XIV. *A Letter on the Alterations that have taken place in the Structure of Rocks, on the Surface of the basaltic Country in the Counties of* Derry *and* Antrim. *Addressed to* Humphry Davy, *Esq. Sec. R. S. By* William Richardson, *D. D.*

Read March 17, 1808.

SIR,

I REQUEST you will be so good as to lay before the Royal Society, the following Observations on the Natural History of that part of Antrim, (contiguous to the Giant's Causeway,) which you and I examined so carefully together. I know not any country that deserves so well to have its facts faithfully recorded; from the important conclusions to which they lead.

The basaltic area (taken in its whole extent) comprehends the greater part of Antrim, and the east side of Derry to a considerable depth.

In a geological point of view, nature * has been very kind to this district, for not content with assembling together in a small space so many of her curious productions, and arranging them with more regularity and steadiness than in any other country described, she has condescended occasionally to withdraw the veil, and lay herself open to view, often exhibiting

* By the word nature, which frequently occurs in the course of this Memoir, I always mean, according to RAY's definition, the wisdom of God in the creation of the world.

a spectacle equally gratifying to the admirer of magnificence, and to the curious naturalist, who can here, by simple inspection, trace the arrangements which are to be discovered elsewhere, only by penetrating beneath the surface of the earth.

As soon as we enter the basaltic area, we begin to perceive traces of these arrangements; as we advance farther north, they increase; and in the tract near the shore, and especially at the island of *Rathlin*, which seems to have come fresher from the hand of nature than the rest of our area; the stratification of the whole is perfectly visible, and the nature of the several strata laid open to us at their abrupt and precipitous terminations.

To the southward we perceive the distinctive features abate, and wear away; the basaltic stratification indeed remains, but is no longer displayed to us in the same manner; the neat, prismatic, internal construction, of the strata, which occurs so frequently on, and near, the coast, is scarcely to be met with at a distance from it; a rude columnar appearance is all we find, and that but rarely.

It is at the periphery of our area, and especially at its northern side, that every thing is displayed to the greatest advantage; here we have perpendicular façades often continuous for miles, and every separate stratum completely open to examination.

Of these façades, four are more distinguished by their grandeur and beauty than the rest, *Magilligan Rock*, *Cave Hill*, *Bengore*, and *Fairhead*.

The two former are at the extreme points of the north-west diagonal of our area, and nearly forty miles asunder; they are at the summits of mountains, and accessible by land.

The precipitous faces of *Fairhead* and *Bengore*, to which had the pleasure of attending you, and which are visible only from the sea, are the most beautiful, and the most curious; for the strata, which at *Magilligan* and *Cave Hill*, are all nearly similar, at *Fairhead* and *Bengore* are much diversified. Of *Fairhead* I have already published an account in NICHOLSON'S JOURNAL, for December, 1801, and I now propose to execute an intention which I have had for some years of giving a minute account of *Bengore*.

I am aware that it will be extremely difficult to convey a clear and adequate idea of an assemblage of 16 strata, (for such is the number of which our promontory is composed), appearing and disappearing at various altitudes, yet retaining each its own proper place, and forming together a most beautiful and regular whole, though never considered as such before.

But as I have the aid of very correct views of the most important parts of the façade, to the accuracy and fidelity of which I have already obtained your testimony—I shall venture to proceed, for I am anxious to bring into notice the most complete exposure of the internal structure of a district, that I have seen or read of; as there is little likelihood that any other person will enjoy the opportunities which I have had for so many years, of exploring this interesting part of our coast, through a turbulent sea, and rapid tides.

Description of the Promontory of Bengore, and its Stratification.

THIS promontory commences at the termination of *Bushfoot Strand*, where the coast, the general direction of which for several miles had been due east and west, turns to the north-east, and after being cut into several semi-circular bays,

deflects to the S. S. E. and near the old castle of *Dunseverick*, resumes its former rectilineal and nearly eastern direction.

The promontory occupies the interval between *Dunseverick*, and the *Black Rock*, at the end of *Bushfoot Strand*, about four English miles; the façades commence at *Black Rock*, and increase in height until we reach *Pleskin*, where the perpendicular part at the summit is 170 feet, and the precipitous part from the bottom of the pillars to the sea 200. As we proceed on from *Pleskin* to *Dunseverick*, the height gradually abates, and is finally reduced to about 100 feet.

In this whole space, wherever the precipice is accurately perpendicular, the several strata are easily distinguished from each other, but where the slightest obliquity prevails, a grassy covering is formed that effectually conceals all beneath it; hence the face of the precipice seems much diversified; the columnar strata in some places only exhibiting detached groups of pillars, while in others they form extensive colonnades.

I shall now state the appearances as we approach, and coast the promontory from the westward, noticing in this first view of the precipice, every thing that may be considered as general, and reserving (as I did with you) for my return in the contrary direction, a detailed account of the strata taken separately.

The first circumstance, that occurs to the attentive observer on his approach, is, that although both the promontory itself, and the strata composing it, ascend to the northward, yet it is not in the same angle, the strata being more inclined to the horizon than the line tracing the surface of the promontory, a fact which I shall account for afterwards.

From the *Black Rock* to the *Giant's Causeway* (about a mile) the materials, and their arrangement, are similar to those of the coast to the westward, viz. strata of table basalt, generally separated by thinner strata of a reddish substance.

At the *Giant's Causeway* a new arrangement commences, one of the little systems I have mentioned in other memoirs, by the aggregate of which our coast is formed; nature having changed her materials, or their disposition, or both, every two or three miles. To the system of strata comprehended between the *Giant's Causeway* and *Dunseverick* I now limit myself, as all the strata composing it emerge between these two points.

As we proceed along the coast from the *Giant's Causeway* eastward, we perceive the whole mass of strata ascend gradually, culminate at the northern point of the promontory, and then descend more rapidly, as the land falls away to the south-east, until having traced them across the face of the precipice we see them immerge separately at and beyond *Portmoon Whyn Dykes.*

The western side of the promontory is cut down perpendicularly, by eleven *Whyn Dykes;* the intervals between them are unequal, but they all reach from the top of the precipice to the water, out of which some of them again emerge in considerable fragments; they are all constructed of horizontal prisms, which are strongly contrasted with the vertical pillars of the strata through which they pass.

One of the dykes at *Port Cooan,* on *Bengore,* half a mile from the *Giant's Causeway,* is very beautiful; an insulated rock about 160 feet high, and 20 in diameter, stands perpendicular in the middle of a small bay; the main body of the

rock is similar to the contiguous consolidated masses; but on the east side a singular whyn dyke is joined to it, composed, (as they often are,) of several walls agglutinated together, with wall-like fragments of other parts of the dyke emerging at their base; the solid mass of dyke is seen cutting down the precipice to the southward at 150 yards distance.

Depressions of the Strata.

Soon after we have passed the last of our whyn dykes at *Port Spagna*, (a name derived from a vessel belonging to the Spanish Armada having been driven ashore in that Creek), we discover a new and curious circumstance, viz. that the western half of the promontory has sunk or subsided between thirty and forty feet, without the slightest concussion or derangement of the parallelism of the strata.

Two other depressions appear as we proceed onwards, one at *Portmoon*, and the other at the angle where the promontory begins to project from the rectilineal coast; these however are far less considerable in thickness than the preceding, neither of them exceeding five feet.

Such depressions occur at the collieries near *Ballycastle*, and generally on one side of a whyn dyke. We have also at *Seaport*, two miles west from the *Giant's Causeway*, a dyke, oblique and undulating, with a depression of the strata of about four feet on one side; but on *Bengore* promontory our dykes are unaccompanied by depressions of the strata, and where we have depressions, we do not find a trace of a dyke.

The portions of this extensive façade, which I have selected for explanatory views, are *Portmoon*, in or near which most of the strata emerge, and *Pleskin*, where the strata culminate,

each of these views too, exhibits one of our depressions, but in that of *Pleskin*, the first apparent depression is purely an optical effect arising from the position of my friend MAJOR O'NEAL, of the 56th, who took his view from the water.

Enumeration of the sixteen Strata that compose the Promontory of Bengore, *taken in their regular Order, and counting from above.*

The country immediately to the southward of *Bengore* is like the Promontory itself, a stratified mass, accumulated to the summits of *Craig Park* and *Croaghmore*, the first five hundred and the second seven hundred feet high; but with these strata I have nothing to do, limiting myself to those alone of which the promontory is formed, and which are exhibited in its façades.

The uppermost of these commences near half a mile to the eastward of the angle, where the coast deflecting from its due east and west course, turns to the north-west, and begins to form the promontory.

So far the course of this stratum is to appearance perfectly horizontal, for the strata all ascending to the north, the intersection of their planes with the plane of the sea, must run east and west, that is, in the present case it coincides with the direction of the coast.

But when the coast changes its direction, this coincidence ceases, and the façade (that is the vertical section of the coast) losing its east and west course, its strata must appear to ascend towards the point it turns to, therefore the strata at *Portmoon*, and along the north-east side of the promontory, should ascend obliquely along the façades, as they actually do.

First Stratum, (*m*).

The stratum I commence with forms the whole façade, from its first appearance until it reaches the promontory; it consists of massive pillars rather rude, and about sixty feet long, its course for half a mile (as I have stated) seems horizontal, but on the face of the promontory it ascends, and continues to rise uniformly until it reaches the summit, which it lines as far as *Portmoon*, on the south side of which it loses some of its thickness, then suddenly disappears and vanishes from that façade, receding westward in the form of a stony ridge, and is seen no more.

Second Stratum (*k*).

The stratum upon which the preceding rests, is red as brick, and about nine feet thick; it appears in spots, and patches just above high water mark, so long as the incumbent stratum continues horizontal, but when that rises obliquely, the second ascends with it; it is now completely displayed, and having supported the preceding in its course to the summit, vanishes with it (at *x* in the view of *Portmoon*,) and is seen no more.

These ochreous matters, so common in all basaltic countries, according to Mr. F. ST. FOND'S opinion, were once pure basalt, but have undergone some chemical process of nature we are unacquainted with, by which their colour has been changed.

Third Stratum, (*i*)

The next stratum is the last of those composing the promontory which appears beyond it; for so long as the first and second continue their horizontal course towards *Bengore*, this third accompanies them, shewing its upper surface be-

tween high and low water mark, but when it ascends along with the others across the façades, it displays its whole thickness, above fifty feet.

This stratum is of that variety of basalt, I have on different occasions distinguished by the name irregular prismatic; it resembles the columnar basalt in grain, but differs from it totally in principle of internal construction, for its prisms are small, not articulated, and indifferent as to the position of their axes, which is perpetually changing.

The irregular prismatic basalt accompanies the columnar in most countries, as at *Pont du Baume*, at *Trezza*, at *Bolsena* in the *Sound of Mull*, and at *Staffa*. In *Antrim*, it is very common; and here is a striking resemblance between the rock crowning the celebrated columns at *Staffa*, and a stratum covering a very neat colonnade at *Craigahullur*, near *Portrush*.

This stratum (as is well exhibited in the view of *Portmoon*) is scolloped off irregularly from the point where it becomes superficial (x), until it completely disappears at (z); a thin stripe of its lower edge alone is ever resumed again.

Fourth Stratum, (h).

The next three strata will require only very short descriptions; the fourth is about seven feet thick, entirely columnar, the pillars small, but not neat; they appear very white from a thick covering of *Byssus saxatilis*, which shews a great predilection for this stratum.

Fifth Stratum, (g).

This stratum is ochreous, and more of a slate colour than any of the other red strata; as it is friable, it soon acquires a

grassy coat, through which it is only in spots that it shews its proper colour; it is about eight feet thick.

Sixth Stratum, (*f*).

This stratum is composed of rude massive pillars so coarsely formed, that on the least abatement of perpendicularity the columnar form can scarcely be traced. This stratum is about ten feet thick, it forms the vertex of the beautiful conical island *Beanyn Daana*, and is marked in the views (*f*).

These last strata, though they have nothing very remarkable in themselves, nor contribute much to the beauty of the façade; yet they exhibit one of the most important facts I am acquainted with in natural history, and which, when attentively considered, throws much light on the nature of the operations performed upon our globe since its consolidation, and leads us irresistibly to conclusions extraordinary and unexpected.

The fourth, fifth, and sixth strata reach the top of the precipice, and vanish together at the waterfall in the north-west corner of *Portmoon*. When they come to the surface, they turn inland to the westward in long stony ridges; these obstruct the course of the waters in their descent along the inclined plane, formed by the surface of the promontory, and throw them over the precipice, in a cascade highly beautiful after rain.

On the façades to the north-west not a trace of them appears, these being entirely formed by the lower strata, which I have not yet noticed; but at the distance of a mile, at the great depression (already mentioned), the fourth, fifth, and sixth strata, with a narrow stripe of the third, suddenly ap-

pear, in their regular posts, their proper order, and with all the characteristic marks peculiar to each separate stratum.

In the interval between the depression at *Pleskin*, and the *Giant's Causeway* (about a mile), these three strata often appear in a desultory way on the summit of the precipice, wherever it is of sufficient height to receive them, always preserving their usual thickness, their characters, and their order; so that a person master of the order I am detailing, as he approaches a rising point of the precipice, can tell its strata, and their order, before he is near enough to distinguish them.

Seventh Stratum, (d).

The rude and massive pillars of the sixth stratum pass into the neater, and much longer columns of the seventh, without interrupting the solidity or continuity of the material; exactly as a down held hand appears to separate into fingers. The thickness of this stratum, that is the length of the pillars of which it is formed, is fifty-four feet; it is marked (*d*) in the two views, and in its passage across the face of the precipice, displays more beautiful colonnades than any of the others.

This seventh stratum emerges from the beach immediately behind the south-east point of *Portmoon*, and where it first shews itself in that bay, has its lower edge raised only a few feet above the water; it forms the upper frustum of the larger of the two conical islands, ascends obliquely along the face of *Portmoon*, and continues to rise until it composes the upper range in the beautiful façade, properly called *Bengore Head*. This is probably the most magnificent of all, its convexity towards the sea producing a fine effect. The lower edge of this stratum, that is the line forming the base of its pillars,

has here, as at *Pleskin*, attained the height of three hundred feet above the water.

This seventh stratum, like those above it, also suffers an interruption; for after having exhibited itself to such great advantage at *Bengore*, the extreme northern point of the promontory lowers, and this stratum disappears for about one-third of a mile; as the promontory rises, it is resumed again in great beauty at *Pleskin*, and is interrupted no more; we scarcely ever lose sight of it until we reach *Port Noffer* (the next bay to the Causeway); here, for want of perpendicularity it is little seen, and is finally lost over the causeway, we know not well how.

Eighth Stratum, (*c*).

The next stratum is of the same variety of basalt with the third, that is, irregular prismatic; it is fifty-four feet thick, and in the views distinguished by the letter (*c*): where it emerges at the south east corner of *Portmoon*, it is quite accessible by land, and affords the best opportunity I know for examining this species of basalt, as it is there very neat.

There is little more of this stratum seen in the façade of *Portmoon* for want of perpendicularity, but it forms the lower frustum of the great conical island *Beanyn Daana*, and the whole of the smaller, except the base; it is well displayed over the remainder of the precipice, it forms the intermediate stratum between the magnificent colonnades at both *Bengore* and *Pleskin*, and finally is lost just over the *Giant's Causeway*. Large globular fragments have fallen from it, and are scattered about the causeway.

Ninth Stratum, (b).

This stratum is forty-four feet thick, that being the exact length of the neat pillars composing it; at its emersion it forms the bases of the two conical islands in *Portmoon*, and is no more seen in that bay, but immediately to the northward it begins to shew itself in colonnades and groups, some of them resembling castles and towers.

It ascends along the precipice obliquely, like those above it, forms the lower range at *Bengore* and *Pleskin*, from which last it dips to the westward regularly, composes the group at *Port Noffer*, called the *Organs*, seen from the causeway, and finally at its immersion, or intersection with the plane of the sea, it forms the beautiful assemblage of neat pillars, so long distinguished by the name of the *Giant's Causeway*.

At these two intersections, each of them accessible by land and water, the prisms exactly resemble each other in grain, size, and neatness; the interval between them is full two miles, through great part of which this stratum is displayed at different heights; it culminates between *Pleskin* and *Bengore*, with its lower edge more than two hundred feet above the water.

We see now what a diminutive portion of our vast basaltic mass has, until lately, monopolized the attention of the curious; and even after it was discovered that we had many other, and much finer collections of pillars on the same promontory, it never occurred, to those who were preparing to give accounts of them to the public, to examine whether these were mere desultory groups, or detached parts of a grand and regular whole, which a more comprehensive view of the subject would soon have laid open to them,

Tenth Stratum. (*a*)

The stratum upon which the pillars of the preceding rest, is ochreous, red as minium, and about twenty feet thick; it is scarcely seen at *Portmoon*, a patch alone of its surface being distinguishable under water at low tide; but immediately to the northward it shews itself, and from its bright colour makes a conspicuous figure across the face of the precipice in a course of more than a mile and half; its last appearance to the westward is at *Rovinvalley*, the opposite point of the bay from the *Giant's Causeway*, from which we have a good view of it. The final dip and immersion of this tenth stratum, as well as its emersion, are lost for want of perpendicularity.

The six remaining strata are all similar in material, but differing much from each other in thickness; they are all of that description called tabular basalt, sometimes shewing a faint disposition to assume a columnar form at their edges, and always separated from each other by ochreous layers.

These six strata are not so perfectly distinct as those above them, for sometimes we think we can count seven, and again not more than five; nor does each of these preserve the same thickness through their whole extent, for they are deeper towards the northern point, where they culminate, forming by themselves a perpendicular façade near two hundred feet high, but they grow thinner as they recede from this centre.

The jets of black rock in the view of *Portmoon*, are the emersions of these strata; their last appearance on the west side is at *Rovinvalley*, where they strongly display the inclination of their strata, (the same with all the rest) to those approaching from the westward; their final immersion is lost for want of perpendicularity.

I shall now proceed to select from the great mass of facts that are exhibited on the face of *Bengore* promontory, and occur in the contiguous basaltic country, such as seem applicable to geological questions, and likely to throw light on such subjects.

Facts applicable to geological Questions.

1. Every stratum preserves accurately, or very nearly, the same thickness through its whole extent, with very few exceptions.

2. The upper and lower surface of each stratum preserve an exact parallelism, so long as they are covered by another stratum; but when any stratum becomes the superficial one, its upper surface is scolloped, or sloped away irregularly, while the plane forming its base continues steady, and rectilineal; but the parallelism of its planes is resumed as soon as another stratum is placed over it.

3. The superficial lines bounding the summit of our façades, and our surface itself, are unconnected with, and unaffected by, the arrangement of the strata below them.

4. Nature, in the formation of her arrangements, has never acted upon an extensive scale in our basaltic area, (at least on its northern side, where our continuous precipices enable us to determine the point with precision,) but changes her materials, or her arrangement, or both, every two or three miles, and often at much smaller intervals.

5. Wherever there is a change of material, as from one stratum to another in a vertical line; or where the change is in a horizontal direction by the introduction of a new system; or where a whyn dyke cuts through an accumulation of

strata; in all these cases the change is always *per saltum* and never *per gradus*, the lines of demarcation always distinct, and well defined; yet the different materials pass into each other without interrupting the solidity and continuity of the whole mass.

6. The façades on our coast are formed as it were by vertical planes, cutting down, occasionally, the accumulations of our strata; the upper part of these façades is generally perpendicular, the lower steep and precipitous.

7. The bases of our precipices commonly extend a considerable way into the sea; between the water and the foot of the precipice, (and especially near the latter) there is frequently exhibited the wildest and most irregular scene of confusion, by careless observers supposed to be formed by the ruins of the precipice above, which have fallen down; such, no doubt, was Mr. WHITEHURST's idea, when he describes one of these scenes as "an awful wreck of the terraqueous globe."

But a more attentive observer will soon discover that these capricious irregularities, whether in the form of rude cones, as at *Beanyn Daana*, and the west side of *Pleskin*; or towers, as at the dyke of *Port Cooan* and *Castro Levit*, at the foot of *Magilligan* façade, even spires and obelisks, as to the westward of *Kenbaan*, and at the *Bull of Rathlin*; yet all of these once formed part of the original mass of coast, stratified like it, and their strata still correspond in material and inclination with those in the contiguous precipice.

8. These vertical sections or abruptions of our strata are by no means confined to the steeps that line our coast; the remaining boundary of our basaltic area has several of them

equally grand; and similar abruptions, or sections (though not so deep) are scattered over a great part of our area, and especially on the ridges of our hills and mountains which are cut down in many places like a stair, by the sudden abruption of the basaltic stratum.

9. Wherever the strata are thus suddenly cut off, whether it be a mass of accumulated strata as in the façades on our coast, or solitary strata in the interior; the materials on one side of the abruption are completely carried away, without a fragment being left behind, while on its other side the untouched stratum remains intire and undisturbed.

I shall not proceed to apply these facts to support, or invalidate, any of the numerous theories which have given rise to so much controversy, in which I myself (as you know) have borne some part; I shall look to nature alone, without much reference to opinions, and shall endeavour to trace, by the marks she has left behind her, some of the grand operations she once executed on the surface of our globe.

VARRO divided the time elapsed since the beginning of the world into three portions, which he distinguished by the names, *prolepticum*, *fabulosum*, and *historicum*.

The first comprehended the period of absolute darkness; in the second some faint lights were thrown upon the history of its events, by fable and tradition; in the third, the historian had the common aids from which history is usually compiled.

The natural history of the world seems to admit of a corresponding division. In the first I include the formation of our strata, their induration, their derangement from the horizontal position in which they seem originally to have been placed

and the operation of cutting them down by so many whyn-dykes.

In the second division, corresponding to VARRO'S *fabulosum*, I comprehend the operations performed upon our globe, posterior to its final consolidation, and antecedent to all history or tradition; operations therefore that can be established by the visible effects alone which still exist, written in strong characters.

The third division contains the period since we acquired some knowledge of natural history, became acquainted with causes and effects, and able to trace the connection between them.

With the operations performed in the first division (corresponding with VARRO'S *prolepticum*) modern theorists assume that they are well acquainted, able to account for every appearance, and to detail the whole process of original formation. I however shall decline noticing these early processes of nature, and limit myself to the second division of natural history, hoping from the prominent features of my country that remain still undefaced, and from its curious facts, to trace and demonstrate the great effects that have been produced upon our surface; and though I do not presume to advance farther, I perhaps may assist in clearing the way for future naturalists, and by establishing effects, encourage them to proceed to causes, and help them to discover the powers and agents by which these grand operations have been executed.

Inquiry into the Formation of our perpendicular Façades.

It is natural that the first great operation we proceed to investigate, should be the formation of our magnificent façades, one of which is the principal subject of this memoir.

The line of coast that bounds our basaltic area on its north side, extends about twenty-five Irish miles, in which course the precipices are nearly continuous, and more than one half of them absolutely perpendicular for a great part of their stupendous height. The operation by which they were cut off so abruptly, and left with a formidable aspect towering over our coast, is the one we inquire into.

That these bold precipices once projected farther in many places is easily demonstrated; at *Beanyn Daana*, and at the *Chimney*, the columnar construction was obviously once carried much farther out.

At the *Milestone*, *Portcooan*, and *Portnabau*, the fragments of dykes extend far beyond the face of the precipice.

These same facts, together with the projecting base, shew that these sudden abruptions were not formed by the subsiding, and sinking of one part, leaving the remainder in its place: still less by any violent revolution, or convulsion; as the stratification has not sustained the slightest shock either above, or below the façade.

The formation of our abrupt coast, has been ascribed to the action of the sea beating violently against it, washing away the lower parts, and leaving a perpendicular façade standing; as we often see on the banks of rapid and encroaching rivers.

A cool examination of our precipices will soon prove that

our façades could not have been so formed, for we always find them on the highest part of the cliff, and receding from the water, which could be instrumental in bringing down the materials from above, only by washing, and so wearing away the bases of the steepest parts; but the elevations of these bases are utterly irreconcileable to this supposition; for instance, the base of *Pleskin* façade is two hundred feet above the present level of the sea, that of *Fairhead* three hundred; now had the sea ever risen to either height, it would have submerged a great part of *Ireland*, and none of the neighbouring country (whatever its level may be) bears the least resemblance to alluvial ground, nor shews any mark of having been once covered by the sea.

The next argument is still more conclusive; the boundary of our basaltic area on its north side, is for twenty-five miles also the confine of sea and land; so far it is natural to ascribe its features, and characteristic marks, to the action of the powerful element that beats against it. But when that precipitous boundary ceases to be the confine of sea and land, turns southward towards the interior, and becomes the line of demarcation between the basaltic and schistose country on the west, it still preserves its former character; that is, of a range or ridge of very high land, steep to the exterior, and sometimes cut down vertically into façades, like its northern part that lines the shore.

Thus *Magilligan Rock*, (four miles inland) is not inferior in magnificence to any of our façades on the coast, its perpendicular section is one hundred and seventy feet, and this continuous for a mile; the façades at *Bienbraddock* are nine miles farther inland, and those of *Monyneeny* thirteen; while

the base of the lowest of these perpendicular precipices is elevated 1400 feet above the sea.

The same style prevails on the east side of our basaltic area, after its boundary ceases to be the confine of sea and land; for the limestone façades at *Garron Point*, (considerably above the level of the sea) exactly resemble those of *Dunluce* and *Kenbaan* at the water edge; and *Cave Hill* (several miles from the sea, and nearly one from the shallow estuary of *Belfast*,) exhibits basaltic façades at the height of one thousand feet, precisely similar, and little inferior to those of *Magilligan*.

The exact resemblance between our inland façades (on the east and west sides of our area) to those on the shore, proves them to be all effects from the same cause, and that our accumulated strata have in all these similar instances been cut down vertically by the same agent, and that this agent was not the sea.

Nor has this powerful agent confined its operations to our coast, or to the periphery of our basaltic area; we can trace it over its whole surface; we find throughout its interior, similar, though very diminutive abruptions, executed precisely in the same manner, that is, strata cut across by a long vertical façade, their planes on the upper side perfectly undisturbed, while on the lower side all the materials of which that part of the stratum was once composed are completely carried off.—(See 6th fact.)

We are now unavoidably led into a discussion of a question which has at all times occupied the attention of naturalists.

Whence arise the Inequalities with which the Surface of the Earth is so exceedingly diversified?

I shall not attempt to encounter this question generally, nor to extend my enquiries beyond the limits I have prescribed to myself; but I shall try whether the curious facts so profusely exhibited over our basaltic area, throw any light upon the formation of our own inequalities, or lead us a step towards the discovery of the operations by which such stupendous effects have been produced.

Some to escape the difficulties in which this question is involved, ascribe our inequalities to original formation; as if the world had come from the hand of the Creator with the variegated surface which now contributes so much to its beauty; but the frequent interruptions, and resumptions of the strata in our area, with the perfect resemblance of the corresponding parts, however great the interval by which they are separated, can scarcely leave a doubt that these strata were at first continuous; of course, the figure of our surface at that time must have depended on the original positions and inclinations of these strata, which, as appears by the 3d fact, are now unconnected with the superficial line, the figure of which is governed by their abruptions and removals alone.

Naturalists have differed much in opinion as to the direction in which the causes acted that produced the inequalities on the surface of our globe; some referring us to the bowels of the earth as to the scene of action; while others assert that the operations were performed upon the surface itself.

But the slightest inspection of our façades will at once prove that the first hypothesis cannot be correct; for obliquity of

direction must have been the result of a disturbing cause acting from below; whereas parallelism and a steady rectilineal course distinguish the basaltic arrangements of which I have been treating.

We have, it is true, occasional depressions of our strata, where they obviously have subsided, and no doubt from a failure of support below; but in no instance that I have met with, in our area, are these attended by the slightest concussion; the permanent and subsided parts, with us still preserve their parallelism, and the continuity of their material; whence it is probable this event took place previous to the induration of the strata, and of course antecedent to the period to which I limit myself.

Buffon ascribes our superficial inequalities to the agitation of the waters while they covered our earth, and argues from the resemblance these inequalities bear to the waves of the sea; a resemblance I cannot trace in any country which I have observed; nor could our sudden and perpendicular abruptions, ever have been produced by any agitation of the waters.

Professor Playfair considers rivers as having formed not only the beds, or channels in which they flow, but also the whole of the vallies through which they run, and in general all the inequalities of our surface; but an attentive observer, tracing the course of any of our most rapid rivers, would soon perceive that the quantity of its depredations have been comparatively insignificant, and that they can be determined with precision; the river has no doubt in several places extended itself considerably on both sides, but in the intermediate space between the remotest boundaries it ever reached, it levels, instead of raising inequalities.

The same result I apprehend would follow from the operations of another agent, which theorists are in the habit of calling in to their aid, when they cannot find some certain material, which from their theory we had reason to expect; they then tell us it has been carried off, and lost in the suite of degradations and decompositions.

But decay and decomposition, instead of creating inequalities would produce a contrary effect, and deface those actually existing; they would gradually abate the height of our perpendicular façades, and increase the green steep at their bases by the accumulation of the crumbling and mouldering materials from above; while the more diminutive façades formed by the abruptions of single strata scattered over the face of our area, and forming its most characteristic feature, would in time (as many are already) be converted into steep acclivities covered with verdure.

Such are the principal causes to which the inequalities of our surface have been generally ascribed. Previous to our deciding finally upon their insufficiency, it may be proper to enumerate a few of those inequalities, where the deviation of our present surface, from the form it probably had originally, is not only striking, but where also the concomitant circumstances afford demonstration, that some great operation has once taken place there.

Thus, by making ourselves acquainted with effects, we shall be better qualified to investigate causes; and if those effects shall appear to be beyond the powers of such natural agents as we are already acquainted with, we shall be justified in admitting the performance of operations to which we have seen nothing similar; and also in admitting the former

existence of powers of far superior energy to any we have ever known in action.

Enumeration of some remarkable Inequalities in the Surface of our basaltic Area, produced since the Consolidation of its Strata.

That we may better understand the facts I am proceeding to state, I shall assume (in the style of the mathematicians *puta factum*) previous to demonstration, that the planes of our uniform, rectilineal strata, however interrupted we may now find them, were once continuous.

Upon this supposition, the valley of the *Mayola*, between the stratified summits of *Seafin* and *Slievegallon*, is an excavation 1700 feet deep, and three miles wide, of which the whole materials have been completely carried off.

To the northward of this excavation, between *Seafin* and *Carntogher*, the continuous accumulated strata of basalt are interrupted, and taken away quite down to the schistose substratum; while the untouched summits of the contiguous mountains, *Carntogher*, *Seafin*, and *Monyneeny*, are still stratified basalt.

On the eastern side of our area, immediately to the southward of *Kello* and *Connor*, a similar operation has been performed, attended by still more extraordinary circumstances.

We here find a district near four miles in diameter, called the *Sandy Braes;* over this whole space the basaltic stratification has been carried off, and the operation has reached deep into a very singular substratum; a reddish breccia, by some

mineralogists called a porphyry, the mass friable, but the component angular particles of extreme hardness.

The hills, of which this little district is full, are every one perfect segments of spheres, while the loftier basaltic hills that surround it preserve their characteristic form, to wit, a gradual acclivity on one side, with a steep abruption on the other.

As we sail along our northern shore we discover another great chasm or interruption of our strata, which also cuts deep into the substrata: for on the west side of *Ballycastle* pier, the bold basaltic precipices suddenly disappear, and at a lower level disclose the substratum, which appears to be an alternation of sand-stone, and coal, sometimes with bituminous schistus.

A mile or two to the eastward the abrupt precipice is resumed, and a basaltic stratum again occupies its summit on to *Fairhead*, with the same angle of inclination in which it was disposed along our whole coast, that is, a slight ascent to the north.

Traces of similar operations and abruptions are to be found over our whole area, but the preceding are sufficient to make us acquainted with the style of these interruptions of our strata; of course it is time to proceed to the suspended demonstration, that our strata, so interrupted, were once continuous, notwithstanding the magnitude of the interval by which the corresponding parts are now separated.

Proofs that our now interrupted Strata were once continuous.

We must now turn back to the façades of *Bengore*, where the strata themselves, and all the circumstances attending them, are so happily displayed, as to throw great light on the subject, and to lead us analogically, step by step, to the conclusion we seek for.

Let us examine and trace the summit of the precipice for a mile immediately eastward from the *Giant's Causeway*, and we shall find a frequent interruption and resumption of the fourth, fifth, and sixth strata, at the shortest intervals, the interruption not always reaching to the lowest of the three, which in that case remains continuous: so far simple inspection removes all doubt, that each of these strata was once continuous as far as the great depression to the west of *Pleskin*.

Here indeed the interruption becomes considerable, not less than a mile; but when we find at *Portmoon* a succession of three strata with the same inclination, in the same order, of the same thickness each, and with the same strong characteristic marks that distinguished the three interrupted, at the depression; above all, when we find the strata they rest upon continuous (at least with very trifling interruptions) for the same extent; I think we can scarcely entertain a doubt that this interval between the corresponding parts, though so much greater than any of the preceding, is, like them, but an interruption, and that these strata were once continuous from the depression to *Portmoon*.

The same style of induction would establish the quondam continuity of all the strata in the face of *Bengore* promontory,

for here the strata are so distinctly marked that we know each of them when we find it again after any interruption.

In the rest of our precipices and façades, the similarity of the strata deprives us of this advantage; yet in their smaller interruptions, the eye, by tracing the rectilineal course of the strata, and so connecting the separated parts, can establish their former continuity: while in the greater intervals we must rest our proof on analogy alone.

That we may be entitled to carry this style of induction into the interior of our basaltic area, and to apply the same reasoning to enable us to form a similar decision upon the more stupendous interruptions of our strata, which I have already enumerated, it becomes necessary to explain the geological construction of our area,—the strata of which it is formed—their arrangement—and their inclinations.

An extensive limestone stratum, white as chalk, and about two hundred feet thick, seems to form the base of the whole district I limit myself to: upon this, accumulations of rectilineal and parallel basaltic strata, are heaped up to most unequal heights.

This great calcareous stratum seems not to be an accurate plane, but rather to resemble a bason, as every where at its periphery it dips to the interior; yet the plane of its section has a slight ascent to the southward: a recollection of these circumstances will enable us to account for every appearance this stratum exhibits, as it happens to be disclosed to us; and by the converse, an attention to these appearances will enable us accurately to determine the position of the stratum.

This stratum, from *Ballycastle* to *Solomon's Porch*, (about twenty-five miles,) keeps very nearly the level of the sea,

often indeed sinking below the surface, but never raising its lower edge above it; but when at *Solomon's Porch*, the boundary of our basaltic area begins to deflect to the south-west, and then to the south, the ascent of the stratum to the southward begins to operate, and we perceive the dotted line of its quarries gradually to rise along the face of the mountain from the shore to *Monyneeny* and *Seafin*, where it has attained the height of 1500 feet: it is true, the actual stratum has not been opened at these two great elevations, but the white rubble immediately below the basaltic façade proves incontestably that it is close at hand.

An accumulation of basaltic strata, had in this southern course, as well as on the northern shore, covered the limestone up to the summits of the hills or mountains.

I have already stated how the ridge of mountain is suddenly interrupted by the valley of the *Mayola*, from 1600 to 1700 feet deep, but if we look to the southward, in the rectilineal course of the strata (the positions of which we have been able to ascertain with so much accuracy), we shall find near the summit of the mountain *Slievegallon* a similar white limestone stratum crowned with basalt, cutting it in the very direction the former ought to have reached it, that is perhaps two hundred feet higher, the ascent of the strata to the southward having elevated their planes so much in a distance of four miles, the probable interval between the summits of these mountains.

We are now to decide whether this calcareous and basaltic fragment, on the summit of *Slievegallon* mountain, be the last remnant of the old arrangement we have been tracing, and ascertaining with so much precision, for seventeen or

eighteen miles from the sea, and twenty-five miles along the coast, but now interrupted by the valley of the *Mayola*, like our former more diminutive interruptions, and also like them resumed at the next elevation, in the same rectilineal course, the strata preserving the same order, and the same characteristic marks. Or whether these strata, appearing on the summit of *Slievegallon*, be the commencement of a new arrangement, abandoned by nature as soon as begun: which is highly improbable, for neither limestone nor basalt are to be found on the mountain except in this solitary hummock.

We might, by a minute attention to the inclinations, and arrangements, of the strata contiguous to the other interruptions I have enumerated, prove in like manner that the basaltic masses crowning the summits of the surrounding hills and mountains, are merely the remnants of strata once extensive and continuous, but interrupted and carried off, as in the preceding case, by the same powerful agent.

The more diminutive inequalities scattered over the whole surface of our area, and always produced by interruptions of the strata, would still more easily admit the appplication of the same reasoning, from the contiguity of their abrupted parts; but the detail would be tedious; those who wish to pursue the subject farther must come to the scene themselves.

Materials completely carried off.

A circumstance perhaps still more extraordinary, is the complete removal of all the materials that once filled up the intervals between the abrupted parts of these strata; I have stated in my 9th fact, that the materials that had formerly

composed the projecting parts of our northern facades, and precipices, had totally disappeared.

The removed parts of the limestone stratum on the west side of our area have shared the same fate, for where the chain of mountains extending from *Magilligan Rock* to *Bienbraddock*, is interrupted by vallies at *Stradreagh*, *Drumrommer*, and *Ballyness*, it is obvious that the limestone stratum was once continuous to the high points where it shews itself on *Keady*, and the mountains on each side; its thickness too, wherever we can try it, is very great; yet this stratum, which in its entire state must have spread like a roof far above the present surface of these valleys (which are now sunk deep into the schistose substratum) has not left a particle of its *debris* behind, nor is a single lump of white limestone to be found, until we come to the quarries, that is, to the edge of the solid, untouched stratum.

Conclusions.

The conclusions that unavoidably follow, from the consideration of these facts are,

That the hills and mountains, in the district I have been describing, were not raised up or formed as they now stand, but that they are the undisturbed remains of strata that were left behind, when stupendous operations carried away the parts that were once contiguous to them.

That the inequalities of this surface were all produced by causes acting from above, and carrying off whatever they touched, without in the least disturbing what was left behind.

*Additional Evidences. Basaltic Hummocks.**

The arguments on which I have founded my opinions have hitherto been all taken from the hollows in our surface, and the interruptions in our strata, both which, the concomitant circumstances have led me to consider as so many excavations; but the lofty elevations, and the abrupt prominencies rising suddenly from our surface, when minutely examined, lead us irresistibly to the very same conclusion.

When you and I examined together the line of our northern façades, we studiously sought for the points where nature had made any change in her materials or their arrangement, hoping that at the junctions of these little systems, we should find some facts that would throw light on the subject; but we generally failed; want of perpendicularity, or other local circumstances, impeding us at the most interesting points.

On the present occasion she has adopted an opposite line of conduct, and in many of the steps she has taken, obtrudes upon us demonstration of what she has done.

Whoever has attended to the exertions of man, when employed in altering our present surface, either by levelling heights, or by making excavations, must have observed that it is the practice of the workmen to leave small, cylindrical portions standing, for the purpose of determining the height of the old surface, and thereby ascertaining the quantity of materials removed.

To these may be compared the stratified basaltic hummocks so profusely scattered over our area, and which seem to shew how high our quondam surface once reached.

* Navigators use the word hummock to express circular and elevated mounts, appearing at a distance; I adopt the term from them.

The hummock of *Dunmull*, three miles south-east from *Portrush*, is very beautiful, it stands on the top of a high ridge, and is a conspicuous object from all parts of the country; it is exactly circular, its flat surface contains an acre, it is completely surrounded by a perpendicular façade about twenty-five feet high, and formed by two strata, a columnar, and an irregular prismatic, resting upon it.

From this elevated station, where I had the pleasure of accompanying you, I shewed you at six or seven miles distance to the westward, among the *Derry* mountains, the still loftier hummocks of *Altabrian* and *Sconce*, hemispherical in form, composed of but one stratum each, while their swelling-out bases displayed accumulations of many more: and also near those the hummock of *Fermayle*, resembling *Dunmull*, but much larger, and also, surrounded by a façade composed of two strata.

I shewed you also at twenty miles distance to the south-east, the gigantic *Slemish*, one of our basaltic hummocks, magnified (as it were) into a lofty and insulated mountain, completely stratified from its base to its flat summit.

I shewed you likewise from the bottom of its ridge, the neat but diminutive hummock, called the *Rock of Clogher*, above *Bushmills*. As our time was precious, you took my word for its stratification being precisely similar to that of *Dunmull*.

There are many other basaltic hummocks scattered over the surface of our area, all of them either stratified or portions of strata; two of the most remarkable are the hill of *Knock Loughran*, near *Maghera*, and a tall hummock (whose name I forget) a mile eastward from *Lisanoure*.

We meet still more frequently an imperfect style of hummock, a semi-circular façade on one side, while on the other it slopes away gradually with the dip of the strata, as if the operation had been interrupted before it was carried quite round; the most remarkable of these are *Ballystrone*, in *Derry*, and *Croaghmore*, in *Antrim*, both visible from *Dunmull*.

Regular stratifications on the summits of hills and mountains, have been long a stumbling block to theorists; the historian of the French Academy, for the year 1716, obviously ascribing the superficial inequalities of the earth, (like many others) to causes acting from below, and perceiving how incompatible such assemblages of strata were to his theory, thinks it safer to doubt their existence, as they could not have been formed, he says "unless the masses of the mountains "were elevated in the direction of an axis perpendicular to the "horizon: *ce que n'a pu être que très rare.*"

But as these stratified mounts are in our area by no means uncommon, they lay us under the necessity of suggesting another alternative similar to those we have already stated.

Were these isolated hummocks originally formed as they now stand, (solitary and separate from each other) one by one; or, are they the last remaining portions of a vast consolidated mass, of which the intermediate and connecting strata have been carried off by causes with which we are unacquainted?

To be able satisfactorily to resolve this alternative, it becomes necessary to take a careful view of the contiguous countries, and to try whether their construction, and the arrangement of their strata, will throw any light upon the subject.

When we examine the assemblage of hummocks above *Knockmult*, that is, *Sconce*, *Fermoyle*, and *Altabrian*, we find their materials and stratification, precisely similar to that of the country below them to the eastward, where the abruptions of the strata are displayed in long stony ridges;—to the south, the abruptions on the summit of *Keady* mountain discover the same similarity; and to the north-west the grand façade of *Magilligan Rock*, three miles distant, displays an accumulation of exactly the same sort of strata consolidated into an enormous mass.

The hummock of *Dunmull* is formed of two very particular strata, a columnar, and an irregular prismatic; but I shewed you, a mile to the northward, at the façades and quarries of *Islamore* and *Craigahuller*, at the base of the hill, that the whole ridge, on the summit of which *Dunmull* is placed, was a consolidated mass, formed by alternate strata of the same description: and that the arrangement of the whole country below, and adjacent, was precisely the same with that of the hummock of *Clogher*, I proved to you at the curious opening of the strata at *Bushmills Bridge*, and in the façades at the *Giant's Causeway*.

After these proofs that so many (and I might proceed to the rest) of our detached hummocks, are in their construction and materials, similar to, and connected with, the main consolidated masses of which our country is formed, I think it will scarcely be asserted that these hummocks were originally formed, solitary and separate as they now stand; but rather that they were once parts of that vast whole, and left behind in their present form, upon the removal of the contiguous portions of their strata, by some powerful agent, of whose

operations and modes of acting, we have hitherto obtained little knowledge.

The highest point on the façade of *Cave Hill* is called *M'Art's Castle*, and appears to be a solitary fragment of a stratum, precisely similar to those below it, and obviously once extended like them.

The irregularity of the summit of *Fairhead*, plainly shews that its gigantic columns once reached higher.

And in the façade of *Magilligan*, the highest of all, a few desultory patches of an upper stratum (no doubt once perfect and continuous) are to be traced along its summit.

Our mountains themselves seem to shew clearly that they were once higher; the top of *Magilligan* mountain is an extensive plain, over which a wandering stratum is interrupted and resumed at intervals for a great way.

At the highest part of *Donald's Hill*, over the valley of *Glenuller*, we find a hummock; also at the termination of the ridge, at its highest part over the valley of *Mayola*, similar hummocks.

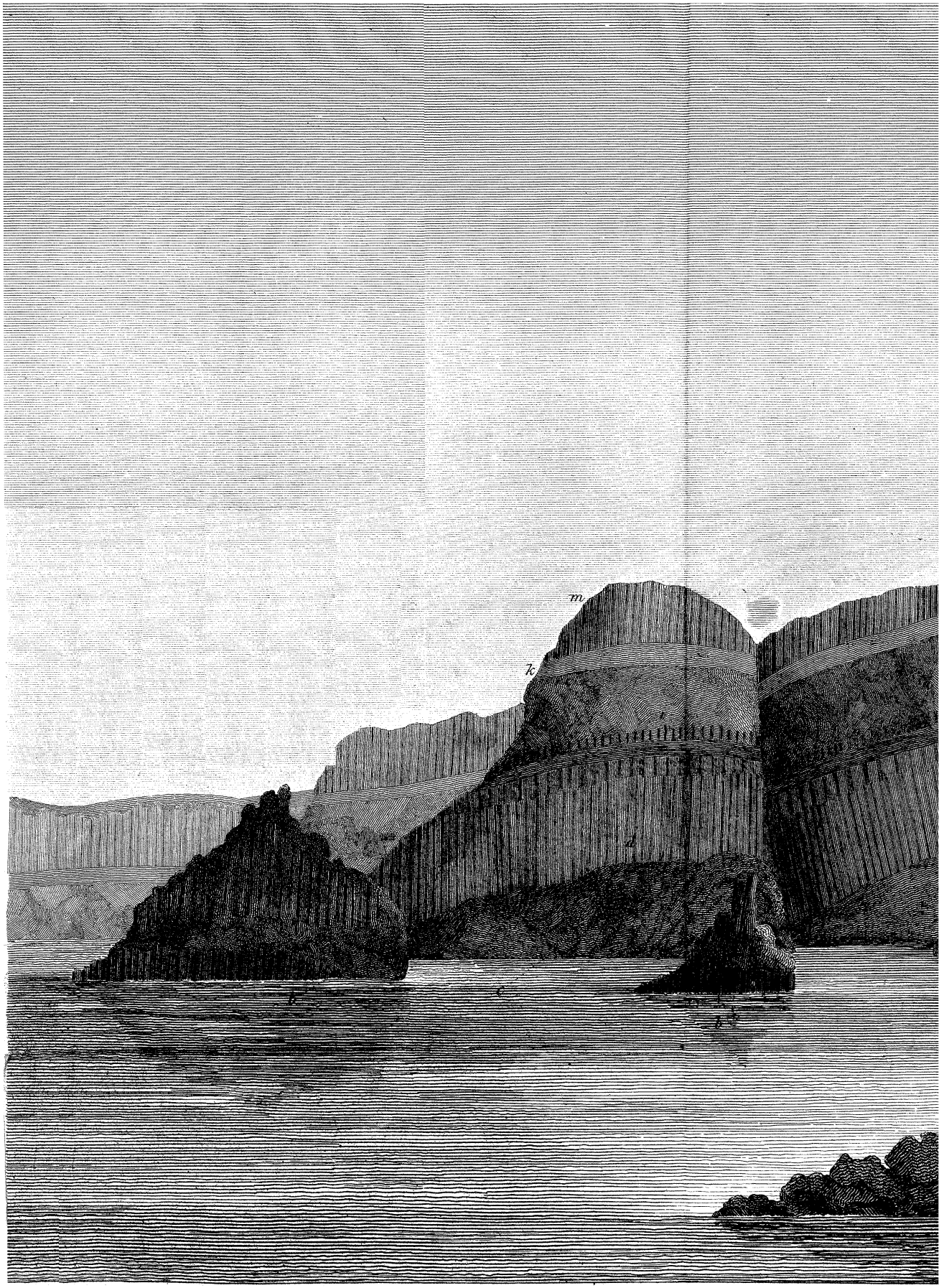
I have the honour to be,

SIR,

Your obedient, humble Servant,

W. RICHARDSON.

Clonfecle, Jan. 2, 1808.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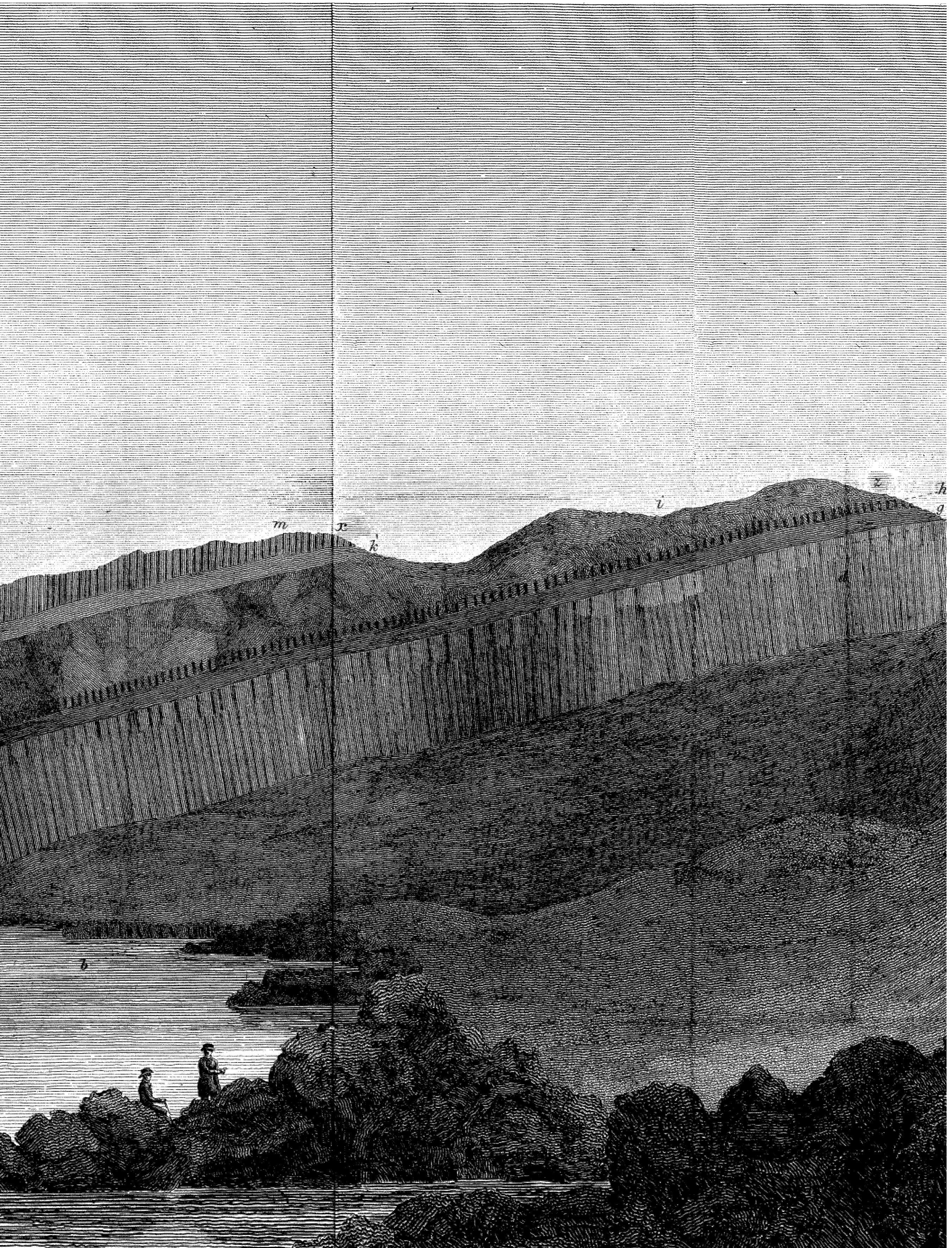
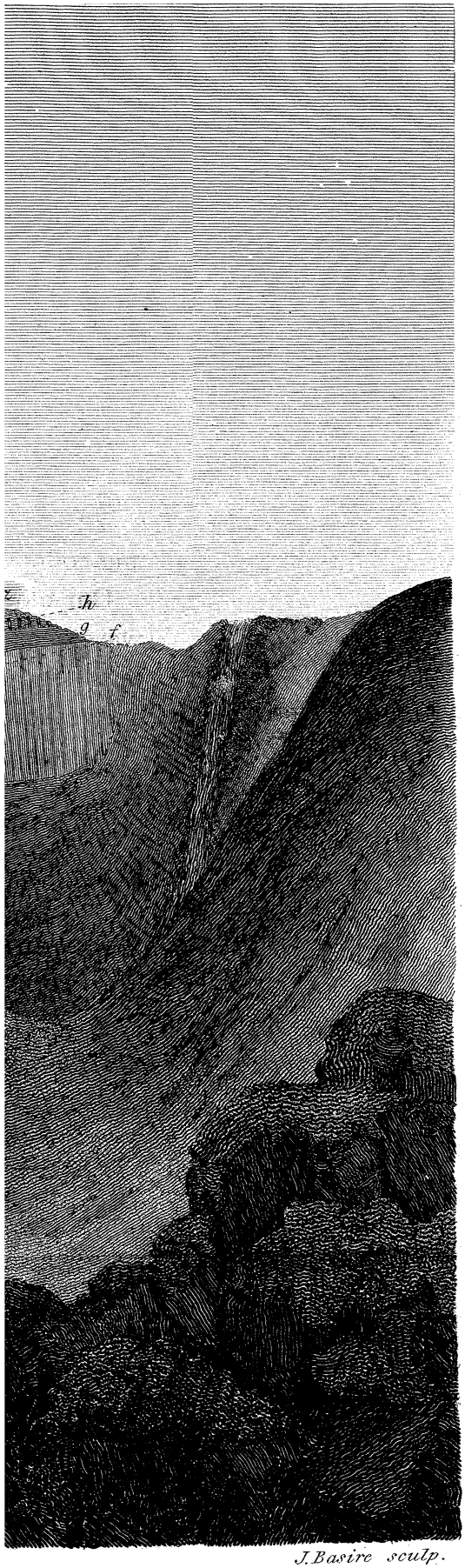


View of Portmoon



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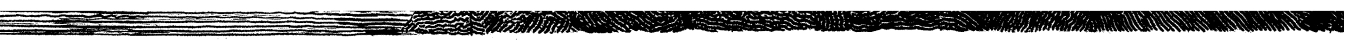

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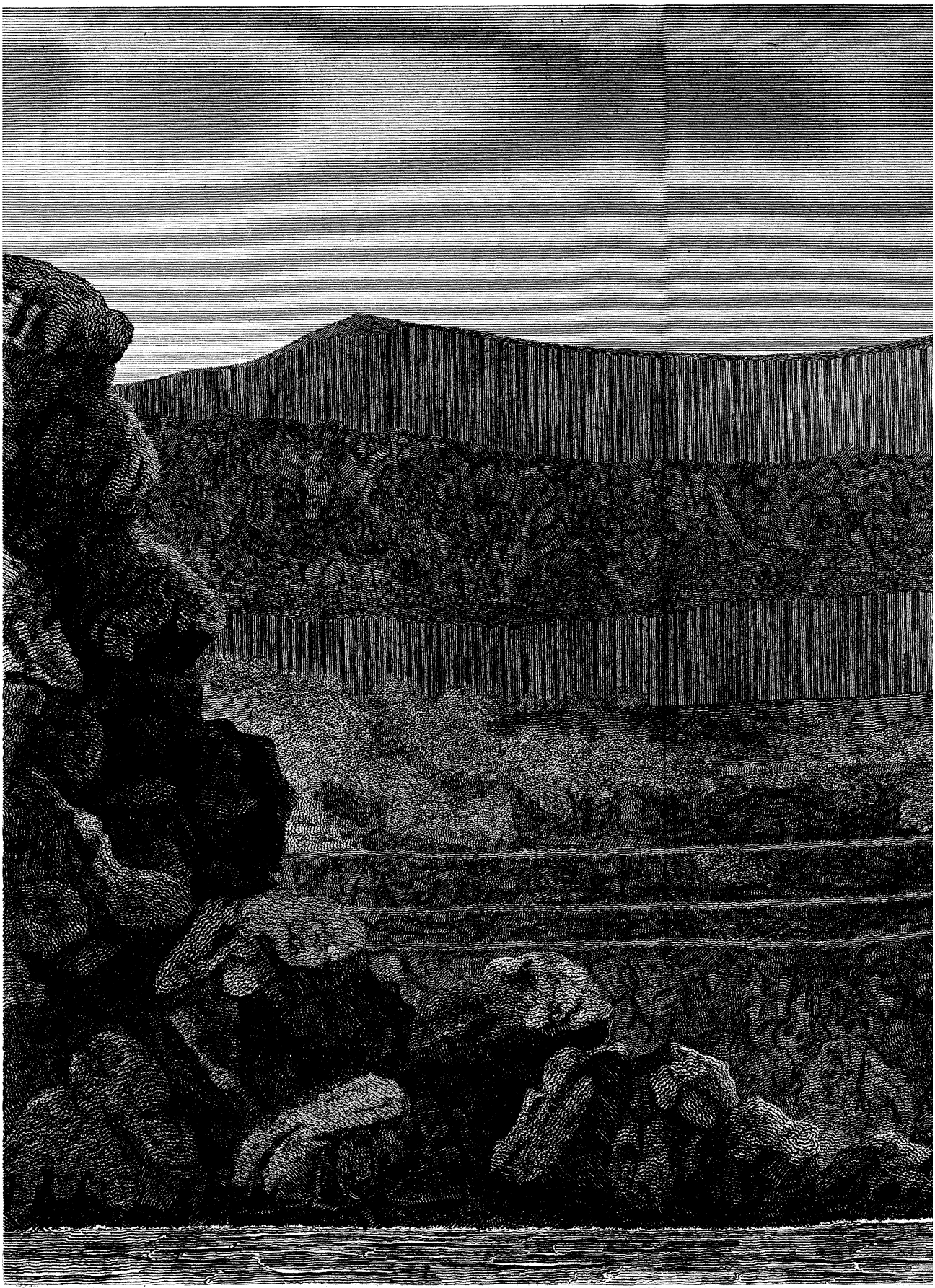

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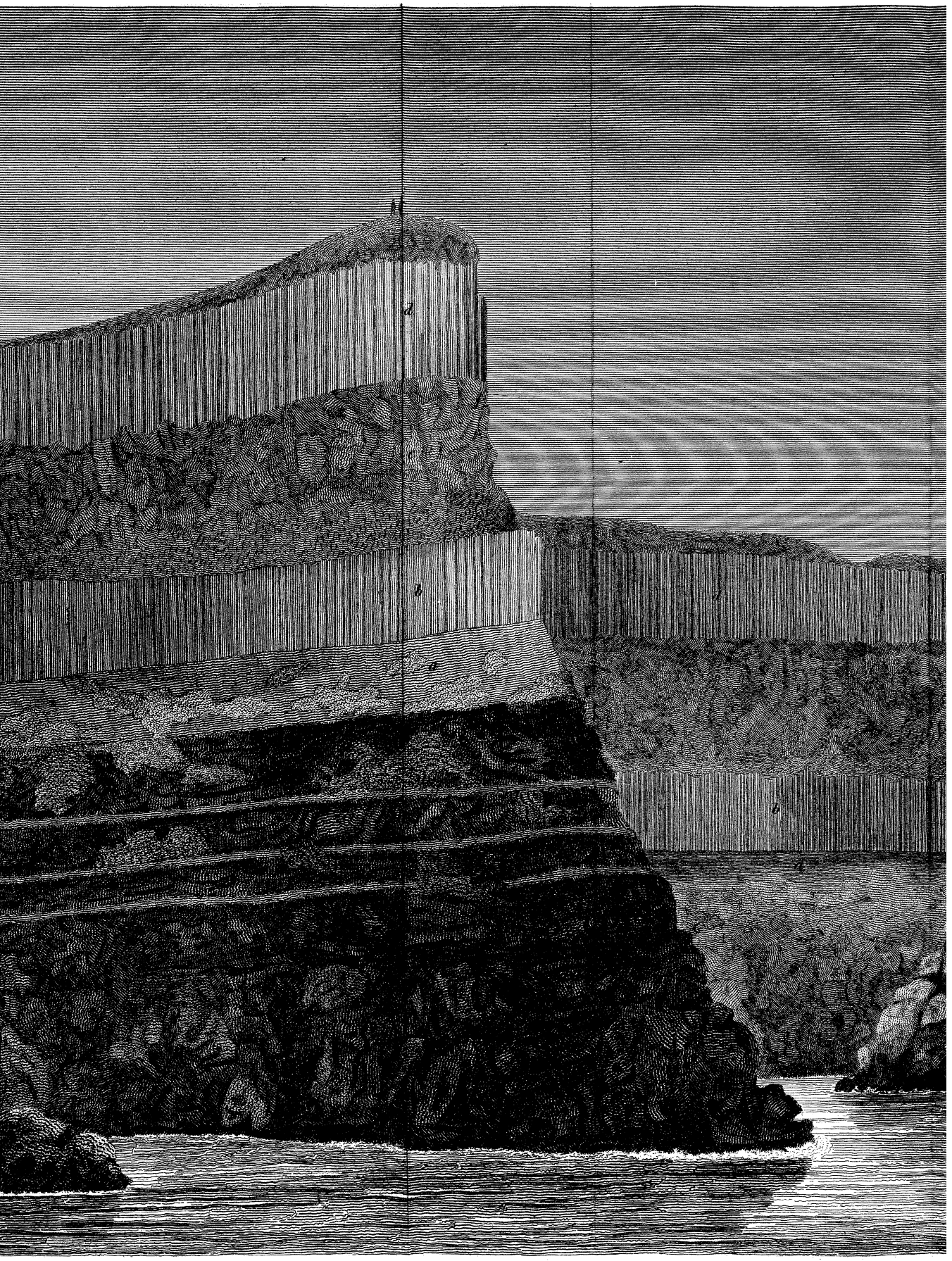
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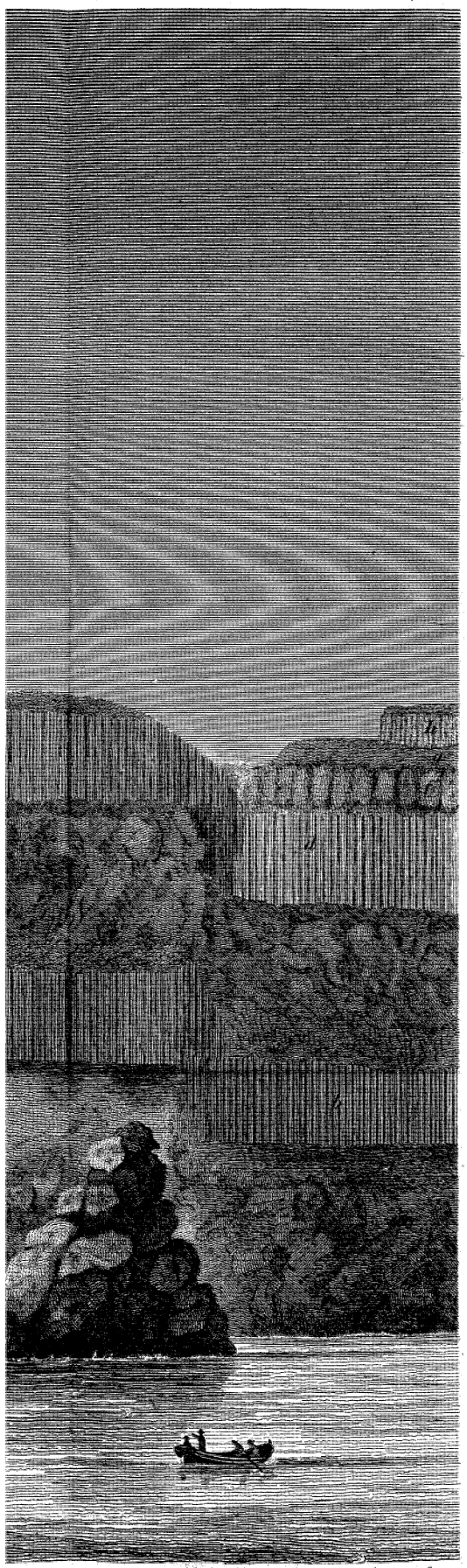

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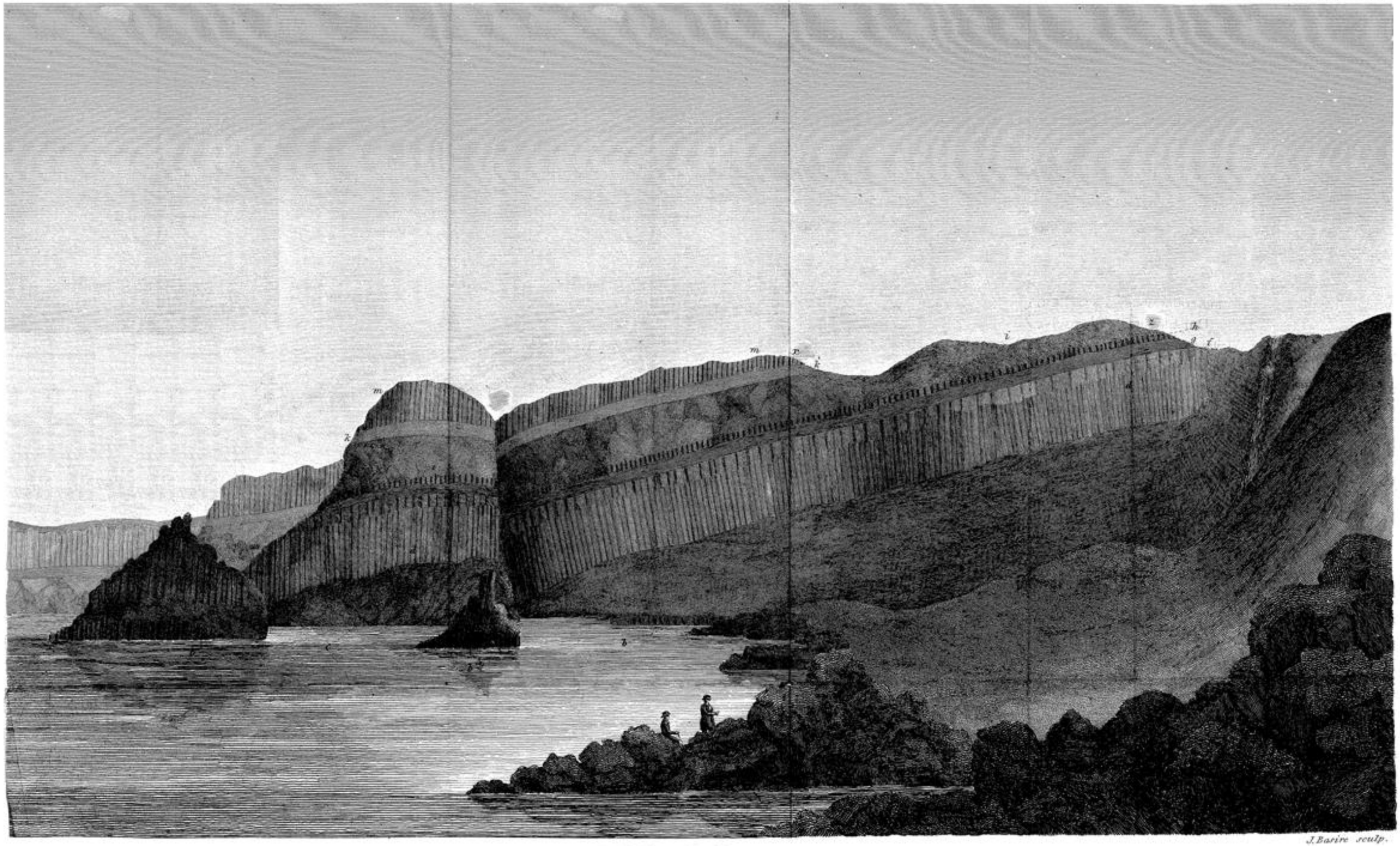
View of Pleskau on the

the North West side of Bengore Promontory.

J. Basire sculp.



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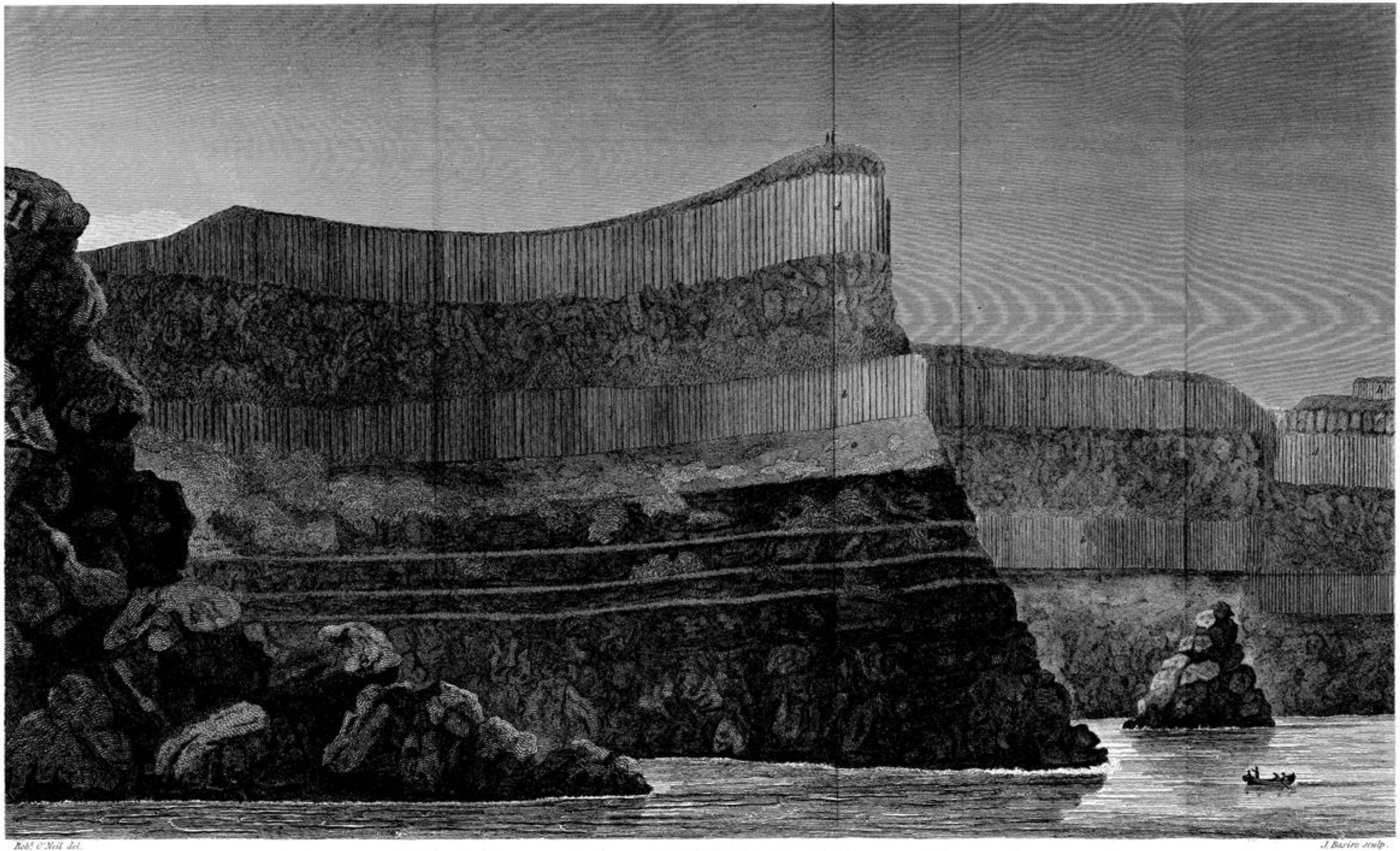

Robt O'Neil del. *J. Basire sculp.*

View of Pleskin on the North West side of Bengore Promontory.