that require the explanation of such a subsequent disturbance to reconcile them.

Section 10, drawn across the rectilinear lower valley of the Crouch, shows the East Essex gravel cut through by this rectilinear valley; while Section 11 is drawn across the same valley a little higher up, where it has cut through the London-clay side of the more ancient valley which contained the East Essex gravel. The low level occupied by that gravel in Section 10 should be contrasted with the far higher ground of London clay, through which the Crouch cuts in Section 11, in order that it may be realized that the East Essex gravel, although it is thus cut through by the altogether independent and much newer valley of the Crouch, is as truly the deposit of a valley hereabout (save that the eastern slope of it has now disappeared into the North Sea) as it is more to the south, where it occupies the lower valley of the Medway. Section 13 has been added to show the structure of the upper valley of the Crouch, which, it will be remembered, is part of the one original great trough that was afterwards re-excavated in part by the Crouch in its estuarine condition, and in the rest by the more-extended estuary of the Blackwater, and divided between them. From the section it will be seen that this original trough is cut down from the Boulder-clay on the western side, but that on the other the Bagshot sand and London clay, only, form the valley side. This is due to the peculiar structure of the Upper Drift over the south of Essex, that formation having, at its commencement, eroded the Bagshot sand and taken its place, but afterwards, by submergence of the land, overspread it; so as in one place to lie under a brow of Bagshot sand, and in another to rest upon it, in that case occupying a much higher level than in the other place. The post-glacial denudation which gave rise to the valley, has, on the east of the section, removed the Boulder-clay and left the Bagshot sand; while on the west of the section, it has partially spared the Boulder-clay, the sea of which had long anterior to this removed the Bagshot in that part. It is to this structure that the Boulder-clay does not remain on the summit of the eminences crowned by Bagshot sand, which form Langdon, Thundersley, and Hockley Hills, the Isle of Sheppey, and Hampstead and Highgate Hills, while traces do remain on the similar eminences forming the Brentwood plateau, and the Havering and Epping Hills.

In the next number of the Magazine, I propose to consider the relation which the East Essex Gravel bears to the Structure of the Weald Valley.

IV.—On the Disintegration of a Chalk Cliff.

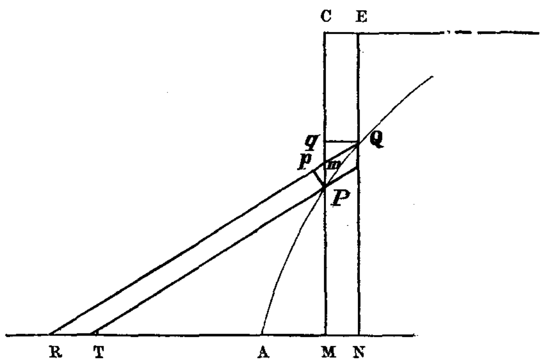
By the Rev. Osmond Fisher, M.A., F.G.S.

As a slight contribution to the elucidation of questions of denudation, and at the same time an exemplification of the application of mathematics to a geological problem, I send the following:

Noticing a lofty chalk cliff, forming the face of an old quarry in the neighbourhood of Lewes, I remarked that the action of the weather upon the surface was to disintegrate it equally all over, so that the face of the quarry remained vertical, while the stuff that fell down formed a talus, whose surface was approximately a plane, inclined to the horizon at that particular angle at which such materials will stand. The question then occurred to my mind—*What will be the profile of the solid chalk behind the talus?*

The solution of this question is given in the note. The form of the solid surface is there shown to be a semi-parabola, whose vertex is at the base of the original cliff.

It is evident that an old sea cliff deserted by the sea, or a river cliff from which the stream had receded, would disintegrate after the same law. If any subsequent circumstance, such as the return of the sea or river, should remove the talus (and it may be observed that the corollary proves that an undermining action would do so completely) we should have the parabolic form disclosed. This is the shape observed in that form of cliff known as a "Nose." The undermining action of the sea upon a chalk cliff would of itself produce a vertical wall. When, therefore, we see a cliff of a parabolic form, or vertical below, and parabolic in the upper part, it seems to me that we may expect to find that we have an ancient cliff, once deserted by the waves, now attacked again, and the peculiar form due to disintegration exposed by the removal of the talus.



NOTE.

Suppose C P to be the face of the cliff: A the bottom of the quarry: T P the surface of the talus: and let the disintegration of the face to Q E raise the talus to R Q. Then P Q will be a portion of the curve whose form we are seeking.

P p is perpendicular to R Q, Q q to C M, and R Q meets C M in m. C M = a, and the angle P T M = α. Then, because the material disintegrated from P C has raised the talus to R Q, we shall have in the limit—

$$C P \times Q q = T P \times P p.$$

or, if $A M = x$, $M P = y$

$$(a - y) d x = \frac{y}{\sin a} \times P m \cos a$$

$$= \frac{y}{\sin a} (d y - d x \tan a) \cos a$$

$$= y \, dy \cot a - y \, d x$$

$$\text{or } a \, d x = y \, dy \cot a$$

Integrating. and observing that x and y begin together—

$$a x = y \frac{y^2}{2} \cot a$$

$$\text{or } y^2 = 2 a \tan a \, x$$

which is the equation to a parabola, of which the vertex is A, and the *latus rectum* is 2 a tan *a*. The proportions of the curve will therefore be increased by an increase in the height of the cliff, or by an increased capacity in the talus to stand at a high angle.

We have $\frac{d y}{d x} = \frac{a}{y} \tan a$

$$= \tan a \text{ when } y = a$$

Hence we have the very elegant result that the curve will be continued unbroken to the very top of the cliff, at which point its inclination to the horizon will be identical with that of the talus.

V.—Some Observations on the *Zoantharia Rugosa*.[1]

By Gustave Lindström, Ph.M.

[PLATE XIV.]

Professor Steenstrup,[2] some years ago, questioned the fact as to whether the *Zoantharia tabulata* and *rugosa*, included by him under the common name of "*Cyathophylla*," might be considered as true polyps. MM. Edwards and Haime in framing those great subdivisions of their "*Coralliaria*," remarked their striking dissimilarity from the other *Actinozoa*. Professor Agassiz, in his grand monograph on the *Acalephæ* of North America,[3] considers these differences so important that henceforth all connection between the above-named groups and the *Zoantharia aporosa* and *perforata* will be impossible. But besides these peculiar characteristics of the *Rugosa*, such, for instance, as the compact imperforate structure of the calyx and septa (the septa originating from four primary ones), the absence of costæ, the strange septal fossæ in the bottom of the calyx, the processes resembling rootlets, the transverse floors or tabulæ in the interior, which often have a

[1] Translated by the Author, from the original Swedish—"Ofversigt af Vetenskaps Academiens Forhandlingar."

[2] On the Systematic Place of the *Brachiopoda* and the *Cyathophylla* (in Danish), p. 20, 1843.

[3] Contrib. to the Nat. Hist. of the United States. Vol. iii. p. 121.