
Height	...	...	...	...	...	...	...	...	...	25	"

¹ K. von Fritsch, "Die Echiniden der Nummuliten-Bildungen von Borneo," *Palæontographica*, Supp. III. 1. 1, Hft. 2, 1877, p. 89, pl. xiii. figs. 2 and 3.

Cardiaster has not hitherto been described except from the Cretaceous. The late Rev. J. E. Tenison-Woods recorded¹ the genus from Mt. Gambier, but gave neither figure nor description; and, as has been often pointed out, little value can be attached to his generic determination of Echinoidea. The present specimen is somewhat broken, and, as is so often the case in this genus, the fascioles cannot be seen; nevertheless the general form, the deep anterior groove, and the tuberculation, leave no doubt of its correct generic position.

The species agrees most closely with the European *C. ananchytis*, and most nearly with the variety *cordiformis*.² It differs, however, in the greater prominence of the ridges that bound the anterior groove; the test is higher, the anterior end is steeper, and instead of the gentle slope of the posterior interradius, this forms a horizontal keel, which is terminated abruptly by the almost vertical posterior margin.

Fam. SPATANGIDÆ.

Division *Prymna*dete.

Genus *Pericosmus*, Ag., 1847.

Sp. 1. *Pericosmus M'Coyi*, sp. nov.

Pericosmus compressus, M'Coy. Prod. Pal. Victoria, dec. vii. 1882, pp. 21-2, pl. lxvii. fig. 2, and lxviii. (Non *Megalaster compressus*, Dunc.)

Sp. 2. *Pericosmus compressus*, Dunc. sp. Pl. XIV. Fig. 1.

Megalaster compressus, Dunc. Q.J.G.S. 1877, vol. xxxiii. p. 62, fig. 1.

Prof. Duncan, in 1877, described as *Megalaster compressus* a large Spatangoid, evidently an ally of *Pericosmus*, but for which, owing to the absence of fascioles, he instituted a new genus. Prof. M'Coy five years later, in the course of his admirable figures and descriptions of the Victorian *Pericosmi*, named one species *P. compressus*, because he was deeply impressed with its resemblance to the specimen described by Dr. Duncan, and with the probability that *Megalaster* would turn out to be only a badly-preserved representative of this genus. Prof. von Zittel³ seems previously to have entertained the same doubts, as he only accepted *Megalaster* with a query. Prof. Duncan, in his "Revision of the Australian Echinoidea," in 1887, referred to Prof. M'Coy's remarks, and after a brief discussion left the question open. In his recent "Revision of the Echinoidea,"⁴ however, the genus is again quoted without any expression of doubt.

The question of the retention of the genus *Megalaster* depends upon whether the absence of fascioles in the type-specimen is due to their never having been developed or to their having been obliterated during weathering. The specimen has certainly been greatly worn; none of the tubercles on the abactinal surface are shown in Prof. Duncan's drawing, nor are they preserved in the British Museum specimen. It is therefore not surprising that

¹ J. E. Tenison-Woods, Geol. Obs. in South Australia, 1862, p. 77.

² Samuel Woodward, Geology of Norfolk, 1833, p. 50, pl. v. fig. 6.

³ von Zittel, Handbuch der Palaeontologie, i. 1889, p. 541.

⁴ Journ. Linn. Soc. Zool. xxiii. 1889, pp. 221-2.

fascioles cannot now be recognized; but in his discussion of the question Prof. Duncan emphasizes the fact that the specimen is certainly specifically distinct—quite apart from the fascioles—from any described species of *Pericosmus*. Prof. M'Coy, on the other hand, regarded it as probably identical with his *P. compressus*, though he noted that in addition to the fascioles the latter has a convexity, instead of a concavity, near the summit of the unpaired interradius.

In Mr. H. P. Woodward's collection there is a *Pericosmus* which agrees in the character noted by Prof. M'Coy, and in other points with Dr. Duncan's specimen. After a comparison of this with the specimen of *Megalaster*, I entertain no doubt that the two are specifically identical, and that consequently *Megalaster* must be abandoned.

As to the second question, whether *Pericosmus compressus*, Dunc. sp., is the same as *P. compressus*, M'Coy, I agree with Dr. Duncan rather than with Prof. M'Coy and Prof. Hutton. The two species differ in the following points: *P. compressus*, Dunc. sp., is longer than wide, whereas the other is wider than long; in the former the anteal sulcus is wider and shallower; the anus is oval instead of round; the anterior slope is steeper; the test is higher; the apical disc is more anterior; there is a concavity behind the apical disc; the ambulacra are less lanceolate, blunter and sinuous. These form a combination of characters that are quite sufficient to continue the separation of the species. But the absorption of *Megalaster* in *Pericosmus* necessitates the adoption of a new name for the later species. I have much pleasure in calling it after Prof. M'Coy, as, owing to his admirable work, his name must always be associated with the species; its renaming is only required owing to the perspicuity with which Prof. M'Coy interpreted Prof. Duncan's description and outline figure, and to the caution with which he hoped to save palæontological nomenclature from a useless synonym.

After Prof. Hutton's¹ remark, it is perhaps advisable to compare *P. M'Coyi* with the description of *Meoma crawfordi*, Hutton. The Australian species differs from the New Zealand one in that (1) it is not a *Meoma*; (2) it is broader than long—not longer than broad, as shown by Prof. Hutton's measurements; (3) the antero-lateral ambulacra are equal or slightly longer than the postero-lateral.

II.—Dr. Taylor's Collection. From the banks of the Murray River at Morgan.²

Fam. ARBACIDÆ.

Gen. *Cælopleurus*, Ag., 1840.

Cælopleurus paucituberculatus, sp. nov. Pl. XIV. Figs. 4 and 5.

Test tumid; depressed abactinally; concave below. Circular.

¹ F. W. Hutton, "On the Correlations of the 'Curiosity-Shop Bed,' in Canterbury, New Zealand," Q J.G.S. 1885, vol. xli. p. 554.

² The sections at this point have been fully described by Prof. Tate in his "Notes on the Physical and Geological Features of the Lower Murray River," Trans. Roy. Soc. S. Australia, 1885, vol. vii. p. 35.

Apical system large; ornamented with tubercles; radials narrow. Anus slightly elliptical.

Ambulacra: narrow above with small tubercles; but wide at the ambitus with large tubercles; both sets are uncrenulate and imperforate. The bosses are large and fill up nearly the whole of the areola. Two rows of small flat granules run up the centre of each area at the ambitus, but disappear above. Eleven plates in a vertical series.

Interambulacra.—The bare median band at the summit of each area is bounded on either side by a row of large, and a row of small granules. At the ambitus the number of granules widen, and there are three rows of subequal granules on either side. No primary tubercles. Fifteen plates in the vertical series.

Mouth large; in a concavity. Buccal slits broad.

DIMENSIONS.

Diameter	19 mm.
Height	12 „
Width of ambulacral area at ambitus	7 „
Width of interambulacral	6 „
Diameter of anus	3 „

Distribution: Middle Murravian, Morgan, S. Australia (preserved in the Ipswich Museum).

Cælopleurus is a typically Cainozoic genus, but has not previously been recorded from the Australian Tertiaries. The type-specimen of the new species is broken, but the apical disc and most of the abactinal surface, a complete ambulacrum and the halves of the two adjoining interambulacra are shown: all the points in the anatomy of the test can therefore be determined. *Cælopleurus paucituberculatus* is very easily distinguished from any other species of the genus by the complete absence of primary tubercles on the interradii (the character which has suggested its name), and by the persistence to the apical disc of a pair of granules on either side of the bare median area. In the latter feature it resembles *Cælopleurus sindensis*, Dunc. and Sl., which is apparently its nearest ally. It can be easily distinguished from this by the absence in the new species of the primary ambital interradiial tubercles.

Fam. CLYPEASTRIDÆ.

Gen. *Clypeaster*, Lam., 1816.

Clypeaster gippslandicus, M'Coy.

Prod. Pal. Victoria, Dec. vi. 1879, pp. 33-5, pl. lix.

There is one well-marked specimen in the collection which is of interest, as the species is usually characteristic of the uppermost beds of the South Australian and Victorian Cainozoic series.

Subgen. *Monostychia*, Laube.

Monostychia australis, Laube, sp.

Sitz. k. Akad. Wiss. Wien, lix. Abth. i. 1869, p. 190, fig. 3.

The collection includes several specimens of this species, and one belonging to the var. *elongata*.

Gen. *Hemiaster*, Desor, 1857.

The genus *Hemiaster* has not been hitherto described from Australia, but a species is known from New Zealand. *H. planedecclivis* belongs, however, to a very different group to this *H. posita*, Hutton,¹ which has a cordate, inflated test, with the pores on the inner side of the postero-lateral ambulacra obliterated near the apical area. Moreover, the latter species is said in the diagnosis to have neither subanal nor peripetalous fasciole. If this be correct, the species is not a *Hemiaster*, but must be transferred to the genus *Epiaster*.

The generic determination of this Echinoid may be considered doubtful by the French palæontologists who separate from *Hemiaster* all the Cainozoic forms. But apart from the disputed question of the validity of the new genera to which these species are referred, the affinities of *H. planedecclivis* are so distinctly with the Cretaceous group that it must be regarded as a true typical *Hemiaster*.

III.—FROM NULLARBOR PLAINS.

During the exploration of the country between Port Augusta and Eucla,² a few Echinoidea were collected from the Nullarbor limestone; these have also been presented to the British Museum (Nat. Hist.) by H. Y. L. Brown, Esq. At Tallowan Well in the Fowler's Bay district an *Echinolampas*, sp., and some fragments probably referable to *Eupatagus* were collected. The other specimens were without definite locality: they are *Echinus woodsi*, Laube, and *Lovenia forbesi* (Woods and Dunc.).

IV.—THE AFFINITIES OF THE ECHINOID FAUNA.

Many attempts have been made to classify the Australian Cainozoic deposits, and to establish definite correlations of the beds of the various localities with each other, and with the European formations; no very definite classification has, however, as yet been agreed upon. But an examination of the faunal lists clearly shows that various horizons are represented, and until the relations of these are at least approximately known, no definite conclusions as to the affinities of the fauna can be established.

As Mr. Woodward's collection was made at a new locality, it is necessary to consider the relations of the fauna to those from other places in South Australia and Victoria. Of the five recognizable species three are new, but the other two are well-marked forms; they suggest that the beds belong to the lowest of the three divisions into which it seems generally agreed that these Australian Cainozoic deposits can be divided. As to the terms to be applied to these divisions, however, opinions differ greatly. The banks of the Murray River exhibit the longest continuous sections, and afford the best oppor-

¹ F. W. Hutton, Cat. Tert. Mollusca and Echinodermata of New Zealand, New Zealand Geol. Surv., Miscell. Publications, No. IX. 1873, p. 42. Hector, Cat. of Geol. Exhibits, New Zealand Court, India and Colonies Exhibition, London, 1886, p. 54, fig. 1.

² H. Y. L. Brown, "Report of Country passed over from Port Augusta to Eucla," Adelaide, 1885.

tunity for the working out of the sequence of palæontological zones; it is therefore probable that this series will serve as the scale with which the disconnected beds of other localities will be compared; hence Prof. Tate's terms,¹ Upper, Middle and Lower Murravian, may be conveniently adopted. The beds at Mordillac, and some other Gippsland localities belong to the highest part of the marine Cainozoics, and their correlation with the Upper Murravian seems generally admitted. The beds at Mount Gambier, Wauru Ponds, Muddy Creek, Geelong, Bird Rock Point, and Cape Otway are referred to the Middle Murravian; no serious effort to establish a precise correlation of the beds at these localities seems to have been made, but their Echinoid faunas have much in common; thus of the four species from Mount Gambier, three occur in the middle division of the Murray River beds, and the fourth occurs at Cape Otway; of the four at Cape Otway, one (*Holaster difficilis*—an unsatisfactory species) is peculiar, one occurs at Mount Gambier, and the other two in the Middle Murravian of the typical locality.

The collection made by Mr. Woodward has a somewhat oldish facies: *Pericosmus compressus* (Dunc.) is elsewhere commonest in the Lower Murravian beds, while the species characteristic of the upper division are absent. Hence though the evidence is insufficient for any positive opinion, it is probable that the beds at this point will turn out to be Lower Murravian.

When considering the distribution of the Australian Cainozoic Echinoidea, one must compare them with those from New Zealand made known to us by the labours of Prof. von Zittel² and Prof. F. W. Hutton.³ The latter has described a fauna from the Curiosity Shop beds, which in its main features greatly resembles that of South Australia and Victoria, while some of the species are regarded as identical. The brief diagnoses given by Prof. Hutton do not, in the absence of illustrations, allow of any close comparison being made between them and the Australian species: nevertheless the resemblances are sufficient to show that they are of approximately the same age, and to necessitate their inclusion in any full consideration of the relations of the fauna.

The attempt to correlate the Murravian beds with their European equivalents is of course much more difficult than their classification. Prof. Duncan, distrusting the application of European terms in such distant regions, calls the Mount Gambier beds Middle Cainozoic, those below that horizon the Lower, and those above the Upper Cainozoic.⁴ Profs. Selwyn and McCoy and the authors of Skene's map of Victoria, agree in the main with Prof. Duncan, though they call the Gippsland beds Pliocene and the others Miocene and

¹ Tate, "Notes on the Correlations of the Coral-bearing Strata of South Australia," Trans. Roy. Soc. South Australia, vol. i. 1878, pp. 120-3.

² K. von Zittel, "Neue Mollusken und Echinodermen aus Neu-Seeland," Novara Reise, Palæontologie.

³ F. W. Hutton, "Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand," New Zealand Geol. Soc., Miscell. Public. ix. 1873.

⁴ P. M. Duncan, "On the Fossil Corals of the Australian Tertiary Deposits," Q.J.G.S. xxvi. 1870, p. 315.

Oligocene: as long as we regard these terms as implying only a general homotaxis, they are synonymous with and more convenient than the others. Professor Hutton¹ however assigns his New Zealand Echinoidea to the Cretaceo-Tertiary; but the fact that more than 20 per cent. of the species from this horizon are still living would appear to conclusively negative this opinion. Prof. Hutton, however, in his latest note,² correlates the Cobden with the Ototara limestone, and says that the fossils "indicate an Upper Eocene or Lower Miocene, i.e. an Oligocene age." Prof. Tate's conclusions³ are rather intermediate between the two extremes of Prof. McCoy on the one hand and Prof. Hutton's earlier paper on the other: he correlates the Upper Murravian as Miocene and the Middle Murravian as Eocene. Mr. Dennant⁴ again would make the beds older. As the Upper Muddy Creek beds, including Mordillac, contain only 6.5 per cent. of living species, he assigns them to the Oligocene, and the lower beds with 1.5 per cent. to the Lower Eocene. Nummulites, it may be remarked, also occur on this horizon. The Echinoidea seem to support the views of Mr. Dennant. The presence of so many genera peculiar to or characteristic of the Cretaceous, such as *Cassidulus*, *Catopygus*, *Cardiaster*, *Holaster*, and *Micraster*, and the closer alliance of some species, as *H. planedeclevis*, to the Cretaceous rather than the Tertiary representatives of their genera, suggest that the fauna is early Tertiary.

Some other genera, as *Cælopleurus* and *Echinolampas*, are characteristically Eocene, and some peculiar forms have their nearest allies in the same period: further the absence of the typical Upper Tertiary genera is very noticeable; both of these points strengthen the same conclusion. Moreover, as far as the Echinoidea go, the differences of the faunas of the Upper and Lower Murravian are too slight to allow one to consider them as separated by so long a period as that between the Eocene and the Pliocene; there is certainly nothing in the Echinoid fauna that would debar the uppermost beds from entering the Oligocene.

But the real correlation of these beds will depend more on the Mollusca than on the Echinoidea: the latter are so anomalous a collection that little faith can be attached to their evidence on this subject. The interest of the fauna depends on its bearing on other problems. It seems to be composed of two constituents: about a third are species of the ordinary Palearctic Upper Cretaceous genera; these seem to have migrated southwards and became mingled on their journey with a fauna that agrees most closely with that of the Eocenes of India and Malaysia. No abyssal types were picked up on the march, nor do any of the species retain any

¹ F. W. Hutton, Q. J. G. S. xli. 1885, pp. 558-64.

² "On some Fossils lately obtained from the Cobden Limestone at Greymouth," Trans. N. Zealand Inst. xx. 1888, pp. 267-9.

³ Tate, "Census of the Fauna of the Older Tertiary of Australia," Journ. R. Soc. N. S. Wales, xxii. 1888, pp. 242.

⁴ J. Dennant, "Notes on the Muddy Creek Beds, with Brief Remarks on other Tertiary Strata of S. Western Victoria," Trans. R. Soc. S. Australia, vol. xi. 1889, pp. 53-4.

trace of the influence of a deep-sea habitat. Hence the route may have followed the coasts of Asia and Malaysia, in which case we may hope for much further light to be thrown upon its progress by collectors in that area; or the line may have lain across what is now occupied by the deep abysses of the Indian Ocean, but if so it must have occurred before its bed had subsided to anything like its present depth.

EXPLANATION OF THE PLATES.

PLATE XIII.

FIGS. 1, 2, and 3. *Cassidulus longianus*, sp. nov., Willunga, S. Australia. Nat. size. Brit. Mus. E 3380. Fig. 1. Abactinal view. Fig. 2. Actinal view of another specimen. Fig. 3. Side view of former specimen.

FIGS. 4, 5, and 6. *Echinolampas posterocrassus*, sp. nov., Willunga. Nat. size. Brit. Mus. E 3381. Nat. size. Fig. 4. Side view. Fig. 5. Abactinal view. Fig. 6. Actinal view of same specimen.

FIGS. 7 and 8. *Echinolampas ovulum*, Laube. Birnsdale, Victoria. Brit. Mus. E 1107. Nat. size. Fig. 7. Actinal view. Fig. 8. Side view of same specimen.

PLATE XIV.

FIG. 1. *Pericosmus compressus* (Dunc.). Willunga. Brit. Mus. E 3383. Half size.

FIGS. 2 and 3. *Cardiaster tertiorius*, sp. nov. Willunga. Brit. Mus. E 3382. Nat. size. Fig. 2. Abactinal. Fig. 3. Side view of same specimen.

FIGS. 4 and 5. *Cælopleurus paucituberculatus*, sp. nov. Morgan, S. Australia. Fig. 4 $\times 2$ dia. Fig. 5. Diagram of apical disc and surrounding plates $\times 4$ dia. Ipswich Museum.

FIGS. 6 and 7. *Hemimaster planedectvis*, sp. nov. Morgan, S. Australia. Nat. size. Ipswich Museum.

II.—QUATERNARY CHANGES OF LEVELS.

By WARREN UPHAM,
of the United States Geological Survey.

THE article by Prof. J. W. Spencer in the last May number of this MAGAZINE brings together many evidences of high continental elevation of North America preceding the Pleistocene or Glacial period. Though Professor Spencer has not proceeded to interpret these observations as revealing in continental elevation the probable cause of the severely cold climate and accumulation of ice-sheets during the Glacial period, I believe that this is a legitimate conclusion, and that it strongly re-enforces the arguments long ago advanced by Lyell and Dana, and recently emphasized anew by Wallace.

But certain other observations bearing on the length of the Post-glacial or Recent epoch lead me to differ from Wallace, who combines high elevation with maximum eccentricity of the earth's orbit as necessary concomitant conditions of glaciation. Closely accordant computations of the length of Postglacial time have been reached quite independently by Prof. N. H. Winchell, from the rate of recession of the Falls of Saint Anthony;¹ by Dr. E. Andrews, from

¹ Quart. Journ. Geol. Soc., vol. xxiv. 1878, pp. 886-901; Geology of Minnesota, Fifth Annual Report, for 1876; and Final Report, vol. ii. 1888, pp. 313-341, with numerous plates and maps.