

canoes, and mode of navigation, by which they have frequently visited the Society Islands, a distance of 2,400 miles. They knew much of astronomy, and possessed an accurate calendar, dividing their year into twelve months of thirty days, with allowance for the bissextile. Their year begins at the time when the Pleiades rise at sunset. They count to millions, with names for all their numbers. The priests know every plant on the islands, and are especially familiar with their toxic properties. Interesting remarks were made on their language, their mythology, and their religion. Legends and royal pedigrees are handed down with great exactness by a special class who make this their only business. The language of their classic lore is archaic, and unintelligible to the common people. The genealogy of kings is traced back a hundred generations. Descent is here in the male line, but descent of property among the other classes is in the female line. This is rendered necessary from the fact, that with the exception of the queen, who is *tabu* and therefore chaste, chastity in women is regarded as a disgrace, in that it denotes a want of attractions. Monogamy prevails, but divorce is easy and sexual morality excessively lax. The dead are buried in caves in the mountains, in a sitting posture. Until recently human sacrifices were of frequent occurrence. Criminals are executed secretly with a club. Walled enclosures constituted their "cities of refuge." Their temples in the form of parallelograms were also described.

Captain Dutton closed his remarks by rapidly glancing at the influence of the missionaries, and the modern innovations and modifications in Hawaiian society.

#### VARIATIONS IN THE VERTICAL DUE TO ELASTICITY OF THE EARTH'S SURFACE.

In the Philosophical magazine for December, 1882, Mr. G. H. Darwin discusses this subject. He considers first the disturbance due to variations of barometric pressure; second, those due to the rise and fall of the tides. Mr. Darwin has previously investigated "the state of stress produced in the earth by the weight of a series of parallel mountains" of such shape that the equation to the outline of the section made by a plane traversing all the mountains and valleys perpendicularly is  $x = -h \cos \frac{z}{b}$ ; the axis of  $x$  being supposed vertical, and that of  $z$  horizontal and perpendicular to the mountain chains.

Taking the origin in "the mean horizontal surface, which equally divides the mountains and valleys," and midway one of the mountains, and letting " $a, \gamma$ , be the displacements at the point  $x, z$ , vertically downwards and horizontally," he finds, when  $x = 0$ ,

$$a = \frac{gwh}{2v} b \cos \frac{z}{b}, \quad \gamma = 0, \quad \frac{da}{dz} = -\frac{gwh}{2v} \sin \frac{z}{b}.$$

In these equations,  $w$  is "the density of the rocks of which the mountains are composed;  $g$ , gravity;  $v$ , modulus of rigidity."

If we suppose the region to have been originally a plane, such as would be formed by toppling over the upper half of each mountain into the neighboring valley, the quantity  $\frac{da}{dz}$  above is the present real inclination of what was originally the horizontal surface stratum.

The apparent inclination, however, as measured by means of the plumb-line, is something different from the above, owing to the change in the direction of the latter due to the changed distribution of the attracting

masses about it. One of the most interesting portions of Mr. Darwin's present paper is the proof of a very simple ratio, for any such case as that now under consideration, between the deflection of the plumb-line and the slope  $\frac{da}{dz}$  of the stratum  $x = 0$ .

This relation, which was pointed out to Mr. Darwin by Sir William Thomson, though the proof here given is due to the former alone, is as follows:—

If  $\delta$  be the earth's mean density,  $r$  the earth's radius, and  $v, g$ , as above, the deflection bears to slope the same ratio as  $\frac{v}{g}$  to  $\frac{1}{3} r \delta$ . "This ratio is independent of the wave-length  $2\pi b$  of the undulating surface, of the position of the origin, and of the azimuth in the plane of the line normal to the ridges and valleys. Therefore the proposition is true of any combination whatever of harmonic undulations; and as any inequality may be built up of harmonic undulations, it is generally true of inequalities of any shape whatever." With rigidity as great as that of steel, the slope is  $1\frac{1}{2}$  times as great as the deflection.

"In the problem of the mountains,  $w h$  is the mass of a column of rock of one square centimetre in section, and of length equal to the height of the crests of the mountains above the mean horizontal plane. In the barometric problem,  $w h$  must be taken as the mass of a column of mercury, of a square centimetre in section, and equal in height to a half of the maximum range of the barometer."

This maximum range is assumed to be 5 centimetres. The rigidity of the earth is supposed to be  $3 \times 10^8$  million grammes per square centimetre, — greater than that of the most rigid glass. The distance from the region of high to that of low barometer is taken as 1,500 miles.

With these data, it is found "that the ground is 9 centimetres higher under the barometric depression than under the elevation."

The maximum slope of the surface, which is found midway between the regions of high and low barometer, is  $0''.0117$ ; and for the maximum apparent deflection of the plumb-line, "this is augmented to  $0''.0146$  when we include the true deflection due to the attraction of the air."<sup>1</sup>

In the problem of the tides, Mr. Darwin imagines, as before, "an infinite horizontal plane which bounds, in one direction, an infinite, incompressible, elastic solid." Upon this he lays off straight strips of equal and uniform width, representing alternately areas of land and of water. At full tide, the surface will be such that for it  $x$  will be a discontinuous periodic function of  $z$ . This function having been developed according to Fourier's theorem, the results of the previous investigations become applicable.

It is thus found that "midway in the ocean and on the land there are nodal lines, which always remain in the undisturbed surface," whether the tide be high or low on either coast; "that the land-regions remain very nearly flat, rotating about the nodal line, but with slight curvature near the coasts."

<sup>1</sup> Mr. Darwin remarks that this last result is independent of the wave-length of the barometric inequality, and so it appears from the formula. It would seem, however, that the above correction for the attraction of the air is only applicable when the wave-length is very considerable compared with the height of the effective atmosphere.

This apparent deflection is so great, that, with the deflections caused by the tides, Mr. Darwin concludes it will probably forever mask the lunar disturbance of the plumb-line, the amplitude of this latter disturbance being by calculation only  $0''.0216$ . This conclusion will probably put an end to the laborious and refined experiments which he and his brother have been conducting for two or three years in order to detect and measure the lunar action.

Assuming the width of the seas and continents to be 3,900 miles, the rigidity of the earth to be  $3 \times 10^8$ , as above, and the range of the tides to be 80 centimetres, Mr. Darwin computes and gives tables of the slopes, real and apparent, of the land at various distances from the coast. Such deflections, he thinks, might actually be observed at points near the coast, and the measurements thus obtained might possibly serve as a basis for computing a more trustworthy value of the earth's rigidity than we now possess.

Under the conditions above assumed, the amplitude of vertical displacement between high and low tide is 11.37 centimetres on the land at the coast.

"As long as  $h \neq 1$ " — i.e., the semi-range of the tide multiplied by the width of a sea or continent — "remains constant, this vertical displacement remains the same; hence the high tides of ten or fifteen feet which are actually observed on the coasts of narrow seas must probably produce vertical oscillations of quite the same order as that computed." E. H. HALL.

### LETTERS TO THE EDITOR.

[Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.]

#### Age of the rocks on the northern shore of Lake Superior.

PERMIT me, through the medium of your journal, to correct a mistake which Prof. N. H. Winchell has made (*Tenth ann. rep. surv. Minn.*, p. 125) in stating that I regard the trap and sandstone of Lake Superior as Huronian.

Up to the present time I was not in a position, never having examined them, to express any opinion about the Lake Superior formations referred to.

During the past summer I have somewhat closely examined these around the whole of the Canadian shores, from Prince Arthur's Landing to Sault St. Mary, including the shores of Thunder Bay, Black Bay, and Nipigon Bay and Straits. I spent two months in this examination, travelling from point to point in a small boat.

My opinion now, respecting the character and age, — within certain limits — of these rocks is very decided, and is as follows: —

They occupy the geological interval elsewhere filled by those divisions of the great lower paleozoic system which underlie the Trenton group. Various considerations point to the Potsdam and Primordial Silurian (Lower Cambrian) as their nearest equivalents. They are entirely unconformable to, and physically distinct from, the Huronian. They are divisible on the Canadian shores into two, perhaps three, groups, between which there may be slight unconformities. These, however, are quite likely only such as might result from the intermingling of ordinary sedimentary strata with irregular layers of erupted volcanic material, molten, muddy, and fragmentary; the whole being subsequently, and even during their accumulation, further disturbed by faulting, and the irruption of igneous dykes and masses.

To my mind, there can be no doubt as to the nature of the causes which have built up the vast masses of strata, which now, together with ordinary sedimentary layers, form the so-called upper copper-bearing rocks of Lake Superior. They are essentially volcanic, subaërial, and subaqueous formations, and in every sense analogous to the wide-spread tertiary volcanic rocks of Australia and other regions. The only differences are their greater antiquity, and the consequent greater changes and modifications they have undergone through the operation of long-con-

tinued metamorphic agencies, disturbance, and denudation; though these changes are far less than those which the rocks of the same age, and to some extent similar origin, have undergone in eastern America and in Britain; and in this they correspond with the higher fossiliferous groups in the respective regions.

The groups in ascending order are, —

1. Black shales, flinty and argillaceous, banded chert, with black dolomites and beds of fine-grained dark-gray sandstone with mica in the bedding planes; the whole interbedded with massive diabase or dolerite, often columnar, the columns vertical. — Pie Island, McKay's Mountain, Thunder Cape, etc.

2. Red conglomerates, red and white and green mottled shales, red and white sandstones and dolomites; no gray or black beds. At perhaps a hundred and fifty or two hundred feet from the base, these become interstratified with massive beds of volcanic material, amygdaloids, melaphyres, tuffs, etc., making many thousand feet of strata. — East shores of Black Bay, Nipigon Strait, St. Ignace and other islands, Michipicoton Island, Gargantua, Mamainse, etc.

3. The Sault St. Mary sandstones. These may be only the upper part of 2, without any intermingling of volcanic material. The exposures on the Canadian side are too fragmentary and isolated to decide this. In any case the St. Mary sandstones are not younger than Chazy (Cambro Silurian), but in the absence of fossils it is impossible to correlate the Lake Superior groups exactly with any one of the subdivisions of the New York or the Atlantic coast series. This, however, is no sufficient reason for inventing and adopting new and unknown names for them; and I prefer to call them all Lower Cambrian, which includes Potsdam and Primordial Silurian. There is, at present, no evidence whatever of their holding any other place in the geological series. Through overlapping and faulting, all three divisions are found locally in contact, both with Huronian and with Laurentian rocks. The dips are generally south-eastward, but vary greatly in amount, those of division 2 being often locally much higher than any observed either in divisions 1 or 3. A. R. C. SELWYN.

Geol. and nat.-hist. survey of Canada.  
Ottawa, December, 1882.

#### Movement of the arms in walking.

Every man has observed that the tendency to swing the arms while walking is a most natural one. The action is rhythmical, the anterior and posterior extremities of opposite sides of the body moving in unison. It is also involuntary, being performed most readily when thought is not bestowed upon it. When voluntarily suspended, as in the American army, it gives an air of 'stiffness.'

In view of these facts, does it not seem that the statement of Prof. J. D. Dana (Cephalization; *Amer. Journ. sc.*, xli, 1866, p. 167), sanctioned by Dr. T. Gill (Classif. families of mammals, 1872, p. 50), — namely, that "Man stands alone among mammals in having the fore-limbs not only prehensile, but out of the inferior series, the posterior pair being the sole locomotive organs," — must be somewhat modified? Have we not at least a ghost of a pre-existing function? Does man walk by means of his feet and legs alone? FREDERICK W. TRUE.

U. S. national museum, Washington, D.C.,  
Nov. 18, 1882.

#### Cleaning birds.

When obliged to wash birds, collectors will find it an advantage to use salt and water instead of plain