

### III. *On the Granite Tors of Cornwall.*

By J. MAC CULLOCH, M.D. Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich.

I Have the honor of presenting to the Society three drawings which I have selected from my portfolio, for the purpose of illustrating the changes which the influence of time and weather produces on certain varieties of granite. The subjects are all chosen among the granites of the west of England ; and that I might at the same time preserve memorials of circumstances which are remarkable independently of their geological interest, I have taken two of my examples from places which have called forth more admiration from the common spectator than even from the philosopher, and which form two points of attraction for the curious or idle who annually visit Cornwall. Not only indeed have idle curiosity and ignorant speculation busied themselves in accounting for phenomena which many of the vulgar have deemed little less than miraculous, but learned antiquaries have tortured their inventions and have constructed religious systems for the purpose of explaining these very simple and intelligible natural appearances, by the rites of a mysterious and Druidical worship. I trust I shall be pardoned, if while I deduce from these facts the geological consequences which depend on them, I likewise give a more particular detail of the appearances themselves which have excited so much of the attention of all visitors.

Dr. MAC CULLOCH *on the Granite Tors of Cornwall.* 67

The Logging rock (Pl. III.) is situated on a peninsula of granite, in the parish of St. Levin, which stretches out about 200 yards into the sea, its isthmus still exhibiting remains of the ancient fortification of Castle Trereen. The mass of granite which forms this peninsula is split both perpendicularly and horizontally by numerous fissures, and is thus divided into a number of cubical and prismatic masses. A similar disposition in all the rocks of this shore has caused them to assume those singular forms which are so conspicuous at the Land's End. The appearance of the perpendicular fissures on approaching the Logging rock from the isthmus is so remarkable, that we might for a moment fancy it the effect of stratification, as geologists have in other instances been tempted to suppose. Crystals of tourmaline are found in this granite, which has supplied the cabinets of collectors with so many specimens as to be too well known to need description.

The general height of the mass of rock on which the logging stone is placed varies from 50 or 80 to 100 feet, and it exhibits almost all round a perpendicular face to the sea. It is divided into four summits, on one of which, near the centre of the promontory, the stone in question lies. If the whole peninsula be viewed laterally, the conformity of the rocking stone to the mass on which it stands and to the other small stones which crown the summits, is such that the eye cannot detect it, so perfectly it seems in its place. It is in the front view only that it appears detached, as if occupying an accidental and not its natural and original place. Its general figure is irregularly prismatic, and foursided, having at its lower part that protuberance on which it is poised. So inclined is the plane on which it rests, that it appears at first sight as if a slight alteration of its position would cause it to slide along the plane into the sea, standing as it does within two or three feet of the edge of

68 Dr. MAC CULLOCH *on the Granite Tors of Cornwall.*

the precipice. The breadth of the apparent contact between the plane and the centre of motion of the stone is about a foot and a half. As this support is curved only in one direction, being of a cylindrical and not of a spheroidal figure, the motion of the stone is consequently limited to a vibration in one direction, which is nearly at right angles to its longest dimensions. The general aspect of the stone would scarcely enable a cursory spectator to assign the reason of its vibratory power, as from the point of view in which it is usually seen, the centre of gravity would appear placed rather above than below the centre of suspension. It is said that the motion is now much more limited than it has been within the memory of those who live near it; a circumstance rendered very probable by the progress of disintegration at those points of contact where water can be detained. A continuance indeed of the very process to which it owes this property, must ultimately destroy its motion if it operates by bringing a wider surface into contact, thus defeating the enlarged vibration which would otherwise follow from the increasing distance between its centres of suspension and of gravity. A quantity of loose quartz gravel may be generally found near the points of contact, marking the progress of this disintegration.

In the trials which I have at different times made on it, the greatest force that three persons could apply to it was sufficient to make its outer edge describe an arc whose chord was  $\frac{3}{4}$  of an inch at 6 feet distance from the centre of motion. When suffered to return it vibrates for a few seconds before it falls again to rest. A force of a very few pounds is however sufficient to bring it into a state of vibration, and to maintain a visible motion. Even the wind blowing on its western exposed surface produces this effect in a very sensible degree. It is the largest of its kind at present

Dr. MAC CULLOCH *on the Granite Tors of Cornwall.* 69

moveable in Cornwall. I made an attempt to ascertain its weight by measurement. It may without much inaccuracy be resolved into two frusta of pyramids, on a common trapezoidal base, their union forming an irregular four-sided prismatic figure, 17 feet in length, and  $32\frac{1}{2}$  feet in circumference about the middle part. Comparing the solid content of the stone, as deduced from this approximated measurement, with the sp. gr. of the granite of which it is composed, the weight appears to be 65,8 tons, a deduction if not precise, sufficiently accurate at least to satisfy general curiosity.

It would be superfluous to combat the opinion of those, who like the Iconoclasts of Cromwell's time, in the instance of the rocking stone of Merramber, fancied these stones to be the productions of art directed to religious purposes. The accidental coincidences which give rise to their formation, will be considered when I have reviewed the other tors which are the subject of this paper.

The Cheese-wring, (Pl. IV.) of which the second drawing is a representation, occupies the highest ridge of a hill to the north of Liskeard, one of that collection of hills which decline from Rough-tor, and Brown-willy, and which form the most elevated part of Cornwall. The summits of all these hills are covered with granite cairns in different states of ruin and disintegration, and their sides are strewn to great distances with the bowlders which have fallen from them at different times.

The migration of stones is here readily to be traced upon a scale easily comprehended. The granite of which these hills are composed is well known, and has been often described.

It is not far from the Cheese-wring that the first traces are found of the asbestos and steatites which are known to be so abundant and conspicuous in the parish of St. Cleer.

The inspection of the drawing will show that this remarkable cairn

70 Dr. MAC CULLOCH *on the Granite Tors of Cornwall.*

consists of five stones, of which the upper ones are so much the largest as to overhang the base on all sides. The collective height of the whole pile is about 15 feet, from which compared with the drawing, the sizes of the different masses composing it are easily appreciated.

The rounding of the angles in this instance, has proceeded in some parts so far as almost to give an appearance of convexity to the touching surfaces from certain points of view; a state which once attained will speedily compel the Cheese-wring to join its former companions in the plains below. It is evident enough, that the cairn of which this is now the only remaining memorial, has been of considerable dimension.

An abstraction of its support, occasioned probably by the gradual disintegration and sliding of the summit of the hill, has permitted the lateral parts to fall away, leaving, in its present whimsical position, that part which happened to be best poised. It is unnecessary to suppose that the chisel of Druidism has been employed to reduce it to an image of Saturn. Natural causes are sufficient to account for its appearance. Dr. Borlase reports that the upper stone of this pile had been a logging stone, and thus attempts to strengthen his Druidical system. It would doubtless be a great improvement on the statue of Saturn, to be furnished with a moveable head, but an inspection of the upper stone is sufficient to show that its centre of gravity is placed much too high to admit of the conditions requisite for the production of that effect.

The last of these tors which I have chosen for the purpose of this illustration, is the Vixen Tor on Dartmoor. (Pl. V.) There is nothing extraneous or traditional connected with this rock to render it an object of interest in any other point of view than that for which I have selected it.

The granite of this county is known to be in general split by fis-

Dr. MAC CULLOCH *on the Granite Tors of Cornwall.* 71

tures in different directions, but most commonly tending to the perpendicular and horizontal. By those it is divided into masses of a cubical and prismatic shape. Of the exceptions to this rule there is one among many other instances, in Shaugh rick near Plymouth. If we examine a rock of this kind near the surface of the soil, we shall find that the fissure is a mere mathematical plane, separating the two parts, and that the angles are sharp and perfect. If we turn our attention to granites which from their greater elevation above the present soil appear to have been longer exposed to air and weather, we shall find, as the first step to change, a gentle rounding of the angles, such as is exhibited in the drawing last cited, the Vixen Tor. By degrees the surfaces which were in contact become separated to a certain distance, which goes on to augment indefinitely. As the wearing continues to proceed more rapidly near the parts which are most external, and therefore most exposed, the masses which were originally prismatic acquire an irregular curvilinear boundary, and the stone assumes an appearance resembling the pieces which constitute the Cheese-wring. If the centre of gravity of the mass chances to be high and far removed from the perpendicular of its fulcrum, the stone falls from its elevation, and becomes constantly rounder by the continuance of decomposition, till it assumes one of the various spheroidal figures which the granite bowlders so often exhibit. A different disposition of that centre will cause it to preserve its position for a greater length of time, or in favourable circumstances may produce a logging stone.

It is not necessary to call in the aid of long continued friction or distant transportation to account for the rounded form of these granite bowlders. The changes which they undergo in their places of rest, by their more rapid disintegration at the angles than at the sides, are sufficient to prove that this spheroidal shape may be pro-

72 Dr. MAC CULLOCH *on the Granite Tors of Cornwall.*

duced by chemical action of air and water, without the necessity of any mechanical violence. However difficult it may be to give a very satisfactory account of this peculiarity, the fact is undoubted.

There is less difficulty in accounting for their separation from each other at their surfaces of contact, after the fissure has been formed, if we consider that they are liable to lodge water where the surface is horizontal, or to detain moisture where it is vertical.

That the wearing of these granites on the surface arises from the action of water, will be evident on examining the stones themselves, and the result of their disintegration. Wherever a stone is disintegrated by the most usual process, the oxidation of the iron which it contains, a change may always be observed to have taken place from the surface downwards to a more or less considerable depth in the stone. Sometimes even the whole mass of rock will appear to have undergone this gangrenous process at once, and to have become a bed of clay and gravel. But in the case of the granite now under view, it is evident that the change is merely superficial, and that no process of oxidation has taken place. Indeed, many of the varieties of which the mica and felspar are nearly white, contain so little iron that they are hardly subject to decomposition from this cause, however much they may, in such particular cases as that of the St. Stephen's granite, resolve entirely into gravel and porcelain clay. The most satisfactory proof however that the mere agency of water is sufficient to disintegrate this granite, is presented by those objects which perhaps in consequence of the Druidical speculations of Dr. Borlase are best known by the name of rock basons.

On the flat surfaces of these stones are frequently to be observed excavations, assuming some curved figure with rounded bottoms. Occasionally they are circular in their boundary, and as regularly spheroidal internally as if they had been shaped by a turning lathe.



Dr. MAC CULLOCH *on the Granite Tors of Cornwall.* 73

They are of various depths, and they may be sometimes observed to communicate with each other. Their artificial appearance was sufficient to convince of the truth of his system regarding them, this strenuous supporter of a worship which must on his hypothesis have required a priesthood sufficient to exclude all other population, if every rounded cavity which the granite exhibits was a pool of lustration.

Their true origin is easily traced by inspecting the rocks themselves. On examining the excavations, they will always be found to contain distinct grains of quartz and fragments of the other constituent parts of the granite. A small force is sufficient to detach from the sides of these cavities additional fragments, showing that a process of decomposition is still going on under favourable circumstances. These circumstances are the presence of water, or the alternate action of air and water. If a drop of water can make an effectual lodgment on a surface of this granite, a small cavity is sooner or later produced. This insensibly enlarges as it becomes capable of holding more water, and the sides as they continue to waste, necessarily retain an even and rounded concavity, on account of the uniform texture of the granite. In time, the accumulated gravel is blown away by the winds, although in the deeper hollows it may often be found forming considerable accumulations.

The same solubility of granite in water, (to speak generally) is the cause of that wasting of the surface which these rocks undergo, and to which I have before attributed the enlargement of the vacuities at the surfaces of contact, and the separation of the prisms into detached masses.

We need not hesitate in admitting the solution of granite in water to an extent capable of producing this effect of disintegration, since we know that silex is soluble in that fluid by natural means, however we



74 Dr. MAC CULLOCH *on the Granite Tors of Cornwall.*

have been unable to imitate the process in our laboratories. It is also not improbable, that the quantity of potash which enters into the composition of felspar, may confer on it a similar property, and that even in a greater degree, although direct experiments are wanting to prove this fact. Whichever of these bodies is acted on in the case of this disintegration, the quantity of matter actually dissolved is probably very little; we can even conceive it possible that the mere alternation of the states of moisture and dryness, combined with frequent changes of temperature at the surface, may be sufficient to produce this effect without any actual solution of the substance of the rock. It is a matter of more difficulty to assign the cause of the change of figure which the masses undergo, by what process Nature “mutat quadrata rotundis.”

Whatever disputes and doubts may have existed relating to the stratification of granite in general, I believe there is no one now who conceives the granite of Cornwall more than that of Arran or Mont Blanc to be stratified. The favourers of different hypotheses, must each be allowed for the present to adopt the opinions which to them seem the best founded, and it must depend on the conclusions which shall ultimately be adopted, relative to the aqueous or igneous origin of granite, whether these fissures are to be considered as the effects of contraction produced in the mass by the evaporation of water, or by the abstraction of heat. The cause of their peculiar form remains for the present involved in the same difficulties which attend on the more regular prismatic figures found in the trap rocks. But the fissures themselves having been formed in whatever way we chuse to suppose, we have still a difficulty unsolved, and that is the tendency which they exhibit to wear more rapidly on the angles and edges than on the sides, and thus to assume the spheroidal forms which facilitate the ultimate ruin and migration of the summits.

Dr. MAC CULLOCH *on the Granite Tors of Cornwall.* 75

That this would be the consequence of a gradual action merely mechanical is undoubted, as the mass must ultimately acquire that figure which, being the last result of the action of decomposition is the one which will offer the greatest resistance to further change. In a chemical view, the same must also to a certain extent hold true; since any given particle, supposed cubical and placed at the angle or edge, will be exposed to the action of the solvent on two or more surfaces, while that on the side of the mass is exposed but on one, hence the angular body must ultimately change its figure, and approximate to a spheroidal form: it is easy however to see that the influence of this cause will be retarded in a quickly increasing ratio, and that it is insufficient to account for the extreme change of form suffered by granitic masses. If it were sufficient in the case of granite, it should equally produce in sandstones of prismatic fracture a determination to the spheroidal form. But in these we see that the process of superior waste at the angles and edges, soon ceases to produce an effect in modifying the figure of the mass, and that sandstone never assumes the decidedly spheroidal forms which are exhibited by granite. Mechanical causes of change are here out of the question. If we now suppose the hardness of a mass of granite, or its resistance to the disintegrating power of air and water, to vary in any given ratio at certain distances from the centre, it is evident that the effect of chemical action on the surface, will be to change the figure of that mass, and that the ultimate effect will be to disclose the sphere inscribed within that cube. Let us consider how far the facts bear us out in this supposition.

De Luc has observed in his *Geology*, that granite sometimes decomposes into spheroidal forms, and he describes piles of this rock in Silesia, resembling, as he says, Dutch cheeses. I need not quote more authorities for a fact witnessed by innumerable observers. In our

76 Dr. MAC CULLOCH *on the Granite Tors of Cornwall.*

own island of Arran (that little abridgement of the world) nodules of spherical granite are found in the valleys which descend from Goatfield, decomposing on the surface in crusts, and marking decidedly the very construction which my supposition requires, in a much greater degree than is requisite for the purpose. Similar granite balls have been seen in other places, so that their existence is well ascertained, and this is one of numerous instances, where the decomposition of a rock gives us most useful information with regard to its structure, and where without that aid, we should never have divined the secret of its formation. It is certain that these balls, now rendered spherical by decomposition, have been quadrangular masses, and hence we may step, without any great hazard of unsound footing, to this general conclusion, that these masses of granite, which show marks of wearing on their surface with rapidities proportioned to their distance from a central point, have had their hardness, and probably their crystallization or formation, determined from that centre.

The analogy of this circumstance to the similar balls formed in basaltic rocks is illustrative of both the cases, and probably both will equally tend to confirm the opinions which have been held relating to the igneous origin of these substances. Thus, if for the sake of argument I may be allowed to assume that granite is of igneous origin, it will be easy to explain the peculiar appearances exhibited by that *formation* of granite, which, like those of Cornwall and Arran and many others, is separated into cuboidal masses.

Here we must conceive, that in a homogeneous mass of fluid matter, crystallization had commenced from numerous centres at the same time. While there was yet space for the formation of successive solid deposits round any set of these imaginary centres, a spherical or spheroidal figure would be the result. As the surfaces

Dr. MAC CULLOCH *on the Granite Tors of Cornwall.* 77

of these spheroids approached each other, the successive crusts would interfere, and the remaining intervals would be filled by portions of spheroidal crusts, until the cuboidal figures of all the contiguous masses were completed, thus forming that aggregated mass of cuboids, which we witness in the granites of this aspect which remain uninjured in their places. We need not be surprised that this regularity is not more constant, nor the forms more perfect, as we are unacquainted with the numerous circumstances which may determine the several centres of crystallization, or which may interfere with the ultimate regularity of the resulting masses. It is certain from chemical experiments, that the fact which is the basis of the foregoing supposition, occurs in various instances of the cooling of slags and of rocks artificially fused, as Mr. Watt's experiments have so well shown. But in these experiments, certain as they are, we are unacquainted with the causes which determine the places of the several centres of crystallization, and though equally unacquainted with those which may have influenced the centres on which the granite masses were formed, we may yet from analogy understand how the irregularity of these masses may have been caused by a corresponding irregularity in the position of their centres.

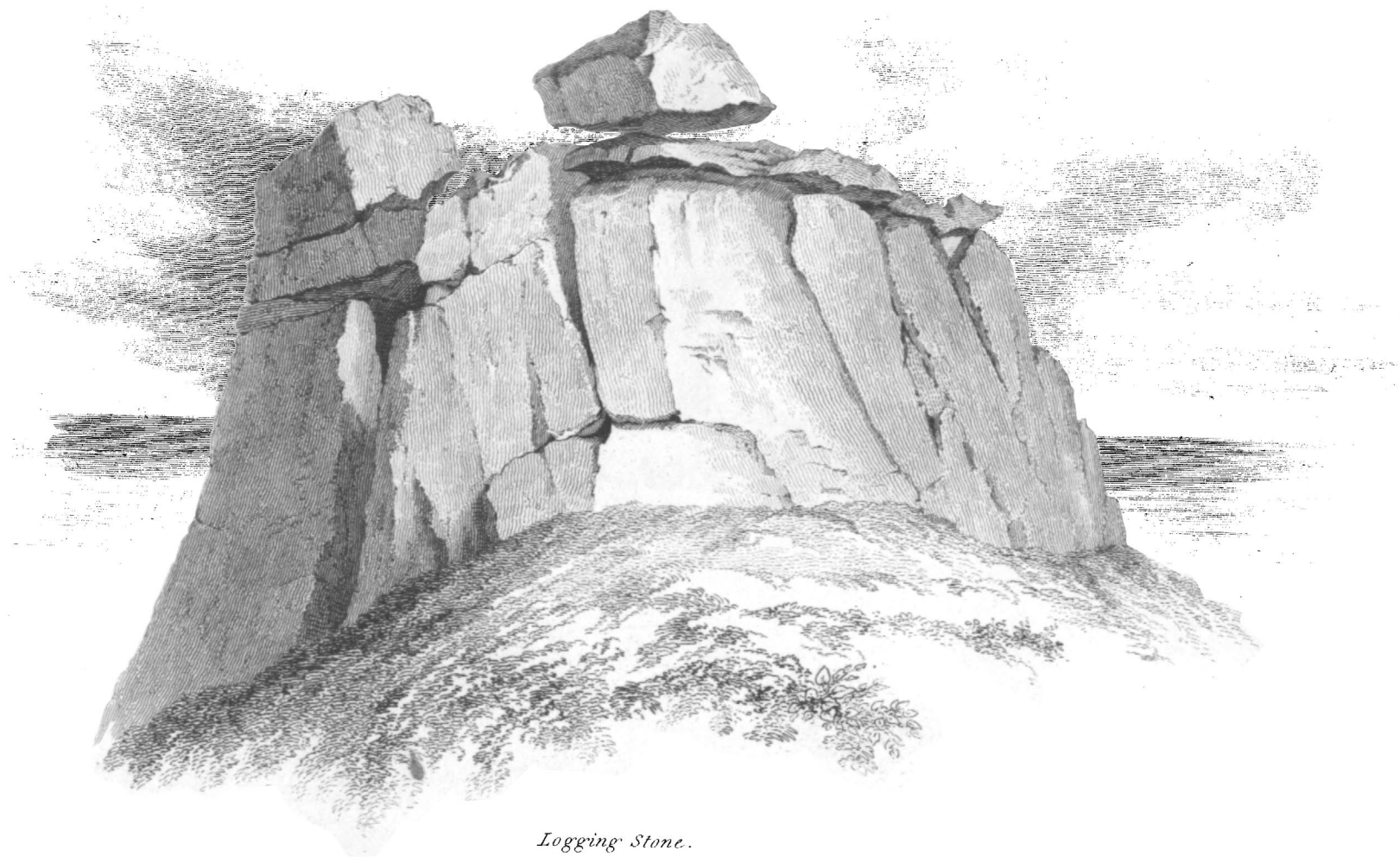
We can also easily conceive that in certain cases, the peculiar circumstances of which lie equally hid from us, the approximation of the spheres of crystallization may have caused the crystalline polarity of the several masses to interfere with each other, so as to have produced in many cases an irregularity still greater than this, and in some instances even entirely to have obliterated the appearance of central tendencies. To the chemical facts above adduced in support of this explanation, I might subjoin, what every one's mind will immediately suggest, the illustration which the commenced spheroidal

78 Dr. MAC CULLOCH *on the Granite Tors of Cornwall.*

forms of the Cheshire rock salt, and the igneous explanation of the forms of basaltic columns, add to this supposition.

On a smaller scale, a phenomenon of rare occurrence in Nature may also be suggested in aid of it. I mean the spherically disposed granite of Corsica, which exhibits the various constituents of granite formed round numerous centres, and producing those beautiful specimens still so rare in the cabinets of collectors. Similar radiating tendencies in the smaller parts have been noticed by Saussure, and although I had not the good fortune to see them in Arran, my friend Professor Jameson has described them as existing there. I have also witnessed a similar disposition in the mica which is included in the granite veins near Portsoy, and the same structure is well known to exist in that variety of granite which is called Tyger granite, where the hornblende or shorl forms radiating spheres.

It is sufficiently apparent from the history of this granite, and from its progress in decomposition now described, that the migration of stony masses may to a certain extent be explained, at least as far as this variety of granite is concerned, even without having recourse to any very violent mechanical action. But the decision and complete explanation of this very common and puzzling phenomenon, must in most cases rest upon a question of a different nature, and of greater difficulty, namely, the alterations which the surface of the earth has undergone at different eras, as well as the comparative antiquity of those changes. This phenomenon is only one of many, which prove the former existence of a different distribution of those parts of the globe which are at this present time land and sea, hill and valley.



*Logging Stone.*

*Drawn by J. Mac (collected M.D.).*

*Engraved by G. Cooke.*

*Published by William Phillips, London, 1844.*



Drawn by J. Mac Culloch M.D.

*Cheese-wring.*

Engraved by S. Sear.

Published by William Phillips, London, 1844.





*Vixen Torr.*

*Drawn by J. Mac Gillivray M.D.*

*Published by William Phillips, London, 1844.*

*Engraved by H. Deke.*