striking facts and considerations to show, that most of the inland pillars and projections of rock hitherto attributed to *weathering* are due to the former action of waves, tides, and currents; that many rocks are capable of withstanding atmospheric action for thousands, if not hundreds of thousands of years; and that the amount of atmospheric denudation is small, when compared with that resulting from the littoral action of 'the great excavator,' the ocean.

VIII. Dr. A. Leith Adams and Professor Busk communicated their First Report on the Exploration of the Maltese Caverns.

THERE were two caverns in the island of Malta, one in the South-East, and the other in the centre of the island, in which remains had been found; in the latter the remains being those of the Elephant, and in the former chiefly Hippopotamus. Recently another cave on the south coast, and not 100 yards from the Phœnician ruins in that part of the island, had been discovered, and Capt. Spratt had found in it some remains, after which Dr. Adams proceeded with the further exploration of the cavern, resulting in the discovery of relics which proved that that part of the surface of the earth which now constituted the island of Malta was once the home of two species of Pigmy Elephant and one species of Elephant of the size now existing. The island would not now yield a month's food to many individuals, of even one species of Elephant; therefore, the island must at one time have joined to the opposite coast of Africa; and in this opinion the authors of the paper were supported by other considerations.

CORRESPONDENCE.

ON MACRAUCHENIA PATACHONICA.

To the Editor of the Geological Magazine.

Sir,—The most important and unexpected statement in Prof. Burmeister's account of the *Macrauchenia patachonica* relates to the dental formula which he ascribes to that genus and species; viz.,—

$$i\,\frac{3-3}{3-3},\ c\,\frac{1-1}{1-1},\ p\,\frac{4-4}{4-4},\ m\,\frac{4-4}{3-3}=40;$$

the exceptional fact being the presence of 16 teeth in the molar series of the upper jaw, instead of 14 as in all other Perissodactyles, in which the full type-number of the series is maintained. Of the 16 molar teeth thus assigned to the upper jaw,* Burmeister refers

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* 'La *Macrauchenia* tiene como el caballo, seis dientes incisiors en cada mandibula, cuatro colmillos chicos, ocho muelas en la mandibula superior, y solo siete en la inferior, de cada lado, es decir, en todo cuarenta y seis dientes.'—P. 42.

'Delante de la letra C de esta figura (pl. i. fig. 2) se ven dos aberturas negras, indicando los alviolos para dos dientes, que faltan; la primera pertenece al diente canino, la segunda á la primera muela.'—P. 37.

the 4 anterior ones on each side to the premolares (*muelas falsas*), and the 4 posterior ones on each side to the true molars (*muelas verdaderas*); the true molars being distinguished by their larger size, quadrangular crowns, and by having three roots instead of one.

The number of true molar teeth 4—4 here ascribed to the upper jaw of *Macrauchenia* is not only an exception to the dental formula of Perissodactyles, but of all other Ungulates, and indeed of all diphyodont-placental mammalia: it would be an anomalous resumption in the Ungulate order of a character of the Marsupial one. Again, the reference of the fourth grinder, counting from behind forwards to the series of true molars, gives a distinctive simplicity to the alleged four premolars in advance, which has hitherto been seen only in the Artiodactyle Ungulates, and which would be a more striking example of the tendency of the Perissodactyle *Macrauchenia* to the Artiodactyle order, than its cameloid cervical vertebræ, or its coalesced antibrachial bones.

After a careful study of the figures of the jaws and teeth in Pl. 1 of this interesting monograph, I am led to offer a different explanation of the phenomena. In the upper jaw of the incisive series the outermost only are in place, viz., $i\,3$—$i\,3$; these, with the alveoli of $i\,2$, $i\,1$, $i\,1$, $i\,2$, form, as in the horse, a convex curve at the anterior boundary of the upper jaw.

After a short interval or 'diastema' behind $i\,3$, there is either a single alveolus for the bifid base of a canine tooth, or two small confluent alveoli for two distinct small, simple-rooted teeth. Prof. Burmeister adopts the latter view, ascribes the anterior depression to a small single-rooted canine, and the posterior one to a similar premolar, which is accordingly the first of that series. Immediately behind the empty socket is the first of the premolars in place, with a crown equalling in antero-posterior extent the antecedent double-pitted alveolus. To judge from the socket of the mandibular tooth answering to the first maxillary premolar in place, and from the appearances in the side view of the same tooth, in pl. 1, fig. 3, I infer that the maxillary premolar, with the mandibular one, was implanted by a partially or wholly divided fang, in a two-holed socket; the same is more plainly the case in the second premolar in place; whilst the third, having acquired a greater transverse thickness of crown, may have also a third fang or rudiment of one, on the inner side of the two principal fangs. The fourth molar, in place, with a further increase of transverse diameter of crown, resembles the three succeeding true molars in the general pattern of the grinding surface, having an antero-posteriorly extended enamel-lined depression on the outer half of the crown, and two round enamel islands, one behind the other, on the inner half of the crown.

Now, my interpretation of the foregoing appearances is, that the upper canine was implanted by a compressed, antero-posteriorly extended fang, pinched in the middle so as to approach to a division of it into an anterior and posterior root, and with a correspondingly partially divided socket: it may be that the base of such fang of

the upper tusk or canine was actually divided, or bifid. The mammalia are not wanting in examples of canines so implanted. According to this view, the hinder division of the empty socket, behind the outermost incisor, did not contain a distinct tooth from the canine, but only the hinder division of the base is a canine. In this case the first premolar in place is *p* 1; the fourth, which has assumed the complex character, shape, and almost size of the true molars, is *p* 4. The number of true molars then enters into the rule, viz., three on each side, as in the lower jaw. I feel very confident that when the permanent upper canine of *Macrauchenia* be found, it will confirm the interpretation above given of the dental formula of the upper jaw. In the lower jaw of the *Macrauchenia* (pl. 1, figs. 3, 4, 5, 6), all the incisors are wanting, the fang of a simple-fanged small canine is near the outer incisor; a very short diastema divides the canine from the first two-rooted premolar, which, with the second, is wanting: *p* 3, *p* 4, and *m* 1, 2, and 3 are in place. The lower jaw differed from the upper jaw, in its dentition, not in the number of teeth, but by the smaller size and simpler implantation of the canine, as well as by the difference of size and modified character of the grinding surface of the molar teeth, exemplified in my 'Odontography,' and in Burmeister's edition of poor Bravard's excellent drawings of the skull of *Macrauchenia*.

Reasoning on the basis of the foregoing interpretation of the dental system, I conclude that *Macrauchenia* manifested the essential Perissodactyle position to which it was originally referred, by the extension of the character of the true molars into the premolar series; but, as in the Tapiroid genus, in which Cuvier first pointed out this deviation from the dental character of the type-Perissodactyles, 'the premolars offer some differences from the true molars.'*

In *Lophiodon*, however, as in *Pliolophus*, the last premolar *p* 4, differs from the first true molar *m* 1 in the reduction of the two inner lobes of the crown to one large conical lobe: the penultimate premolar *p* 3 resembles the foregoing, but is of smaller size; the antecedent premolar *p* 2 is suddenly reduced in size, and the inner lobe is almost obsolete. *Lophiodon* has no *p* 1. The three molar teeth of *Lophiodon Isselensis* (Cuv.) figured in tom. cit. pl. vi., fig. 2, are *m* 3 ('*n*'), *p* 4 ('*o*') and *p* 3 ('*p*'): they well exhibit that character. In like manner *Paloplotherium* differs from *Palæotherium*, in the almost suppression of the hinder of the inner pair of lobes in *p* 4. In *Macrauchenia* the difference between *m* 1 and *p* 4 is rather one of size than of structure, but the simplification of the crown is well marked in *p* 3, and is carried out in *p*. 2 and *p*. 1. *Palæotherium* resembles *Equus* and *Rhinoceros* in the conservation of the type of structure of the true molars in all the premolars save the first, which in *Equus* is represented only in the deciduous series;

* 'D'un genre d'animaux voisins des tapirs,—mais dont les molaires antérieures et postérieures effroient quelques differences: genre auquel je donne le nom de *Lophiodon*.' Op. Foss., 4to., 1822, tom. ii., p. 176.

but in *Palæotherium* there is a gradual diminution of size from *p* 4 to *p* 2, and a sudden one in *p* 1. In *Tapirus*, *p* 3, *p* 2, and *p* 1 of the upper jaw progressively depart from the true molar type, as well as diminish in size. RICHARD OWEN.

PERMIAN STRATA IN THE VALE OF CLWYD.

To the Editor of the GEOLOGICAL MAGAZINE.

DEAR SIR,—The letter from Mr. Davies in your last number compels me to again trespass on your space, with a little further explanation of the evidence upon which I premised the existence of Permian strata in the Vale of Clwyd, and the erosion of the Carboniferous rocks before their deposition.

I fully agree with most of the generalisations expressed in the early part of Mr. Davies's letters, and I can assure him that the points he mentions had not escaped me in weighing the evidence bearing on the age of the strata at Pentre Celyn.

When strata become either entirely 'thinned out,' or reduced in thickness by causes connected with their deposition, the reduction in their bulk rarely takes place abruptly, but generally by a somewhat regular rate of diminution. For instance, if a particular formation diminishes to half its thickness in a given distance, say 20 miles, it will only have lost one fourth of its thickness in half the distance.

The Lower Carboniferous rocks in North Wales and the west of England are remarkably consistent in this respect over a very large area; and there is perhaps no class of evidence which more conclusively proves that the various separate masses and outliers of Carboniferous Limestone and Millstone Grit once formed an unbroken and connected deposit, than the regularity with which their thickness diminishes both from the NW. and SW. towards the middle of England. In the north-west of Wales the Carboniferous Limestone attains a thickness of at least 800 feet. At Llanymynech, on the borders of Shropshire, its thickness is reduced to about half; and following the same rate of diminution in a south-easterly direction, the Limestone is only 30 or 40 feet thick round the flanks of the Wrekin, and becomes entirely lost under the Shropshire Coal-field.

The same regularity of diminution is observable from the SW., where by regular steps it becomes reduced in bulk from the great mass underlying the Bristol and South Wales Coal-fields, through Farlow in the SW. of Shropshire (where it is considerably diminished) until it thins out to nothing in Shropshire and Staffordshire.

The Mountain Limestone, overlain by a great mass of Millstone Grit, occurs but a few miles to the east of Pentre Celyn. Exposed as bold escarpments, and about two miles to the north, a small outlier of the Millstone Grit crops up in the vale.

At Pentre Celyn no Millstone Grit occurs, and the Limestone is unusually thin. Now, as the absence of the Millstone Grit at this point, on the theory of 'thinning out,' is entirely inconsistent with its general uniformity in North Wales, or any rate of diminution at