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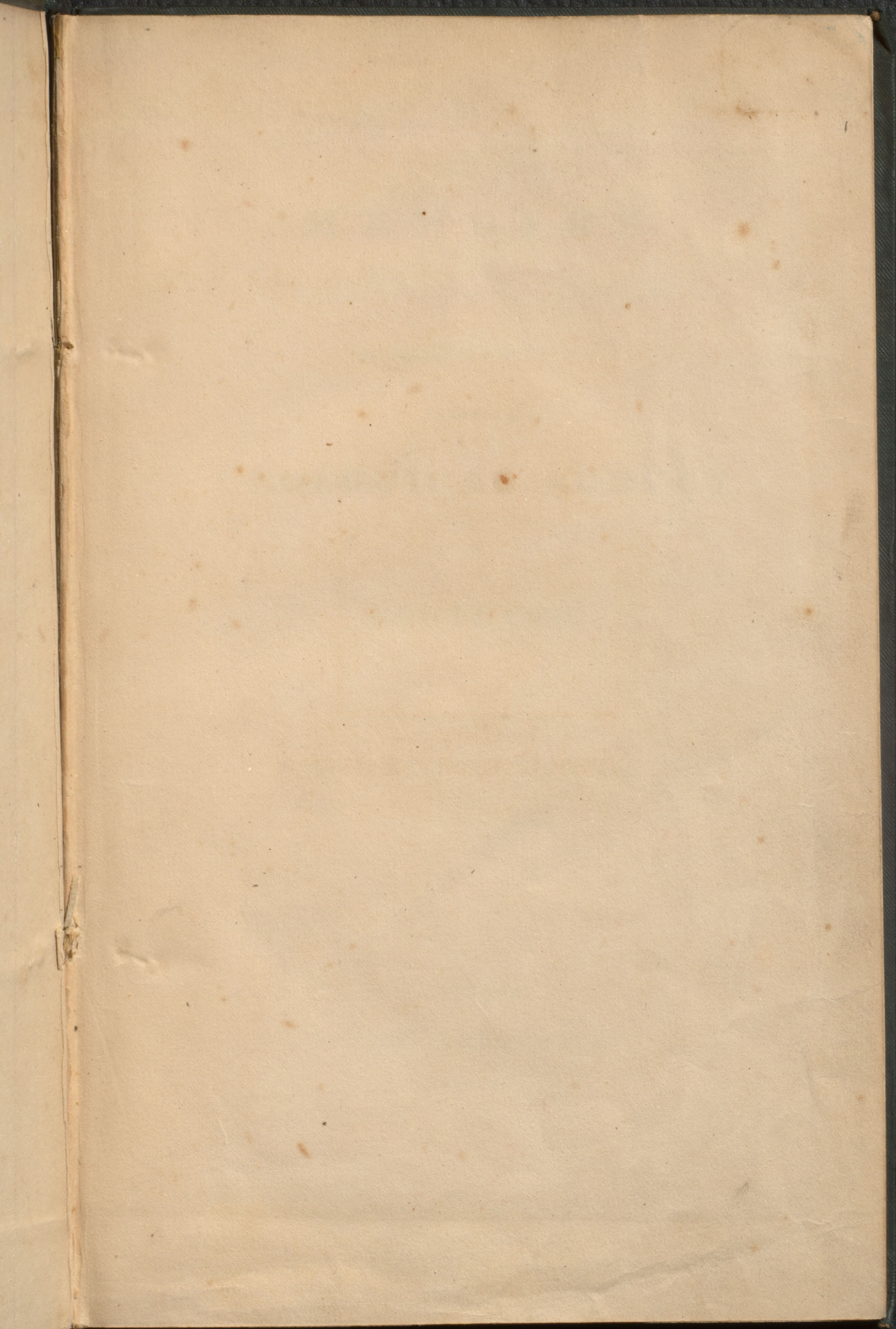
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*In manu Domini sunt omnes fines terrarum.*



*Ex Libris*  
*Frank Dawson Adams*











*Indanbile*

**M E M O I R S**

TO

HIS MAJESTY'S TREASURY

RESPECTING A

**GEOLOGICAL SURVEY**

OF

**SCOTLAND.**

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By J. MAC CULLOCH, Esq.

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LONDON:

SAMUEL ARROWSMITH.

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1836.



MEMOIRS

HIS MAJESTY'S TREASURY

AND

GEOLOGICAL SURVEY

OF

SCOTLAND.

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near Lincoln's-Inn Fields.



THE following "MEMOIRS" have been printed *verbatim* from the manuscripts of the late Mr. Mac Culloch, without note or comment. His sudden and lamented death has prevented my remarking on certain of his opinions and statements; but these, it is hoped, will be received as he meant them to be, by such as are competent judges of the real errors and deficiencies in the unfortunate Map, that became so fertile a source of his indignation.

S. A.



## EXPLANATIONS

RESPECTING THE

## GEOLOGICAL MAP OF SCOTLAND,

AS NOW PRESENTED TO THE TREASURY IN THE BEST STATE  
WHICH THE CIRCUMSTANCES PERMITTED.

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SIR,

THE Map chosen for the purpose of recording the nature, extent and boundaries of the Rocks of Scotland, being the object of this Survey, is that of Arrowsmith, since there is no other in existence uniting a sufficient size with equal detail. Even this size, being on a scale of a quarter of an inch to a mile, is inadequate to the representation of the smaller tracts, where many different rocks occur in approximation, and to that of those rocks, such as primary limestone, which occupy very narrow lines in nature; as I shall explain more fully in speaking of the colouring hereafter.

But if a much larger Map would be desirable for the purposes of such a survey and record, there are countervailing objections, arising from the expense, and from the unwieldiness of one of materially larger dimensions. The mere doubling of the scale of this, would, it is evident, demand sixteen sheets of paper where there are now four; while a scale, intermediate between a half and a quarter of an inch to the mile, would not be attended by any material accession of advantage.

A greater objection, however, to an enlarged Map, at present, consists in the want of accurate materials for such a work. The inaccuracy of the present one is so very great, that it would be to render error more striking, and to waste money, were it to be re-engraved on a larger scale. It is true, that it might be corrected in many places, from some of the more recent county maps and private surveys, and thus rendered less erroneous than at present. But it would still be a work of errors. If some of these newer county maps are of a very respectable accuracy, this is not the case with the whole: while, of every one, I believe, I may say, that the forms of the ground, so indispensable to an accurate geological survey, and to the production of a corresponding map, are laid down in so false or unintelligible a manner, that it would be idle to copy them, and impossible to reform them. If there is any one among them so tolerable as to admit of such reform by a practised surveyor and able draughtsman,



there would even then be little gained; since the greater number are quite absurd, and since there is but little correspondence between those which have been executed at very distant periods, and by different surveyors, generally careless as irresponsible, and every one taking his own peculiar views, and adopting his own conventional method of representing ground. But, under any consideration, I know not who is likely to execute such a work of labour and expense as a new compilation of a Map of Scotland. No publisher would undertake it, under the double obstacle, of the present Map, and of the prospect of an accurate one from the hands of Government; while Government, of course, would not bestow expense on so bad a subject, especially for so limited a purpose as the present, when it has already commenced a regular survey of Scotland, in conformity to that of England.

But be all this as it may, there was no resource left to me, but to take the Map as I found it, to use it in the investigation of the ground, and also to adopt it as the draught on which to record the rocks as they were ascertained. When I first commenced there were but few of even the present county maps; so that any corrections from such sources were impracticable. As they continued to appear, sometimes offering useful corrections, it often proved that the geological work had been already done by me, and entered on the present general Map; so that although it was seen to be inaccurate, from the inaccuracy of the Map, it could not be corrected without a fresh survey of the ground under the guidance of the new county map: a proceeding for which no time could be allowed, as it would also have been to prolong the work to scarcely a prospect of any termination.

If it is thought that the better class of county maps might have been used in the work, or at least in correcting the errors of the general one, it was not for want of many attempts that I was obliged to abandon all hopes of this nature. Portions of surveys were made on county maps; as all of them nearly were used in the actual surveying, for the purpose, or with the hope, of more certainly assigning the surveyor's place, and the features of the country. But the want of conformity and fitting between the works of different surveyors, sometimes in the scales, at others in the accuracy, and, at others again, in the mode of drawing and engraving, rendered it quite impracticable to enter a consistent geological survey on two of these Maps, or to continue a given tract of rock from one county to the conterminous one. Even where this might have been partially done, it became impossible to transfer the larger-scaled survey thus executed, to the general Map: so extraordinary and frequent were the discrepancies between this compilation of Arrowsmith's and the surveys of these more recent surveyors. Even passing by all these objections, the unwieldy magnitude of an extensive collection, or of that number of those large county maps which



must have been carried about, generally in the pocket or on the person, in consequence of the many counties which were often examined, to a greater or less extent, in the same season, would have rendered the use of these impossible; and far more so, when it must be recollected, that every map must have been used in the open field, perhaps a hundred times in a day, and in all kinds of weather, frequently in rain, so as to render unmanageable a larger piece of paper than could be sheltered under an umbrella; without which precaution a few minutes might have effaced the work of many weeks, or of a whole season. Hence, however occasionally useful these county maps proved, in the manner already noticed, that utility was compulsorily limited to the objects just mentioned.

It might be thought, by those who have not considered this subject, that a substitute might have been found by re-drawing these maps, or the most needful and correct of them, in a connected or a continuous manner, to one common scale, and on one of inferior magnitude and more convenience. But while such a work would have required the labour of regular draughtsmen, of an establishment, in reality, superadded to that of the mere geological surveyor, when the comparisons, the adaptations, the reductions, and even the mere labour of the work, are considered, such a work would not then have answered all the necessary purposes, unless as many copies could have been furnished as the geological surveyor might have called for. The wear of maps is unavoidable, under the frequent use of them already alluded to; under the friction which they must undergo in the pocket or otherwise, especially at the foldings and angles, and under the inevitable exposure to rain, or to the wet clothes of the surveyor. Thence a frequent renovation, of parts at least, is necessary: so that nothing but an engraved plate, capable of furnishing many impressions, would have answered the purpose: while I need not repeat the objections to such an attempt as this.

Thus do the reasons appear why I was condemned to the use of Arrowsmith's Map; inaccurate as I daily found it to be, as well in the political as in the physical geography, and greatly as these inaccuracies continued to increase on my hands as I became better acquainted with the country: to say nothing of the great inconvenience, difficulty, and obscurity, which I have elsewhere noticed as arising from the blackness of the engraving, in confusing or rendering doubtful many of the colours applied to the distinctions of the rocks.

These reasons for the proceeding here adopted, which are due to the Government that directed this work, ought also equally to satisfy those who may consult this Survey; unless, indeed, it be such persons as seek for a ground of censure in the non-performance of impossibilities. But let it at the same time be understood, that these unavoidable explanations are the sole reasons for the criticism and consequent censure often here be-



stowed on the Map in question, since it is with great unwillingness that I have said aught which may depreciate the value of a tradesman's property, to which, after all, recourse must be had, in some manner, for the object of publication.

But where there was known inaccuracy in this Geological Survey, of which I shall hereafter point out examples, it was not just that the geological surveyor should be blamed for faults not his own; as, without this explanation, His Majesty's Government might have equally seemed to deserve blame for the choice of an incompetent person. The faults actually exist in the Geological Survey, as I know far better than any other person, or any hundred persons are ever likely to do: but those faults lie in the Geographical Draught, and he who has committed them is the person who ought to bear the blame; as even he cannot expect that the surveyor, who has already suffered most deeply by them, is to bear them for him.

I must now add, that it was found necessary to make some additions to this Map, in replacement of omissions and errors; with respect to which I must here make the following remarks:

The rocks called Stack and Skerry, lying to the north of the Sutherland coast, are omitted in Arrowsmith; but I have not added them, though I examined them as wishing to leave no blot in this work; because they do not seem to justify the extension of the printed sheet to which they belong, so far, or even such an appendage as those two which I have added in other places: it must suffice to say that they consist of gneiss.

The islands of Barra and Rona (North) are grievously misplaced in that Map, both in latitude and longitude; and having therefore observed for their places when I examined them, I have restored them to their proper situations, in a Rider to the engraved Map.

St. Kilda is omitted entirely; nor is there even any note for its place, as there is neither map nor measurement in existence. I have taken its place from the Nautical Tables; and its form and measurement are the result of an examination by walking and a pocket compass; inaccurate, of course, but sufficient for the present purpose, as the rocks are very simple. It is also appended as another Rider to the engraved Map.

It is now indispensable to make some more detailed remarks on the inaccuracy of Arrowsmith's Map, before proceeding to any description of the coloured work, as an intended representation of the places, spaces, and boundaries of the several rocks which constitute the mineral structure of Scotland. No one can know this inaccuracy as it is known to me; since nothing but that minute examination of the entire country which I have made, and which will never again be made by one person, could detect these errors. The ordinary use made of maps leads to no knowledge or criticism of this nature; since that seldom relates to more than the political geography, in which also even great errors pass unnoticed. Thence, and from the magnitude, splendour



and reputation of this work, it is generally esteemed unexceptionable. But should any geologist or mineral surveyor, believing this to be true, examine the coloured work, and compare it with nature, he will find it full of errors, as to the dimensions and boundaries of rocks, and will, as naturally, attribute them to the geological surveyor, not to the map-maker, or the incorrect basis which the former was obliged to use as the draught for his entries. If it is important to the reputation of the surveyor to show where the real errors lie, and what were the causes which rendered an accurate geological survey impossible on so bad a basis; so is it even more due to His Majesty's Government, which adopted part of this Survey, and ordered the remainder; lest blame should fall on them, as I have just remarked, for an improper choice, or for not doing what it is not, now, in the power of any Government to effect.

This reason will also apply to the enumeration of other sources of error, doubt, or imperfection, which I shall hereafter notice: it being essential that no pretence be supposed, of giving out as an accurate work that which is known not to be such. But it is those persons alone that may have attempted such a one, who know that accuracy is unattainable, and will probably ever be so, under any increase of knowledge and length of labour. They who are ignorant of this subject, and who may therefore have formed higher expectations, ought also to be now undeceived; which I can only do by showing, together with the errors, what are the sources of these, and how often they are irremediable ones.

If I have noted down, for my own satisfaction, all those errors in this Map which rendered an accurate geological survey impracticable, the detail is infinitely too long for this report. The enumeration of a few of the principal ones, of different kinds, which I have selected as examples, both in the physical and the political geography, may, I hope, suffice; and he who will multiply them all, a hundredfold and more, (I might almost say a thousandfold), will be in no danger of exceeding the truth; so widely does error pervade the whole of this unworthy Map.

Whatever other disgrace may attach to the actual surveyors whose documents are thus compiled into this whole, it is the pure fault of the compiler not to have adopted a system of progressive correction. But if the ancient defects in the physical geography thus remain uncorrected, while they might have been amended from more modern surveys, that which I shall first notice relates to the political geography; as it admitted of easy correction, and as this class of error gives the geological surveyor more trouble than all else in the actual investigation of the ground, while equally depriving him of the power of laying down on the map what he has examined and ascertained.

His points and lines of reference for the places and boundaries of rocks, consist partly in objects of physical, and partly in those of political geography. Without these he can do nothing; and



in proportion to their number and truth will the work of surveying be easy and sure, and the records accurate. Reversely, defect or error in these renders the first laborious, and often impracticable; as the latter become a mere matter of chance, and as likely to be wrong as right.

In the political geography (to note this first), the objects are towns, churches, houses, and so forth, together with roads; and these last are of the chief importance, since they are not only the most extensive references, but are those to which any one examining the work, for whatever purpose, that he may know the facts in nature by means of it, will naturally refer; as his examinations will also be chiefly made from roads, in the act of travelling. It is even more important to recollect that they form the chief basis of the surveyor's operations. He is not indeed confined to roads, but he must make a principal use of them; as by them he will ascertain most frequently what object or ground in nature finds its correspondent mark and place in his map. And similarly, it is by referring the places of the rocks in nature to such roads, that he will find the best, and often the only means of noting those places on the map. I need not say that a record of rocks by any mode of triangulation or measurement would be impracticable, by at least less labour than a geographical survey would demand,—the labour of many men and many years; while, though executed, it would be purposeless, unless it referred to and coincided with that geographical survey by which all future observers will be guided in their studies or inquiries.

Now it has happened in Scotland, that entire new systems of roads have been constructed all over the country, since this Map was compiled, while many of the old ones have been abandoned. If these new roads are sometimes found where no road ever was before, it is evident that they at least furnish no assistance, if they produce no positive evil; since there are no means of ascertaining on this Map whereabouts they lie. But the most insurmountable difficulties, with consequent incorrigible errors, arise where the new roads lie near the old ones; deviating from them, or interspersed among them. The surveyor thus sees a road in the Map, which he believes to be the one he is on; not finding till too late, or perhaps never discovering at all, that they are miles asunder; in consequence of which his entries are made in a wrong place, with a frequent consequent production of grievous errors, or of a confusion which he has afterwards no time to remedy. And thence also, amid this misplacement, and from the want of correspondence between the actual roads and those in the Map, does the physical geography become so confused or unintelligible, that he cannot make out what it is, nor conjecture where to seek it on the Map; since no portion of it but what consists in rivers and lakes and sea-shores is given with even tolerable truth. These also are of far too rare occurrence, compared to the total extent, to offer much assistance, considering



the innumerable wants of this nature: while the representations of the ground, instead of giving any aid, are generally so false as to assist in misleading him.

If this source of difficulty and error is nearly universal, so is it true that the incorrect manner in which the roads actually drawn, are placed, leads to frequent similar errors and difficulties. In nature, the boundary of a tract of rock will bear a certain relation, first, to a river or other circumstance in the physical geography, and next, to a road entered on the Map. But this last entry being inaccurate, the rock, as delineated on the draught, cannot be brought into a true relation to both; and it has thus turned out that the boundaries of the rocks, in many different places, as I have been compelled to lay them down, cannot be made to reconcile with anything; for the obvious reason, that the two kinds of geography, the physical and the political, are irreconcilable.

It is plain, therefore, that in all these cases, he who attempts to investigate the country with the Map in his hand, will find himself at a loss, or suppose error on the part of the surveyor, where the real error is in the Map itself. If he examines from a road, it may be a different one from that used by the surveyor; or he may make the same species of mistake, by referring to the road which he sees on the Map, when he is, in fact, in a far different place: or, reversely, if he examines by the physical geography, that which the surveyor has referred to a road, he will equally suppose the latter in error; unaware of the circumstances which I have thus noticed.

This is but a slender sketch of the nature of these sources of difficulty, and of error, real or apparent; it would be tedious to state them more fully. It would be still more so to point out the facts themselves on the Map, as a statement of its errors would occupy no small volume. Two examples must suffice: they will be specimens of what will be found everywhere, by him who shall pursue the comparison of this Map with the ground in nature; as I might myself have added hundreds of similar ones.

The road between Ayr and Dalmellington is accompanied by a river, for some space, through a very marked valley, where the several boundaries of red sandstone, coal, and trap, lie. The river or the road form the best references for these different and most important boundaries; as the ground might have done had it been well laid down, since it is very strongly characterized. But the road is so extremely incorrect, that a reference to the river causes the boundaries to bear a relation to the road, which any one, going along it, will see to be false; while, if it is attempted to prevent this by referring to the road, then the same falsity of entry takes place as to the river.

Of the error or confusion which may occur by mistaking a new road for an old one, or by referring to the map road that which has been examined by the road in actual use, a case near



Pennycuik will afford a sufficient example. Here, the boundary of the slate and the coal series is very accurately defined by the old road to Peebles; but this having been replaced by a new one at a little distance, is abandoned, while it is the only one in the Map. He who travels the new road does not perceive this; and thence, on inspecting the coloured Map, he will imagine a gross error, in having placed a boundary of slate where he cannot see it.

If these and similar facts might be multiplied without end, it is also unfortunate for the apparent accuracy, or repute, of the work, that the most numerous changes of this nature occur in the most intricate and interesting parts of the country; as they do also in those which, from their populousness and value, are most likely to be the subjects of examination. Among these I may name Fife, where, from the inaccuracy, defect, addition, and misplacement of roads, added to the gross errors in distances, to the utterly false or absurd representation of the physical geography, and to the intricacy of the country itself, both on this point and in the disposition of its rocks, it becomes utterly impossible to give on the Map a true representation of that which, in itself, offers no difficulty whatever.

Of the whole of Scotland, indeed, I may say generally, that whatever the personal labour and the ordinary difficulties of travelling through such a country as much of it presents, may be, there is extremely little obscurity either in the disposition or the boundaries of its rocks; as, for the greater part, nothing can be more clear and satisfactory to the geological surveyor than the structure of the country. With an accurate Map, therefore, there would be no difficulty in giving a very true geological survey; and it is scarcely possible, therefore, to describe the mortification which is felt, from finding that all this knowledge is wasted, since it cannot be recorded; or in similarly discovering that it must be falsified in some manner or other, if it is to be brought into any tolerable coincidence with that false geography which the Map represents. Let the vexations, fatigues, privations, or absolute sufferings have been what they may, the whole united have been far exceeded by the mixture of never-ending anxiety, disappointment, and mortification proceeding from this single cause.

The other errors in the political geography of this Map, arising similarly, more from its antiquity than any other cause, are of less moment than those which relate to the roads: yet they are often sufficiently troublesome to prove great sources of confusion and error, both in the examination itself, and in the entries on the geological Map; while, in a similar manner, the attempts to verify the present work on the ground, will often lead to the supposition of error, even where the boundaries are correctly given, but where they have been laid down under a different reference from that which the verifier may have supposed.



This Map is very laudably filled with names of petty villages and houses, and nothing can be more desirable than this to him who wishes to give an accurate geological survey: since it not only facilitates references, but renders the work more useful, by the accurate definition of boundaries. And as it is also a test of truth, it is especially desirable to him who knows that his work is accurate: while he who omits such points in his geological maps, when he might have possessed or introduced them, is conscious that his work will not bear examination; or is giving a general, and often a conjectural sketch, rather than a work deserving the name of a geological map.

But the immense increase of population, with the enormous extent of new cultivation in Scotland since this Map was compiled, has produced the most extraordinary discrepancy between the actual state of the country with respect to houses and villages, and that which is represented on it. Farms, which appear important references in this geographical work, have vanished, or have become so insignificant that they cannot be found, their names being forgotten by the country people, to whom we must refer as *gudies* for this purpose: while if many have been transferred, under the same name, to new situations, there are thousands, in every part of the country, being also the most conspicuous, which are without name or place in the Map. The confusion and difficulty hence resulting are extreme, and often perfectly inextricable; as the consequences are similar, both in the investigations and the entries, to those which arise from the actual state of the roads compared to their dispositions and numbers on the Map. Nor is this discrepancy true of the farm-houses and petty villages alone; since many of even the parish churches are rebuilt in situations far wide of that which they held when this Map was compiled, so as to aid very particularly in confusing the records of the geology, and in misleading the observer; as they must hereafter mislead him who attempts to verify the present work, or, as is most likely, make him believe that he has discovered faults of carelessness or neglect.

To this I may also add the errors and the omissions of the Map, respecting objects of this nature which were in existence at the period of its compilation; including, not only conspicuous farms and manorial houses, but even ancient villages, castles, and parish churches. An important parish church, important to the geological surveyor, as it serves to define the course of a narrow tract of red sandstone near the southern Esk, is not noticed in it. In Aberdeenshire there is a road to Echt, by which a complicated boundary of gneiss and granite might have been defined; but there is no road in the Map. Failing this, there is an ancient castle, by which an essential part at least of that boundary might have been fixed; as, in other places, there are villages, and in another again, an ancient inn. But all are equally wanting; and as not even the forms of the ground are noted, it be-



comes utterly impossible to know where to place on the Map those rocks which there is no difficulty in ascertaining. In Fife, and where a geological reference might have been found in a large ancient village, there is no such place marked; but this, and similar things, are so true of that intricate piece of geology, that it would be endless to note them. And not to extend the examples of this class of error, I shall lastly content myself with pointing out a large tract of country near the Dee, and extending from Strahan, which the Map represents as a tract of barren, roadless, uninhabited mountain land, whereas it contains villages and houses beyond enumeration, with roads in abundance, all of a high antiquity, and thus forming one of the most populous portions of this county. The slightest reflection, even on the part of those who are utterly ignorant of this subject, must show how impossible it must be to give a true survey of this nature on a basis so utterly false. For aught of resemblance between the country itself, and its pretended Map, whether under physical or political geography, there are many parts of it which might as well pass for draughts of Africa as of Scotland.

I presume that I need not extend this class of remarks, as I dare not here occupy more space with them. He who may hereafter choose to examine the country by means of this Map, whether he shall do it for the purposes of geology or not, will soon convince himself that I have not told the least part of the truth; and, if a candid examiner, he will seldom find much difficulty in explaining the source of the actual errors and apparent mis-statements which he may discover in the geological survey. A great number of these, at least, are now well known to myself; and I once intended to have given a list of them, since it was impossible to correct them without that fresh survey for which time could not be allowed; while even then but a very small portion of the whole could have been corrected on the Map, from its own incorrigible inaccuracy and deficiencies. But I found that such a list would have proved far too long, and much too difficult to verify on the Map, from the same causes; so that I must now be satisfied with this general statement, which will at least serve to prove that few will hereafter find defects of which I am not perfectly aware, and which I could not myself have pointed out.

I must now turn to those deficiencies which belong to the physical geography of the country; errors, or falsities, or defects, which alone would suffice to produce as much difficulty and mis-statement as those just pointed out, but which, united to them, augment these in an incalculable degree. If there was truth in either, it would correct the falsity of the other in some measure; but the complication between two modes of falsity is a source of confusion which no one can comprehend who has not made the same attempts as myself, with the same anxiety after truth.



It is partly an irremediable defect arising from the smallness of the scale of the Map, and partly from the badness of the surveys and drawings, that tracts of complicated hilly ground are not correctly expressed in it, or not expressed at all. And as such complicated ground is generally the consequence of diversities in the rocks, while there are not a sufficient number of points in the political geography to which they can be referred, there are no means whatever of representing on the Map that which is perfectly obvious on the ground itself, and could be recorded without the least difficulty on a true map. If examples of this source of mis-statement occur all over Scotland, they are especially remarkable in Fife, where also they are especially vexatious, because it is a question between the places and boundaries of coal strata, often producing workable coal, and the trap rocks which interfere with and interrupt these. But it must suffice here to point out the tract which includes Burntisland and Auchtertoole, in which it has proved impossible to enter on this Map the several rocks as they occur on the ground, absolutely defined and easy of investigation as they all are.

It is a simple error in the physical geography, to have stated distances on the Map differently from what they are in nature. This, sufficiently unpardonable fault in a geographical survey, is of perpetual occurrence; and though sometimes of no great moment to the geological surveyor and his work, it frequently leads to difficulties and doubtful entries, or to absolute mis-statements, for which also there is no correction to be found. Where political or physical points of reference are wanting, there is no resource but to measure for the boundary of a given rock, from some assigned point on the Map, as the nearest convenient distance. But the distances of two such points being falsely given, the reference which may be true for one, is not true for the other. Thence a great apparent error, to him who may have chosen a different point of reference from that of the geological surveyor, supposing that he has adopted this method; while if he has adopted the expedient of averaging and dividing the error, the examiner of the ground by means of the Map, will necessarily find both references wrong. And thus also, in some cases, where many rocks occur in such a space, there is not room for them on the Map, if that has been made too small at this part; while, if too large, they must be displaced or magnified, that something at least like a true general record may be made.

To notice an example, out of many, under each of these cases: the successive boundaries of clay slate, mica slate, gneiss, and granite, on the Cairney Mount line, can only be ascertained by a measurement of each belt with reference to the bridge of Dye, or to a more southern point; whereas the distances on the Map are so false, that the measures taken from that point, and from the reverse one, entirely differ, so as to throw confusion into the whole, and to compel a mere statement of the general fact. And



near Kilbride, where many edges of limestone occur in a somewhat narrow tract, the same incorrectness renders it quite impossible to place them in the situations and proportions which they possess in nature.

But the defects in the physical geography of this Map are far from being thus limited, while they pervade almost every part of the country. The great exceptions to this are in those tracts which appear to have been surveyed under General Roy, and chiefly on the north-western coast, and in the private surveys of Lord Macdonald's estate, including North Uist, with a portion of Sky. In most other districts, the errors, omissions and falsities are nearly incredible, so that the country can scarcely be recognized; while, unfortunately, this Map has proved worst where the wants of the geological surveyor, arising from the intricacy of the rocks, especially demanded accuracy of detail. And perhaps this is most true of Aberdeenshire, which being in every respect one of the most difficult portions of Scotland to examine and record, seems also to have the worst map in the whole of this compilation.

I need not repeat that the circumstances of the physical geography form joint references with those of the political, for the placing of the rocks on the geological draught. But in the uninhabited tracts there are none but the former, since these are without houses or roads; so that when false or deficient, there is neither guide nor resource, while no system of measurement short of a new geographical survey would serve any purpose. An inspection of the Map will show the great extent of country possessing this character, and the corresponding amount therefore of difficulty or impossibility in attempting to give a true geological survey.

It is scarcely necessary to repeat, that the circumstances in physical geography here alluded to, consist in the outlines of sea-coasts, in the courses of rivers, in lakes, and in the forms and distribution of hills, together with the relative altitudes of land. With some exceptions, which are chiefly on the eastern coasts, though not thus limited, and in the misplacement of Barra and Rona, there has been little reason to complain of the maritime outlines, though there are abundant geographical errors in them. The same for the most part is true of the rivers, as far as my work has been concerned with them. But a large and most important lake, together with a smaller neighbouring one, is omitted in Sky, sufficiently marking the negligence of this Map. I allude, in the first, to Coruisk. And from its antiquity, it happens that many spots represented as lakes are now solid land, whether from alluvium or drainage; as in Aberdeenshire, in Kinross (or Fife), and at the upper part of Loch Awe.

But these are of small moment to the geological survey, compared to the deficiencies in the drawing of the ground; while even the total omission of all the interior physical geography, as in Rasay, Lewis, Benbecula, and more places, however discredit-



able, has fortunately produced no evil effect as to this Survey, from the casual coincidence of them with simplicity in the rocks. It is far otherwise as to the distribution and altitudes of the hills.

Were Scotland represented by the drawings of a military surveyor, or in the manner of the best recent maps, there would scarcely be a difficulty to the geological surveyor, either in the examination or the record, above all, in the hilly and mountainous tracts; and an accurate map would be as easy to make as it would be sure of avoiding all criticism. Such a draught of ground is a guide to the rocks, because its forms depend on them; and on such a draught also they can be laid down with precision. It is not too much to say, that every thing the reverse is true of the present Map; and thus does each class of difficulty multiply, as it also becomes impossible to define the several rocks justly. There is no guide at all in the drawing, or else it is a false one; and thus again follows the eternal mortification of finding that all the labour of investigation has been thrown away, for want of the means of recording it.

It would require but a small geologist indeed to lay down the rocks of any part of England on the Ordnance maps; as he is to be envied on whom such a duty may hereafter fall: while the reputation which the public will probably assign to him, ought in justice to be transferred to the geographical surveyors of that splendid work.

It would form too long a criticism to point out in this Map the defects and errors of this nature. Essentially, the deficiency is universal, because the mode adopted to represent the ground is a bad one, even where the basis is not untrue. In the details, the leading errors are, untrue positions, untrue forms as referred to the ground plan, untrue elevations and untrue proportions in those, an entire want of distinctive characters, and lastly, the omissions of existing hills, with the exaggeration of many that have but an indistinct existence, and the fabrication of others which are absolutely non-existent. It is easy to see how much this class of error must add to the apparent geological mis-statements arising from all else already noticed; as also how it must often be a peculiar source of error or uncertainty in the geological draught, in those great tracts where there is no other guide and basis but the forms and distributions of the mountains. As before, I shall select a few examples in proof of this criticism; while any one who shall examine the country may easily multiply them: noticing only, as an act of justice, that with few exceptions, that portion of Sutherland and Ross which I presume to have been derived from General Roy's surveys, is executed in a very creditable manner, and is often remarkably true.

Meal Fourvony, which is scarcely distinguishable from the general ridge to which it belongs, is represented with as much force as Ben Nevis: but if that is of little moment to the mere geological survey, it is far otherwise with Ben Nevis itself, of



which the draught is so very incorrect and fanciful, that it is impossible to lay down on the Map the alternations of gneiss and mica slate which occur along the train of mountain summits lying between it and Loch Treig. But far worse is that tract of mountain land which extends from Cruachan to the moor of Rannoch; where, for a wide open valley in nature, there is substituted in the Map a wall of lofty mountains. And as the joint boundary of the gneiss and granite lies here, it became quite impossible to conjecture where it ought to be placed in the Map: whence the record which I have been compelled to make is that of mere hazard. Of this large tract I may indeed say generally, that the badness of the Map rendered it impossible to lay the rocks down truly, so that, like much more, a true statement, under such corrections as a new geological survey may render necessary, must be deferred till a new geographical one has been made.

I might make the same or similar remarks on a hundred other places, were it not impossible, in a memoir like this, to multiply such details. The same kind of errors exist all over the Map; and they are often the worst that could have existed, because, as I have already remarked, the rocks and their changes are the causes of the hills and of the variations of their forms. Thus a false hill implies the entry of a rock in a false manner, as a misplaced one leads, either to the equal misplacement of a rock, or, if other neighbouring rocks will not permit of this, to the placing it on perhaps a flat, when its place is the summit of a hill. A remarkable case of this kind occurs in Banffshire. And if these very provoking sources of unavoidable, yet, of known and conscious error, in the geological entries, be added to all the rest, it will be easy to conjecture what must be the extent of incorrectness in this work; yet of incorrectness which could not have been avoided, and for which the surveyor is in no manner responsible, as he has here desired that it shall be fully appreciated. Throughout, it is not a true representation of nature, as the geology is concerned, but an attempt to adapt such a representation to a fundamentally false geographical basis. How much additional labour, added to doubt and hesitation, has arisen from this cause, I need scarcely urge; but I can safely say, that on a competent map, the work would not only have been truly done, but done in far less time; as, if it had originally been commenced under a regular plan, with an intention of executing it throughout from the commencement, it might easily have been finished in perhaps half the time which it has occupied, and with a far different accuracy.

But when I thus speak of its inaccuracy, it is from assuming that a geological survey should be truly geographical; from taking a standard which I know will never be reached; since there are many other impediments to perfection than those of a bad geographical basis, as I shall hereafter point out. Yet this



perfection ought to be the aim of every one ; as it has been my own, in all those portions which were examined after the intention to produce an entire Map had arisen, and the work had been commanded ; as far as the limited time allowed of this accuracy of investigation. Hitherto, geological Maps have been of a very different character : being broad general sketches, of which the greater parts were conjectural, without any great regard to boundaries, and with a suppression of those geographical details by which they might be verified ; while, instead of being the produce of actual surveys, they have been largely compiled from verbal and manuscript reports, and from the discordant views of different persons, often very incompetent to such a work. He who merely sees such a map will think it a great, and perhaps a perfect effort ; since it is tried by its own statements : but he who may labour to verify it on the ground will form a truer judgment, and, if a severe critic, or an unpardoning lover of truth, may view it with contempt, or reject it as fiction or pretence. That even such a sketch may have some uses in geological science, may however be admitted ; but it can never form a statistical survey, whatever aid it may furnish to future observers. The present effort, and the first of its kind, while it is all the work of one hand, under at least a consistency of views, will, with all its defects, form the basis of a new æra in geological surveying ; and I can only regret that it was impossible to execute all that I wished.

After such a statement of difficulties and imperfections, arising from the imperfections of the geographical basis, it is easy to remark that such a work should not have been attempted, and not less easy to represent it as useless for its professed objects. But the imperfections of the Map were not suspected by any one when it was commenced ; they only developed themselves during the progress of the work, when it could not have been abandoned. Nor was it right to abandon, or delay, even so deficient a work, when there was no immediate prospect of a better geographical survey ; since it was to prolong to an unknown period the pursuit of a useful study, because a collateral one was not yet perfected.

Nor is its utility marred by the imperfections which I have noticed. The general distributions and places of the rocks which form Scotland will now be known ; whereas, before this, with exception of my own work on the Western Islands, and Dr. Hibbert's Map of Shetland, (a survey of great merit), not a mile of land in all Scotland had been surveyed and recorded. The whole country, indeed, islands and all, were so absolutely unknown when I commenced this work, that I was unable to borrow the description of a single mile in aid of it ; as, throughout its whole progress, I have not derived even a hint, far less a fact, or an acre, from any other hand.

But while, with its acknowledged imperfections, it will now



form the basis of a more accurate work at some future time, I must here notice what the facilities and the difficulties of such a work will be.

Every geologist has found it abundantly easy to follow in the track of him who has gone before, though utterly incapable of performing an atom of the original survey. All the difficulty of discernment and investigation is overcome; all the greater tracts, requiring all the labour and all the knowledge, are laid down; and nothing remains for the follower, but to settle boundaries with more accuracy than the divided and extended attention of the original surveyor permitted. He may spend months on a few points, where his precursor had not hours to bestow; and with nothing more to do than to correct the mere geography, since all else is done to his hand. And thus also he may discover small tracts of rock which his teacher had passed by, or not approached, over the great surface under his care. Hence he becomes the corrector; as a multiplicity of such correctors, and nothing less than numbers and time, will at length produce a perfect work. If thus also he becomes the petty and censorious critic of what he could never have understood till it was taught him by the precursor whom he criticises, he must seek his praise from minds of a similar calibre and feeling; since he will assuredly be placed in his due station by the learned, the judicious, and the honourable, though men of this nature must be sought in posterity.

He who desires, from views of utility, not from vanity and the love of censure, to extend the present work to a larger scale, and to a greater multiplicity and accuracy of detail, will now have the means of doing this. It is true that he cannot do it without a fresh survey of the ground; but while his limits are likely to be that of a county, or less, his toil will not be great. The places and the natures of the rocks are before him, together with their general extent and limits, and often their accurate boundaries. His first labour will consist in the adaptation of an imperfect to a better geography, and of a small scale to a large one. This done, a re-examination of the stated boundaries, with such corrections as they may require, either from their own defects, or that they may be applied to a larger and better map, will complete his work; and he may thus construct county maps of geology, if such be his wish, with an accuracy as great as can be desired or expected. Nor will it require a refined geologist to do this. The rocks are few, and it is easy to learn to recognize them; there is nothing which any man may not attain, on this narrow subject, with a few weeks of experience. It will confer no particular fame on any future self-constituted geologist, to have done what could have been effected by a surveyor's drudge or a Scottish quarryman.

It will be a task of far other labour, to reproduce a new geological Map of Scotland, whenever a true geographical survey has been executed and published. Yet it will be but an extension



of the same species of labour. It will not be necessary to re-examine more than a very small portion of the whole of Scotland; since the chief work, as before, will consist in the corrections of places and boundaries, deficient or faulty on the present Map, from some of the causes already stated, and from others which will shortly be noticed. It may prove, for aught I know, that the coincidences between a true survey and the present Map are greater than I have imagined; and in this case the labour will be still lighter than I have supposed. But, whatever may be the result, it is plain that such a new work will supersede the present one, as it ought; although the time for the execution of a perfect geographical survey of the whole of Scotland seems now so distant, that our posterity alone can expect that perfect survey which I would willingly have accomplished, had it been possible.

On both these classes of correction, or attempts at better geological maps, I must make this final remark, that they will be better executed by him of an accurate geographical eye and tact, than by a better geologist who is deficient in this most essential quality. It is not nearly so difficult to know the nature of the rocks as to recognize the ground, together with the observer's place, and thence to refer the former truly to the map; and hence it is that I should expect a future and more perfect geological map from the hands of a geographical surveyor rather than from those of a geologist; above all, from a practised military surveyor and draughtsman. In reality, it is to the military engineers who may hereafter survey Scotland, that I should look for the final perfection of this work, as I trust that it may be deputed to those persons, whenever the time shall arrive.

I must now proceed to notice some other circumstances connected with this Survey, which render it a far less perfect work than I should have desired to produce, or to sanction by my name; far more, to produce as a regular survey, ordered from the beginning by His Majesty's Government, and executed under their authority. It would be necessary to do this, merely on account of the public, in case of publication, lest blame should be attached where no blame is attachable; whether to myself, or to the Government which employed me to finish a work begun without any specific order, or sanction, or appointment on their part. This appears the more necessary, because I do not think that my Lords Commissioners of the Treasury are fully aware of the particulars and progress of this work, in as far as those parts of it executed under the Board of Ordnance are concerned, although the general facts were explained at the time that they decided to order its continuance and accomplishment.

The first journeys which I undertook in Scotland were for a partial purpose required by the Ordnance, of a very limited practical nature. But as it thus became necessary to traverse many tracts of country, though somewhat widely dispersed, I felt that



I might, without any diversion of time, or any additional expense to the Government, note the other geological facts which fell in my way, and thus produce some sort of partial surveys of the country in general. Many portions of the ground, of some extent and continuity, became thus known, with considerable accuracy; while, in other districts, dispersed and partial tracts were recorded in a similar manner; yet with no other views than as an aid or a contribution to that philosophical geology which was then becoming an object of new interest in England and Scotland. Of course, no report of such supernumerary work was made to the Board of Ordnance, as no expense to the Government was incurred; whatever proved to be irrelevant to the matters ordered, having been defrayed by myself; as appeared just.

The time occupied in this work having included parts of three summers, the final record of the whole showed that a somewhat notable portion of Scotland had thus been laid down, though in a very dispersed and unconnected manner; while, though it furnished facts of much geological interest, it gave no prospects of any survey of a nature jointly mineralogical and statistical, even for the tracts thus examined. Thus it remained for a time; unthought of, and without any further design or views.

But, immediately after this, it having been suggested by the mathematicians interested in this question, that the estimate of the weight of the earth derived from the observations of Dr. Maskelyne on Schihallien and the subsequent computations of Dr. Hutton, was inaccurate, and that the source of this inaccuracy lay in imperfect geological knowledge, first, and essentially in the choice of a bad subject for the fundamental experiments, the discussions respecting the propriety of repeating these observations on a more favourable subject and mountain were revived. Mr. Playfair had offered a correction, derived from a new geological examination of Schihallien, which gave its specific gravity, as the fundamental element of the whole calculation, very different from that which had been assumed. In the mean time it fell in my way to review this examination; in which I pointed out numerous and serious errors, arising from a false view of the extent and positions of strata of highly different specific gravities, and from a very mistaken and uninformed mode of estimating those as they must have borne on the total effect of this mountain in causing the deflections of the plummets from the perpendicular. Thus it came to light, that if, in the first place, the weight of the earth was not justly assigned from Dr. Maskelyne's experiments, so, in the next, the corrections of Mr. Playfair were not corrections of the error; while the other and final conclusion was, that however Schihallien might afford a convenient object of mechanical measurement, and however perfect a subject it might therefore have been could its specific gravity have been truly ascertained, with the several actions of its complicated structure on the plummets, and thus on the directions



of the observing instruments for the stars, the great intricacy of its geological structure, and the consequent impossibility of justly assigning its influence as well as its absolute weight, rendered it a hopeless subject for this fundamental investigation.

It was in consequence of these discussions that I was ordered to make a general examination of the mountains of Scotland, for the purpose of discovering some one among them, on which these experiments might be repeated with the prospect of a more accurate result. This work occupied many seasons; as it also led me widely, though dispersedly, over the larger part of that country, since the far greater number of the expected subjects proved unfit for the purposes in view, from various causes; while the whole of this investigation is detailed in a special report to the Board of Ordnance.

But it thence happened, that from this compulsory movement from point to point, over so much of the country, I was enabled to see large portions of it; as, in many cases also, the assignment of the structure of a mountain compelled me to investigate the geology of the connected and related tracts. Thus, in addition to the observations made in the first division of these journeys, I was enabled to enlarge and continue a species of general geological survey of Scotland, yet still in a very dispersed and irregular manner; as I did not feel myself justified in expending the time otherwise destined, or the public money, on that respecting which I had no orders. The general intention was, to contribute to geological science and to the topographical knowledge of Britain, as its rocks were concerned; and thus also was this particular survey terminated, with those results of which the Board of Ordnance is informed in a special detailed report.

This service being thus terminated, no further prospects were entertained of carrying the work of a geological survey of this country any further; though all which had been done was entered on the Map, in the best manner that observations so scattered, and spread over so many years, without any general plan or ultimate views of the present nature, permitted.

But there immediately arose another question among the mathematicians under the Board of Ordnance, consequent on some remarks of the Baron de Zach and Mr. Playfair, I presume, and on the visit of the French mathematicians to this country for the purpose of connecting their several meridians as used for the measurement of the earth. It was proved, or suspected, that the deflections of the plummet produced by the nature of the ground, were or might be such as materially to influence conclusions derived from instruments regulated either by this instrument or a spirit level; and that from this cause the observations derived from the times of pendulums might prove inaccurate, with consequent false results.

A third set of journeys and examinations was therefore ordered, for the purpose of affording geological corrections, if any such should prove necessary, to the observations of the mathe-



maticians ; while these were directed, chiefly, but not exclusively, to the meridians that were chosen as forming the only convenient coincidence in one long line, which, as being well known, I need not describe.

Thus another opportunity was afforded of extending the geological survey which had already been effected in the partial and dispersed manner formerly stated ; and at length in such a manner and with such an effect, that some general connection began to take place, so as to give a notion of the total structure of Scotland which had never yet been formed or even conjectured. The final collection of all these scattered observations on the Map, which still, however, continued to be nothing more than an object of philosophical curiosity, or the source of a hope for improving geological science, served at length to show the progress that had been made in a general survey of Scotland ; while that was found to be much greater than had been supposed before this approximation of all these different surveys on a single draught.

It is now necessary to say that, thus far, no public expense had been bestowed on this geological and general Survey. The Board of Ordnance had not commanded these additional observations, nor designed such a survey. They were occasionally informed that this supererogatory work had been done, as the progress was regularly stated after it had assumed a tangible shape. They did not object, as they did not order ; nor was there any apparent reason for objecting, as none of the time due to the commanded service was diverted to this purpose, and as every additional expense incurred by it was defrayed by myself. The final result, at present, consequently is, that out of the whole of this Survey as now completed, but a very inferior moiety has been paid for by the public money ; since a special and distinct survey, under each of the heads already stated, was completed and reported, under the orders that were issued and the payments that were assigned by the established regulations of office. The whole, therefore, of this supererogatory survey, forming the basis and principal portion of the total work, must be considered as having been furnished, or contributed by the surveyor, free of all public expense ; and thence the public money expended on the latter portion must be distributed as if over the whole, since it is the sole one that has been incurred for the total Survey.

It remains to say, on this subject, that when the work had arrived at the condition already stated, so as to afford a rational hope of a complete survey of Scotland, it was proposed to the Board of Ordnance to continue their former orders, for this specific end. This, however, was not deemed expedient on their part ; but the question having been referred to the Lords of the Treasury, the further prosecution was adopted by them, with the result of bringing it to the present termination, in the exact time which had been originally estimated as necessary to its completion.



If this statement be requisite for other reasons, so is it most essential for the purpose of accounting for another source of defects or errors, different from that already detailed as arising from the imperfections of the geographical basis on which this Survey is delineated. If such a work had been originally intended and ordered, a plan would have been laid down, as it would have been consistently pursued; as thus also the attention would not have been diverted from the main object by the petty details of different partial and limited subjects. In the present case, where there was a specific order for an object equally special, every thing was slurred over or omitted which might in any way have interfered with that. Thus it necessarily follows, that if there are not any absolute omissions, there are many imperfections, and unquestionably many errors, in all that portion of this Survey which was executed before it came under an order of the Treasury for this specific end. The time applied to it was inadequate, as the necessary attention could not have been with justice given to it, where there was no order to that effect, and where another set of orders were to be executed. The dispersion of the observations, the very distant times at which they were made, the total absence of any possible plan or connected series of observations, with the necessity of joining these in the best practicable manner at after periods, and the absence of any intention to produce an accurate statistical work, while the only hope was to give some aid to geological philosophy and knowledge through new topographical facts, will also account and apologize for inaccuracies for which no other apology ought to be required beyond this simple statement. It is one which equally relieves from all blame, the surveyor whose work it is, and the Government under whose orders it seems to have been entirely executed. Neither can be justly deemed responsible for the entire accuracy of a work which neither intended or expected to bring to such a conclusion; while it is especially due to the Government to say, that in ordering the conclusion of a work thus unexpectedly commenced, they not only took a liberal view of its utility, but adopted the best expedient also for producing, in as short a time as possible, and at the least expense, a work which, as far as it could be of any use, ought to have been produced as soon as was practicable, though it had been but as a basis for a future and better work of the same nature.

Unquestionably, it would have been very desirable to have reviewed and corrected all those parts of this survey, which were executed under the Ordnance in the irregular and almost purposeless manner already stated; but it was not deemed advisable to do this, under views of either expense or time; and justly, since the gain could not have atoned for either of these sacrifices. I must therefore finally remark, as the main result of this historical statement of the origin and progress of the present Survey, and as that for which it has thus been made, that in addition to the geographical causes of imperfection formerly detailed, the



source of some of its greatest defects must be sought in the unavoidable circumstances under which it was carried on. I have no doubt, therefore, that the imperfections in the earlier parts of this work are considerable: while they are also dispersed over every part of the country, in such a manner that nothing but an entirely new survey, now inadmissible, or imprudent, until a new geographical survey has been executed, could rectify them. But if the very circumstances of these early surveys prevent me from pointing out where they are likely to exist, it is my duty and business to request, that whatever defects, not dependent on a false geography, may hereafter be discovered, they may be attributed to this cause: that all parties may equally be exempted from blame, for what could not have been otherwise.

This must suffice on the two great and leading sources of imperfection in the present Map: it remains to notice a few more, of a far minor influence, that nothing may remain untold, from the knowledge of which future corrections may be derived.

In a country previously unknown to geology, as Scotland was, no plan for intersecting it, so as to ascertain all its rocks in the best manner, could be formed; nor could such a plan have been executed though it had been laid down, since the time allotted to this subject, under arrangements and orders that could not be counteracted, was insufficient for such a purpose. Hence it is a matter of course, that over a surface of nearly 30,000 square miles, and in a country which is frequently of the most difficult access, as it is also widely obscured by bogs and alluvia in addition to soil and cultivation, many portions must have escaped observation altogether; as others, though visited, were rendered unintelligible, by the effect of thick rain, so frequent in Scotland and so well known, making every thing invisible; while it was not often that the allotted time permitted these parts to be re-examined.

If the effect of these several causes in producing imperfections or oversights has not been great as far as the larger tracts of rock are concerned, it is probably otherwise as to the smaller spots, although nothing but future examinations will discover whether it is so or not. I deem it exceedingly probable that there are many such omissions, as I happen also to know, through information which I can trust, that there are some; although in almost every case where I have attempted to verify such information by re-examination of the ground, I have found it so incorrect in some manner, or so entirely false, that I have been obliged to decline the insertion of those additions or corrections which have been offered by persons in whose knowledge or accuracy I could place no confidence. It is enough to be responsible for our own errors.

Now the smaller tracts of rock to which I allude are confined chiefly to granite, porphyry, primary limestone, serpentine, and mountain limestone; though in the vicinity of the trap rocks



There are frequently minute portions of the several strata existing, and often so very small that the Map has no room to express them; while similarly minute parts occasionally occur in almost all the rocks, and perhaps most importantly in that scattered and divided and encumbered tract of lias, with its associated strata, which is found on the western shores of Scotland. The general facts respecting these I must now note, while I must also name the most conspicuous cases of known or conjectured deficiencies; the former as a needful correction to this Map, and the latter as a guide to those who may hereafter labour to improve it.

Though granite often occurs in considerable tracts, it is also found in extremely small portions, surrounded by entire territories of gneiss, and moreover intermixed with it in such a manner, that unless such spot were examined yard by yard, the two could not be defined; while even if thus ascertained, neither this Map, nor one ten times as large, could find room for the record. I may also add that such minute accuracy would form an unworthy pursuit, being of equal inutility to statistics and to scientific geology; as it would be a blameworthy one, were more important things neglected for so paltry and affected a purpose. In any view, this, like much more, is the proper object of partial geological investigations and draughts; where, both the time employed, and the space of the drawing, admit of this minuteness; and it will thus become the future work of others.

Such spots of granite, it ought to be well known, are extremely difficult to find, as it is chance also that must most often lead to their discovery. They have no external conspicuity or characters by which they may be recognized at a distance, so that unless the hand is actually on them they may escape notice. And though most geologists would search the summits of mountains for them, my experience shows that this is no guide or rule. At Loch Spey, Loch Laggan, and the Moor of Rannoch, the lowest lands are of granite, often perfectly flat as well as low, so as to give to the ground the same character as the horizontal secondary strata do, while the surrounding mountains are formed of different stratified rocks. And this also is very widely true in Aberdeenshire, adding enormously to the other difficulties which belong to that county. It is plainly impossible, as it would be a censurable waste of time, to search such a country as the west of Ross and Inverness-shires, inch by inch, for every such spot of granite as it may contain; while even a search of this nature would be unavailing, when such large surfaces are covered by deep bogs and accumulations which render the rocks invisible and inaccessible. In the stratified rocks, it is easy to infer what cannot be seen; while it is thus indeed that geology performs the principal part of its work; but, of granite, nothing can be known except through an actual sight of the rock, and this is too often unattainable.

Of examples of the occasional minuteness of the spaces occu-



ped by granite, I may now point out two or three on the present Map. They were entered as examples of this fact; while many others have been omitted, under the conviction that they would not be discovered on the Map, amid the general confusion of engraving and colouring, and the certainty that the colourmen who might be employed in making copies would overlook the greater number. Even in those which are recorded, I have been obliged to enlarge the spaces a hundred or a thousand times, since they would have been incapable of representation under their actual dimensions; so that, if critically considered, the entries are false.

Such a minute fragment will be seen between Loch Tumul and Loch Rannoch, and its actual breadth is but a few yards. There is such another represented on the Buck of Cabrach, in Aberdeenshire, again near New Galloway, and further, near to Kirkmabreck, and at Heston island; though the space being here forcibly limited by the size of that island on the Map, the facts cannot be decyphered unless a section on a larger draught had been also given.

If these, like many other things in this Map, are partly given as proofs of an accuracy and minuteness of investigation which has almost turned out purposeless, from the impossibility of recording it for want of room, so have I in one place given a representation of the actual facts which occur at the junction of granite with the neighbouring strata. This will be seen on the summit of a hill near Castletown of Braemar; yet even the intermixture of colours, intricate as it is, does not represent these facts, since twenty times the space would not contain them. Whatever number of such intricate junctions were ascertained, it was plainly impossible to represent them on this Map, especially under the heaviness of the engraving; while even an attempt to do this would have produced inextricable confusion, as it would have rendered it impossible for the colourmen to copy them, without an enormous and unjustifiable expense. Hence it has been necessary in this case, as in a thousand others, to give such boundaries in their most simple forms; while this specimen will show what might have been entered, as it was surveyed, had such entries been practicable.

It was equally impracticable to represent the minute intermixtures of granite and gneiss which occur in many places, appearing to arise from the fact that the latter has been bared nearly to the surface of the former. And while it also seemed unnecessary to note this fact wherever it occurred, I have for the same reasons given one example of it, partly as a specimen of the fact, and partly because of the conspicuity of that particular tract. But the hieroglyphic colour used to express it is so very awkward, while I could not find a better one that should be sufficiently visible in small spaces, that I have not repeated it in any other place. This is a tract round Loch Garry; and the ring of Sienna surrounding gamboge is the expression adopted.



Similar remarks will apply to the granite veins. Had they been given, they would have obscured the work by fibres of brown colour, and would also have been invisible, without that enlargement of length and dimensions which would have egregiously falsified their sizes and places. In this case therefore, also, I have confined myself to an example or two, as will be seen near Banff; and if useful in this particular instance, this will also serve to show what might have been done elsewhere, had the circumstances permitted.

The masses of porphyry, though equally an independent rock, have offered less difficulty, especially where they occur in the northern parts of the country. In the south, the case is different, though they are here represented under the hieroglyphic of trap, for reasons which will be explained in another place. Though there are here many large masses, respecting which there is no difficulty, there are also numerous fragments, as well as veins, scattered over the surfaces of the slate hills, in the vicinity of Hawick, Langholm, and elsewhere. The same reasoning applies to these as to the small patches of granite already noticed. The depth of soil and peat entirely obscures many of them, and they have no external form to distinguish them from the neighbouring slate. The search for them is therefore attended by the same difficulties, while the small importance of such fragments, under any view, did not justify the expenditure of time on them, where there was so much more of far greater importance to be done, and when the time for the whole work was positively limited by the Government's plan respecting this Survey.

The absolute nature of that Order compels me now to make the following general remark, as universally applicable, and as leading to many more similar imperfections; or as at least rendering it probable that there are such. It could not be foreseen, at any stage of the work, what there might be remaining to be done, and what time therefore it might occupy. Hence it was necessary not to waste that which was so circumscribed, on a peculiarly difficult tract, especially when it did not prove of much importance, lest it should fall short on the remainder, and thus leave more important tracts untouched and blank. And this compulsory haste, under a limitation of time for the execution of that which was unknown and could nowhere be foreseen, when the due performance of such a work demanded an entire freedom from all restraint, will very widely explain imperfections, or sketchiness of execution, that will in all probability be discovered by future observers in many places; as I could now point out those where I expect they will be found, were it not too tedious an enumeration, and, if made in words, much too difficult to verify on the Map; since it would become an almost impracticable search for names to which a guide could hardly be invented.

To the veins of porphyry I may apply the same remarks as to those of granite. In many places they are so small that they could not be represented on the Map, as no useful purpose also



could have been served. But I have given a few examples of such veins where they were most remarkable, yet, of course, under a dimension on the Map infinitely greater than they possess in nature, since they would otherwise have been invisible. Even now it is difficult to see them, as they are also very likely to be missed by the colourists. In Glenco, where they are most remarkable, they are laid down under a general expression, since their crowd and numbers did not admit of an accurate record. I would gladly have marked them also as they passed through Cruachan and the Oban trap; but I found it impossible to give more than a general indication of the fact by means of a few red lines, the purple colour appropriated to this rock not being sufficiently visible on the engraved ground and the other colouring. I especially desire attention to this, lest they be wilfully or carelessly mistaken for the mountain line, expressed by the same colour.

The difficulty of discovering and representing the primary limestones has been a much more vexatious one, because of the practical uses of this substance, and the frequent inconvenience to agriculture and masonry, arising from its rarity in the primary districts of Scotland.

In every instance this rock exposes only the edge of the strata or stratum, while it is, in almost every instance also, but a single and a very thin bed; so that its superficial breadth seldom exceeds a few yards, and often does not reach to many feet. In addition to this, either these beds are very limited in length, or else they are extenuated till they disappear, to be apparently renewed in a fresh place on the same line of direction. And if to this be added the fact, that so many tracts are covered for miles by deep masses of peat, it is plain that not even an investigation of the ground by inches could find them all, while such a work alone would occupy more than the life of one man. It is utterly impossible, therefore, that I should have discovered, perhaps, the least portion of them, since they must generally be discoveries of pure accident. Yet I have examined and laid down all those respecting which I could procure any information from the country people; further adding many on which I had fallen by chance, and the prolongations of many more to unknown places, effected by tracing the directions of the stratification. Of what remains, I cannot conjecture; except that wherever I have laid one down, it will probably be found in many other places on the same line, by those who may have that time to pursue these partial investigations which I had not.

The unavoidable incorrectness in the mapping of these limestones will now be easily understood and allowed for. Though the geography of the Map had been correct, which it very seldom was found to be for such a purpose, the smallness of their dimensions rendered a great enlargement of the hieroglyphic colour necessary, though I chose, in ultramarine, the strongest and most



conspicuous one that remained to me. The least visible quantity of this, being also but a line, occupies the space of half a mile or more, in breadth, on the Map, that I might ensure its being seen by an inspector of this record, and not overlooked by the colourist copiers. But the actual breadth is not more than a few yards perhaps; incapable of representation, since it would not have occupied half the dimensions of a hair. If in some places this is of no moment, it is not so of all; since the necessary enlargement of the coloured space causes the limestone to appear at some marked geographical point where assuredly it will not be found; as the observer may thus be accused of an error which belongs to the very nature of things, not to him. For this there is no remedy: all that can be said is, that such limestones will be found near the places thus coloured in the Map, though not over the whole surfaces, either in length or breadth, or at the exact points which appear there. I need not refer to particular parts of the Map for the examples, since they occur everywhere; while the same enlargement of dimensions is also followed in other matters, for the same reasons: but I also know that many of the recorded ones are here egregiously misplaced, particularly in Aberdeenshire, from the extreme incorrectness and confusion in this part of the Map especially, rendering it quite impossible for me to discover my own place upon it. I have also retained two or three which I had taken on report, but had not found; while doubting their truth and accuracy, since, on other occasions, I found myself deceived, and rescinded the memorandum first made. Under such circumstances I have been doubtful how to act; and the errors therefore, if they prove such, must be trusted to future corrections.

The case of serpentine is very similar, with some very trivial exceptions where it is found in considerable masses. It occurs in very minute spots, or very thin beds, as it is also very rare; and there is no clue by which to conjecture its presence. Thus the discovery is as accidental as that of the limestones; while in each case, the accident of a shower of rain, or the mere turning of the head to look at another object, may cause a surveyor to miss the very thing under his feet, since he may not be more than a few seconds near to it. What may have been overlooked as to this rock, I cannot therefore conjecture; but I have laid it down in many places where it was before unknown, while also rejecting others which had been reported as existing in certain spots, but which I could not find after a careful examination.

In the record of such serpentine there has been the same difficulty as in the case of the limestones. The spaces of colour have been enlarged that the fact might be visible, with, of course, the same appearance of error. In Aberdeenshire, where it occurs in very small spots in granite, and often accompanied by limestone, the records are nearly invisible, with all the care which I could take. At Portsoy, where it occurs in a complicated mixture with other rocks, and in a very narrow space, the accurate record



of the whole was quite impossible. In this, as in many other analogous cases, large separate drawings were made; as it was afterwards attempted, but in vain, to transfer them to the Map by reduction. Such drawings could not have been published with the Map; while, being mere objects of geological curiosity, not of statistical utility, they have been for the most part destroyed, with such other drawings of special appearances as related to the mere science: having no relevancy to this ordered work, and there being now no means left to me of rendering them useful in any other manner.

The next rock which occurs universally, or at least but with one or two slight exceptions, in small quantities, is the mountain limestone. In most places, the elevated edges of a thin stratum are alone to be found; while in others, if flatter, it is only known as wrought by excavating beneath the coal series. In none, therefore, is it possible, or safe, to give it a larger breadth on the surface than the visible one, though it may cover larger spaces in some parts than I have been able to prove. The quarrymen, it is true, are very generally ready to assert this, and to say that a given tract is all limestone, because they work it at different points; but having so often ascertained that this was a mistake arising from the fractures and undulations of a stratum, and generally in the vicinity of trap, I have not adopted any such continuous tract, except in Sutherland, where it is visible, since I have not been able to prove its existence.

It is plain, therefore, that the discovery of such thin edges of limestone must be, like that of the primary ones, a matter of chance. There would be the same impossibility of making a minute investigation for so partial a purpose; and the difficulties are even enhanced as to this limestone, by the nature of the country where it occurs, and by its unexpected irregularity of disposition. On the usual doctrines of geology, it ought to be found every where between the red sandstone and the coal series; but it is very certain that this is not the fact in Scotland. It cannot therefore be sought for through the usual guides; while, owing to the upturning of the strata, through the influence of trap, it often occurs in the middle of tracts of red sandstone, and of coal sandstone also, under an apparent, if not a real anomaly, in each case. As this limestone also belongs for the most part to the cultivated countries, where the lands are deeply encumbered with alluvia, as well as obscured by cultivation, and are moreover so flat as rarely to expose any rock for many miles, it is plain that to discover it must be a matter of chance or of extreme difficulty; a difficulty not comprehended by English geologists, where this limestone forms large and evident tracts, in every place where it exists.

I may therefore say, that in no instance have I found, in the south at least, any place for these limestones beyond those which were known in the country, and generally as the subjects of quarrying; while it is therefore plain, that their extents and



places, as laid down, must be much less than the actual facts. Nothing but the total removal of the soil could discover the still unknown ones, since the flatness or the irregularity of the strata prevents their courses from being pursued or conjectured. It is true that this might be safely inferred in some cases; but there are so many more where the usual rules would deceive us, that it has not been deemed safe to follow them.

What the extent of the information thus received may be, as compared to the actual facts, is what I cannot conjecture; all that I could do was to verify it on the ground, that I might enter nothing of which I had not ascertained the existence. But in attempting this, if I verified much, there was also much that I could not find by any research. Whence, knowing the propensity of these reporters to exaggerate, and to make imaginary courses for their strata, I have refused admission to such records; while it is very likely that I have thus excluded what has a real existence. I suspect this to be the case in Fife, where I laboured in vain to find what had been said to exist; but I could not make myself responsible for the truth of what I had not proved, while I have almost invariably adhered to this rule throughout the country. It is at least as easy to supply a defect as to expunge a false statement; and while these doubtful spots are sufficiently insignificant, compared to the whole work, they are among those which it will hereafter be most easy to supply and correct, under partial and local surveys; under those surveys which, after all, must ever be the only ones applicable to practical uses.

The same species of error which unavoidably occurs in mapping the thin edges of the primary limestones, pervades the registry of these also, and commonly to a much greater degree. Very often the only accessible portion is a quarry, while there is as often but little certainty respecting its extent and course beneath the soil. Though one of the strongest colours is here also used, in lake, the actual dimensions thus laid down would have been invisible on the Map; thence is the colour extended both in length and breadth, and with those similar results which I need not repeat. For the most part too, although the quarries appear to follow certain lines, or the edges of the strata, I have kept these spots separate; in a few cases only, connecting them by a narrower line, as a general indication of what any one who chooses may extend to other places by means of a hair-pencil and a little colour. This, in fact, is conjectural mapping: there is no objection, for those who desire no more; but it was the very plan of this work to produce a real map; and thus, as far as possible, to infer nothing, especially as to objects of practical utility, which was not tolerably clear.

These are the principal facts connected with the minuteness of rocks, and the consequent difficulty, both of finding and mapping them, which it is necessary for him who may inspect this work to bear in mind. They form a commentary and explanation



scarcely less necessary than the Key, that the work may be justly understood; that the nature of what looks like error may be appreciated, and that there may be no appearance of a pretence to do what cannot and never will be done.

It remains to make some remarks on minutenesses occasionally occurring, as accidents, among those rocks, which for the most part, form large tracts in other countries; things with which Scotland abounds, as they are rare in England, and therefore scarcely suspected by those who know this latter country only. If the difficulty of discovering those is occasionally as great, that of mapping them is often much greater; and therefore, at least, do they demand the present explanation.

It is almost necessary to point out here the occurrence near Loch Greinord, of two small spots of a sandstone which I consider to be the red marl; since they are the only ones that I have found in Scotland, if I except that still doubtful portion in Arran which could not be represented on the Map. They might not otherwise be found, even through the Key; since the colour of that is conspicuous on the white paper, while these unavoidably show the same tint in a very obscure manner.

The series of lias and oolithe, one or both, sometimes attended by the green sandstone, at others containing lignite coal, is so dispersed, over so many places, often in such extremely small portions, and very frequently under trap, so as to show no surface, and to be recognizable only in the vertical cliffs, that I have not been able to represent it everywhere, and seldom in any place, with geographical truth; partly from the minuteness of the Map, and partly from the necessary construction of all maps. This is the more disagreeable, because there is not a fragment of this series, on the western coast at least, with which I am not perfectly acquainted. Thus I could not render it visible, even by the violent green which I have used, in the Shiant Isles, where its shale at least occurs, since these form a mere spot on the Map; nor on the summits of the Morven Hills, where only the thin edge is seen, lying under trap. And thus, also, in Sky and Mull and Rasay, it is greatly exaggerated, while further, often represented as occupying a horizontal space when it is entirely without dimensions in this direction, and would be invisible on the Map but for this expedient. Thus also is it sometimes indicated on the sea, as the only place which would show the colour; another expedient, which I have equally been obliged to adopt for limestones and other rocks in several places, when occurring under trap. Hence also have I had recourse to a further one, which I must equally note here, lest it be supposed intended to express a fact, and might therefore imply an error of examination. This is, to accompany it by the yellow colour allotted to the green sand, which might have been there when it is not, as it is in Rasay and in some parts of Mull, &c., and which, by its hue, serves to bring out the green tint and to separate it from the blue of the trap. It is plain that nothing but a far larger Map would



have admitted of a true record of things so small; and it must therefore suffice, to have given this explanation, when the adoption of such a one was impossible. But in this case and some others, including Sky especially, the minuteness of which in the Map, with the intricacy of the numerous rocks, renders an accurate record on the present draught impracticable, I may refer to the larger maps which I formerly published of the Western Islands. With equal space, almost everything in the present Map might have been equally accurate; and that which is thus done in the well-known work to which I have referred, will serve at least to show, that it was not want of knowledge of the facts which has rendered the present one less accurate than it might easily have been made, if I could have commanded more space.

Although the red sandstone generally occurs in large tracts, there are some extremely minute portions scattered over various parts of the country. I do not believe that I have overlooked any of these, though some are so minute as to occupy but a few yards, insomuch that I fear they will scarcely be found without a verbal direction, in addition to the colour, especially as a minute quantity of lake, used for this rock, resembles the colour selected for granite, when on the black engraving.

If I have sometimes, therefore, adopted the general expedient of enlarging these small spots, so have I drawn out lines at their boundaries, when occurring on the sea-shores; a proceeding which I have also followed with respect to some other boundaries, this being the only part of the Map where such lines could be made visible. Yet I have been obliged to omit some, as absolutely incapable of being represented; but these, being chiefly in the Western Islands, where they occur in this manner, entangled, may be found by a reference to the published maps of the work already mentioned. The others occur chiefly about Oban, entangled in trap also; while being very numerous, and seldom exceeding a few feet in dimensions, there was no possible means of representing them without a total sacrifice of the truth of the neighbouring parts.

It is in this neighbourhood that I must point out one small mass, which is here represented, though in far more than its real dimensions, since it is but a few yards wide: while it has diminished so much, within my memory, through the inroads of the river Awe, that I shall not be surprised to find it vanished in a few more years, when some future examiner may deem this entry of it a fiction. It is near the bridge of Awe, and the colour being very dark on this shaded ground, it might easily be mistaken for some other rock. I ought also to point out a line of this sandstone on the Galloway shore, equally liable to be mistaken, from the same causes, though I have exaggerated it as much as was safe, that it might be visible. Similar exaggerations, for the same reason, will be found on the shore near Montrose, where, especially, a fragment of mountain limestone, which



is nearly wrought out, is represented as of a large size, and accompanied in a very untrue manner by the red sandstone; this being the only expedient by which it could be marked. But with respect to the atoms of this rock which occur near Cullen, Troup Head, Stonehaven, Eyemouth, &c., I think that no mistake can arise, in spite of the small quantity of colour, since they are connected by red lines with the neighbouring visible masses.

With respect to the singularly placed fragments of this sandstone which occur in Sutherland, there can be no difficulty, as they are sufficiently distinct on the Map. There also they are accurately laid down; but not so precisely, I fear, about Loch Torridon, where the incumbrance of the ground with soil, and the impossibility of finding accurate references in the geography, have rendered the places and dimensions of many of these intricate and troublesome parts, matters of considerable chance; although the errors, if there are any, can be of no moment either to the science or the statistics of geology.

One remark more on the minuter portions of this sandstone will comprise all that seems further necessary to be said on that rock, as an explanation and a caution respecting the Map. In the south of Scotland it occurs in many places between the primary slate and the coal strata; as it ought, under the common principles and creed of geology. It is most certain, however, that this order is not constant; since in many places there can be no doubt of the contact of the coal sandstones with the slate, as I have here represented them. Now it happens that in many places, and in the southern coalfield remarkably, the ground at the junction of the primary and secondary strata is so encumbered with alluvia or soil as to render the rocks entirely inaccessible. Here, in some places, the red sandstone can be seen to exist, in others not; while it therefore remains doubtful how to act, since the theory of their necessary consecution may no more be true here than in the places thus noticed. I could do nothing but make the best conjectures which the nature of things admitted; the circumstance itself is of little moment: but by announcing this doubt among others, I shall have pointed out what remains for correction respecting this rock also, that, in all cases he who may undertake the future emendations of this Map, may at least employ his criticisms to some useful purpose, and not waste his time in going over what is already ascertained and accurate.

Though the tracts of clay slate are generally extensive, this is not universally the fact; and there are some, therefore, which demand remarks similar to those already made on the primary limestones.

In the south of Scotland, in Aberdeenshire with little exception, and in the great belt which traverses the country in a north-easterly direction, there is no difficulty in mapping this rock, since there is abundant space; while this is true also of some of the islands where it exists. But there are numerous places where



it occurs in very narrow lines; those being the edges of elevated strata, alternating most commonly with mica slate, but sometimes with gneiss also.

Now the same double set of difficulties occurs here as in the case of the primary limestones, there being indeed no essential differences in the distribution and appearance. The finding them is often a mere matter of hazard. It is impossible, and would be idle, to waste time in minutely intersecting a country in search of what may not exist, and which, though it did, could seldom be found, from the spaces which it occupies being so small, and from the incumbrances of the ground. Even when these things are found, it is seldom possible to distinguish them on the Map; and not often, without a great exaggeration, and with the effects that have already been pointed out. In this case also, the inevitable colouring of the Map produces a much greater difficulty than in that of the limestones; since the colour chosen for the slate, as the only convenient one in the large masses, is nearly invisible on that of the mica slate, especially if placed on that dark engraved ground which unfortunately predominates over this Map.

If I have done the best I could to represent these minute objects, I ought also here to point out, generally, the places where they lie, lest they should escape notice; while they are also very likely to be so ill copied by the colourists as to render this obscurity much greater.

As occurring in gneiss, they are perhaps sufficiently noticeable, from the contrast of colour, on the eastern sides of North Uist and Benbecula, and as occupying some of the intermediate small islands. I must hope that the colourists of the copies will not overlook these atoms, which I have also included within a line of the same colour, in hopes of avoiding this accident. There is a similar atom near Loch Brolum in Lewis; and while on this part of the Map, let me point out a mass of serpentine at Loch Valumis, and another at Scalpa, which might equally be overlooked; and further make a note respecting Loch Maddy, where the two detached rocks called Maddy-more and Maddy-beg are of trap, as the shore is of slate, but where the blue and the green colours used are undistinguishable on the Map, from the minuteness of their spaces.

This portion of the Map, including the whole outer chain of islands, leads also to a remark which it is essential to make; not because it will prove the attentiveness and the labour of the investigations which have been bestowed on this work, (as any one can see even on the Map, in the great and intricate extent of the country examined, especially on these most complicated shores,) but because it will remove a suspicion very naturally attached to a tract represented as so uniform, and thus give confidence to him who may inspect it.

It has been the usual practice in geological maps to lay down whole tracts of country from very superficial and partial examina-



tions, and with as little attention to the minuter parts as to the geography: thus producing maps which I have already justly called sketches, or conjectural works. The sight of such an extensive and intricate country as these islands form, laid down as almost all of one rock, leads therefore to the very natural conclusion, that the same negligent practice has been here followed, and that the survey is but a conjectural representation, conformable to the usual customs. But the minute circumstances thus noticed, show that the ground has really been investigated, as it is also plain that nothing but a very minute and accurate examination could have found them; while he who may repeat it, will discover that it is not an easy matter, amid the confusion of inlets and islands, forming an absolute labyrinth, even to find out such petty islands as those that are marked for slate in the Kyles Wiay of Benbecula.

The other minute edges of slate to which I alluded, occur chiefly between Glen Spean, Loch Swin and Loch Awe, and in the chain of Isla, Jura, &c. I can have no doubt that they are prolonged much farther than they are here represented; but as in the case of the similar limestones, I could not prolong them on so false a geographical basis, by following the usual line of direction, without the hazard of placing them where they would never be found. As it is, their places can seldom be very true, from the necessity of great exaggeration, and from the badness of the geography; while additional suspicions are thrown on that geography, in this case and many others, by finding that when this is followed, the lines of direction do not turn out to be what the strata ought to bear, from a general knowledge of the country, nor what they appear to do when examined by the compass.

And I may make this remark general, since the same anomalies occur in innumerable places. Let no one, therefore, be surprised at seeing deviations and flexures of the lines of direction on this Map: they may be real, but I am tolerably certain that they are the frequent result of a false geography; to which, nevertheless, I was compelled to conform, since it was through it the rocks would be sought, as to it they must have been adapted. A future accurate geographical survey will alone show what the truth and the falsity are, in this case also. But I need not here point out these doubtful things; they will be sufficiently apparent to any geologists consulting the Map.

If I may here, lastly, point out, as to the slate, the remarkable manner in which it occurs in junction with other rocks, as near Troup Head, and about the shores of the Clyde; and if these will also serve to prove the minute accuracy of the survey, so do they also show, that wherever the accuracy on the Map is less, it was not for want of equally accurate knowledge of the facts, but because they could not be equally well recorded. In these cases the Map was found as perfect as was necessary for those purposes.

The quartz rock, as represented on the Map, demands some



similar remarks. Near Loch Leven, and in some other places, it occurs in very narrow lines, as in many more, such as Schi-hallien, it occupies only the narrow summits of hills, visibly at least, while in many the spaces which it covers are very small. Though I therefore chose one of the most conspicuous colours, to render it sufficiently visible, the extreme blackness of the Map has, in many places, reduced the tint so far, that I fear it will sometimes be mistaken, especially by the colourists; in which case it will become an entirely false entry to the possessors of copies. I can discover no means at present of avoiding this source of error, though an extensive work of sections might aid in recording the truth: it is one of the chief instances in which this work will suffer from the absurd, injurious, and unnecessary blackness of the engraving; especially provoking, since a much lighter mode of execution, such as is used for the modern maps of France and Italy, would far better have expressed the geography, while they would have equally removed this evil. And I regret to say, that the strata of quartz rock which occur among mica slate will prove especially difficult to recognize on the Map; as I shall not be surprised to find them totally unintelligible in the coloured copies that may be executed. It is indeed most certain, universally, that this Map never will be truly copied in every part, since nothing but a knowledge of the facts themselves could enable a copier to do this perfectly. Even the copies made by myself have required a constant recurrence, not only to the original entries made in the field, to the draughts on a larger scale, and to the memorandums entered on the spot, but to my own recollections of the places and the facts; as, with all these means, which no one else can possess, and all this care, I have not avoided errors in those copies, which it has required numerous, repeated, and tedious examinations to correct. If, to myself, and with all these advantages, the making a copy of this Map has been the labour of a week, I am really hopeless that any number of correct ones will be produced for sale, if this work be sold, unless a liberal price is allowed.

There is one other difficulty relating to quartz rock which I must here also state; but it is one that relates rather to the difficulty of representation than of investigation; since this, although laborious, is in no other respect difficult. It is too decided a rock not to be abundantly obvious, though never known to exist, in any part of the world, or, as is more likely, never recognized and discriminated by my predecessors in this science, till I pointed it out in Scotland, and gave it a place in the system. The difficulty in question relates to its gradation, sometimes into gneiss, and at others into mica slate; as it occasionally arises from an alternation of these rocks, but chiefly of gneiss, with it, so very frequent and minute, that the approximation of even hairsbreadths of the different colours on the Map would be an exaggeration of the truth.

It was utterly impossible to represent truly either of these



circumstances in this work. In a set of sections I might have attempted to convey an idea, though an exaggerated one, of the alternations, as in others I might have indicated the graduations. On the Map, the slightest endeavour after the former was vain; and if I have attempted, in a few of the most remarkable places, to represent the graduations, it is really never more than a loose indication of the fact, not a true geographical entry, since on such a map and scale this was utterly impracticable. I should have earnestly wished it otherwise, both as to these graduations and those between mica slate and gneiss, so often remarkable, and so especially frequent and striking about Ben Nevis, Glenco, Loch Laggan, &c.; but there are limits to every thing, and this has proved one of the cases in which there was nothing left but to surrender to the impossibility. It is not the only case, by very many, by hundreds, or perhaps thousands, in which I could not communicate the knowledge for which I had laboured; and if this is a very natural source of vexation, I must also desire that this knowledge may not be measured by the present imperfect record. If ever maps shall be made of twenty times the size and truth, future observers will possess advantages where I found nothing but obstacles.

I have little left to say respecting the investigation or the mapping of gneiss and mica slate, beyond that which will appear in a subsequent account of those rocks among the rest. The investigation is seldom difficult; and as all the difficulty of representation is included under the preceding remarks on quartz rock, I may pass from those substances, and next note what relates to trap. Of the difficulty of investigation which attends this rock in so very remarkable a degree, I must, however, speak in some future remarks on this subject in general; here noticing only what belongs to the difficulty of representation.

In some places, as in Fife most remarkably, it occurs in patches, among other rocks, so very small, that the Map will not contain a true delineation for want of room, as I formerly noticed when speaking of its bad geography and drawing. Yet examples of the accuracy with which that rock was examined will be seen at a few points, in this portion of the present work; where the entries are equally true and minute, wherever the space and the drawing of the Map permitted. On a better basis they would have been the same everywhere.

In other places, the minute intricacy of its outline is such, that it was utterly impossible even to approximate to it on so small a space. The general outline which it therefore became compulsory to adopt is consequently untrue, if the Map be compared with the ground itself. As before, that which was well known could not be entered, for want of means.

And if this intricacy of outline depends partly on the more obvious ordinary causes, it arises still more from the nature of this peculiar rock. It is not even so defined a mass as its kindred and equally unstratified granite, but throws out veins or



protuberances in all directions, and in the most irregular manner. Now as the intervals of these are occupied by the neighbouring rocks, generally secondary strata, the ordinary section formed by the surface of the land produces such an alternation or intermixture, that the general boundary, which had been first settled at some one point, must be protracted to perhaps even a mile or more at another place, or under another mode of investigation, while it often becomes finally impossible to fix any point at all in a satisfactory manner. In what modes, therefore, the Map may be defective on this point, I need not say, while it is plainly one of the difficulties which cannot be surmounted.

There is another difficulty peculiar to this rock, which renders it impossible to give such a map of it, everywhere, as would meet all opinions, and, at the same time, declare the structure of the country in question, for objects of utility. In many places, it lies visibly over stratified rocks, as, in some of those, both limestone and coal are wrought beneath it. This is the case near Glasgow, near Blair Adam, at Clunie, and elsewhere. The ordinary proceeding of a geological map is to represent the surface of a country; nor can it represent such an inferior rock, without either misplacing it or omitting the superior one. I have used both expedients in some cases, and in others have taken no notice of the inferior stratum; while those who choose to take opposed views will judge all equally wrong. At Clunie, for example, a limestone appears in the Map as if it occupied the surface, because it is a noted quarry; but it is wrought at a considerable depth beneath the trap. On the north of the Lowmont Hills a considerable breadth is given to the coal sandstone; but it is chiefly remarkable on the nearly vertical section, where, without this expedient, it would be undiscernible on the Map. And the same expedient, as I formerly remarked, I was obliged to adopt respecting the lias and green sand of the western coast, in many places.

If I thus also formerly observed, that very minute fragments of strata entangled in trap could not be represented at all in some cases, as, when deemed useful, they are not represented without great exaggeration, other examples of each, besides those which were then noticed, may be pointed out. The slate which appears on the sea-shore, at the town of Oban, is drawn on the sea, since it would have been invisible on the land, unless so far extended as entirely to falsify the trap. A limestone in the trap of the Lowmont Hills is as much exaggerated as that on the shore of Forfarshire, formerly noticed. At Edinburgh, it was impossible to represent the facts at all, in consequence of the smallness of the space, and of the engraving used for the town; the three junctions of coal sandstone, red sandstone, and trap, all occurring here within a very minute and intricate space, and under the additional difficulties of superposition and veins. They who will look at the white sandstone of the Castle Hill, and the structure about the King's Park, will see that nothing



but a very large draught could have contained the facts in question.

The last remark which I need offer respecting this rock relates to its veins. In many places, and very notably among the Western Isles and on the western coast, the numbers of these are such, that any visible representation of them would have left room for nothing else. As a general result also, the spaces in question would have been deformed by blue lines on the Map; while even these would not often have told any thing useful, though dazzling the eye, puzzling the spectator, and troubling the colourist copiers. It is true that I have thus omitted veins which are used as quarries in several parts of the country, and which it might therefore have been desirable to note; but I found that I could not represent even these without the same hazard, and without the farther one of confusing them with the limestones; since the colour of the ultramarine and of the Prussian blue are not always distinguishable on the dark engraved ground, if the spaces are small. And I request particularly to point out this in Lismore, and in the Garveloch Isles, and also at Loch Earn; where, with all possible care, the limestones of these spots are very difficult to distinguish among the traps by which they are surrounded.

But after much consideration, I adopted the following general rules respecting the mapping of the trap veins; and this I think it necessary to point out in the present subsidiary explanation of the Map and its Key.

Every one knows that they abound in the vicinity of the masses of this rock; and for this reason also, as well as for the former ones, they were omitted. But they were objects of interest where they occurred at a distance from these, as indicating the former presence of trap where it has now disappeared. They have therefore been marked where they occurred, in this manner, in sufficient magnitude or conspicuity to demand such a notice; while I have nevertheless been compelled to avoid mapping too many, from the conviction that they would sometimes be mistaken for limestones, owing to the reason just assigned, and that they would not attract the notice of persons inspecting the Map, or would be overlooked by the copiers.

Thus several indications of them will be found to the north of Dunkeld, in Glen Dochart, on the borders of Loch Earn, near Loch Long, and in Strathearn, as well as in some other places; while, in the latter named tract, their remarkable extent and magnitude were more than sufficient to demand their insertion.

Of the coal series, and of some other rocks which I have not noticed in this enumeration, I have nothing of a similar nature to say; since the representation at least, whenever one was adopted, laboured under no other difficulties than those which appertained to the imperfect geography of the Map, and to that difficulty of investigation on which I must now make some remarks in addition to those already offered. It was a difficulty that arose from very



different causes, as, over very much of the space examined, it must be considered as insuperable.

Whoever imagines that a perfect geological map of any country can be made, is utterly ignorant of this subject; as, for the most part, this is believed to be the fact, from seeing maps covered with different colours, and making pretensions to be perfect draughts of this nature. Whatever geology may infer respecting rocks, and however these inferences may often be accurate, there is a great deal which can never be known, as far as a perfect geography of rocks is concerned, unless the whole surface of loose materials could be removed, and the earth reduced to its original nakedness. Many things, indeed, which are now doubtful in the present Map, might be corrected by very simple excavations at some particular points; since this is to furnish an additional quantity of that evidence whence the actual inferences are drawn. But if the time and expense required for this, even at a very few points, would be intolerable, it is evident that such a wish as this is perfectly absurd, when the whole extent of the obscurity is considered. If the common principles of investigation must therefore be followed, it is convenient that I here notice what those are; that so the nature of the difficulties may be better understood, and that the reasons may appear for here pointing out what I do not know to be correct, and which I have been obliged to lay down under the best conjectures or inferences that I could make. It is not, indeed, a great deal compared to the whole; but I will not permit it to be supposed that I desire here to assert, as of fact or knowledge, any thing more than I know or believe to be the truth. In some of the instances in question this would also be egregious folly; it would be to pretend to superhuman powers, since the eye which could see thus far beneath the surface might equally discern the centre of the globe.

The obscurity of the superficial rocks arises from the covering of alluvial matter and soil, including peat, which occurs over the far larger portion of every country, however hilly, and which, in the flatter lands, conceals nearly every thing. And this is what a geological eye must penetrate in some manner, that it may know how to delineate the rocky structure beneath.

In mountainous and rocky lands, the exposure of the rocks at certain points is so frequent, that there is, for the most part at least, no difficulty in inferring that which is invisible, by connecting these together. Such points are, the fragments of rock which are denuded in consequence of their protrusion above the general surface; and such also are the precipices of mountains and of sea shores, the occasional fracture and exposure of strata, the beds of rivers, and so forth; while to these must be added such artificial works as roads, quarries, shafts, wells, ditches, and more leading to the same knowledge. Such absolute evidence as is thus obtained becomes further enlarged or extended by studying the forms of the ground, though the rocks should be invisible; since the nature of the rock confers on it a peculiar shape and character,



in many cases at least ; if not universally, nor, always so decided as to produce absolute satisfaction. If thus also, further, the peculiar character of the vegetation often becomes a guide, to an experienced eye at least, it is sufficient that I have thus slenderly noted these more prominent sources of evidence.

But whatever an attentive and experienced investigator may perform by these means, they are still uncertain, except in the case of stratified rocks, and where those have a marked and also a consistent elevation, with a direction as consistent. The direction then enables him easily to join two such points with truth, or to prolong that which is seen, to places where it is invisible. But if the strata have little elevation, or are much disturbed, and, besides this, uncertain in their elevations, there is no longer any sure guide to be found in their lines of direction ; so that the inferences as to what is invisible become difficult or doubtful, with a consequent increase of labour and uncertainty.

In England, indeed, this is little felt, from the great spaces occupied by each set of strata, and from the absence of the most usual cause of disturbance, namely, the presence of trap rocks ; whence they maintain a great consistency of position and bearing. In Scotland, it is the direct reverse, especially over all those tracts which, consisting of the secondary stratified rocks, possess strata of low elevations, compared to the generally erected primary strata. For the most part, the whole is cut up into small portions ; while the disturbances of the strata are such, that a consistency of position and direction cannot often be traced for a few miles, or even for one ; occasionally, not even for a few yards. This arises from the frequency of trap rocks, as the Map will show ; whence, added to the denudations of the strata or the loss of the superficial portions, it also happens that the inferior red sandstone comes to the surface in the most irregular manner, producing an equal irregularity in the places of the superior, coal series.

It is seldom possible, therefore, in these cases, occupying a great and most important portion of Scotland, to infer the places of any thing in the usual manner ; so that the difficulty becomes similar to those which beset the unstratified rocks, granite, porphyry and trap.

With respect to this last class of substances, it is not here needful to distinguish universally among these three different rocks, in pointing out the general difficulty which attaches to the whole. In the stratified rocks we have always some assurance of a certain continuance or prolongation of that which we have seen, to places where there is nothing visible, and can therefore procure some kind of evidence ; although when the strata are at low angles, and especially if also undulating at the same time, that is by no means always very satisfactory. But in the unstratified, there is none but that which is furnished by the form of the ground ; while the assistance thus afforded is also rare, or cannot be trusted, since the characters which the ground presents



from such causes are extremely uncertain, and are often variable and contradictory.

To notice some examples of this, and to commence with granite, that of Scotland sometimes protrudes in peaks, so as to give notice of its place; in other situations it is in smooth rounded masses with flowing outlines, while these are also deeply covered with soil, so that its extent cannot be either discovered or conjectured. In some parts it occupies the highest summits, as I formerly remarked, and in others the lowest lands. In these last cases, tracts of enormous extent are sometimes little marked by any elevation, and often nearly flat; while they are at the same time deeply covered with soil, and clothed by trees and cultivation, so as to accumulate one source of obscurity upon another. As an additional difficulty, which, unfortunately, is most frequent also in these very districts, there is a frequent intermixture of gneiss with the granite, in a most irregular and often a very minute manner; so that the difficulty of investigation becomes incredible to those who have not seen this country, or one of a similar character and construction.

In the most favourable cases, therefore, or supposing the granite to be actually and every where visible, its boundaries can only be known by actually surrounding it; producing, for the most part, an enormous labour when compared to that which is demanded by the elevated strata of the stratified rocks. But no labour can ascertain these boundaries truly when they are covered with soil; above all, where the interchanges of gneiss and granite are frequent, and the country very low or flat.

This is the case very remarkably in the eastern parts of Aberdeenshire, though by no means limited to those portions of Scotland. There are miles after miles in extent, where no rock whatever is visible. It might be safely conjectured, without doubt, in many places, if not in all, from those occasional indications which it is the business of a geologist to discern; supposing that the granite formed a single and pure mass, or was of a continuous extent over a certain tract, great or small. But in the case of intermixed gneiss and granite, being that by which the far larger portion of this country is characterized, and where this peculiar disposition of things arises from the fact that the former is denuded down to nearly the surface of the latter, so as to have left it bare in some places, while it continues to cover the subjacent rock in others, we can never be sure that an occasional mass is a prolongation from some other place, and not an independent protuberance. And when there are extensive tracts of soil without any indications of rocks at the surface, all the labour that can possibly be bestowed still leaves doubts; as the very best records that can be made may hereafter prove to be erroneous, should future accidents bring the unseen to light. In such cases, it is plain, even the sight of a rock, or even of a space, consisting of granite, offers no security for its existence beyond that which is actually visible; as reversely, there is equally little proof that



the visible mass of gneiss may not be the only one present in a tract of this complicated and troublesome nature, where, over miles of ground, nothing but the incumbent soil can be seen, as the features of the land are also obscured by cultivation, and not only that, but rendered inaccessible by the same causes.

Under these complicated difficulties, or rather impossibilities, rendered still more troublesome by the badness of the geography, there was nothing to be done but either to surrender, and thus to leave the geological map full of blanks, or to fill those blanks with colours denoting the visible alluvia, or lastly, to make the best inferences which the evidence admitted of. I shall immediately point out the few places where I have adopted the first of these practices, and also show the reason why. The reasons for not adopting the second seem quite satisfactory, although it has been done to a large extent in the geological map of England, and very often where a due degree of labour would have ascertained what the subjacent rocks were. A map of alluvia is not a map of rocks; so that the real object of a geological survey is abandoned. It is abandoned as a mere question of science, in the first place, and in the next, as a question of utility and application. The geologist must search these tracts again for his own purposes: and the practical man is left, not merely without a guide, but without a hint respecting the probabilities, to replace that certainty which possibly could not have been obtained, but which at least has not been attempted under the care and labour that ought to have been applied to such a subject. It would be harsh to call such a practice deceptive, since it probably arises from an unwillingness to leave blanks, where a completely coloured map is expected; but it is plain that such a map of blanks would be of equal utility with one of this nature, for both the purposes to which I have already alluded.

But if alluvia are to be entered in the place of rocks, or blanks to be left where those cannot be seen, there can scarcely be any limit placed to this laxity of representation; as it will always moreover form a ready excuse for withholding due labour from such a survey, or for neglecting it wherever the ground offers any peculiar difficulty. In many parts of Scotland, and especially in the south, above the secondary strata, I have traced miles after miles of alluvial matters, not transported, but the produce of superficial disintegration, as in some places I have ascertained their depths to reach to fifty feet. In other places, extensive plains and valleys are formed of river alluvia, or covered by them, or by blown sand, or by peat, often reaching to enormous depths, or simply perhaps by soil, rendering every thing invisible over large tracts. If any alluvia are to be entered in a coloured record, I know not where the limit can be drawn; while a geological map would thus become nothing, whatever deceptive appearance of actual investigation it might present to an ignorant eye. The very theory and principle of such a work is, that the naked surface be displayed, as it can best be seen or inferred:



and if blanks be left instead of coloured alluvial spaces marked, the work as a geological record, would in reality be just as useful, or rather useless, though in this case at least it would deceive no one by the pretence of doing what it has not performed. The work, though essentially as good, presents a deformity in addition to its deficiency.

What aspect the present work would have presented, had I adopted either of the systems which I have thus condemned, can easily be conjectured: to myself it would unquestionably have been exceedingly convenient, as it would perhaps have saved nine-tenths of the labour which was bestowed on this survey. But as I should not, most assuredly, have considered this to be what I equally undertook and desired to do, so have I adopted a different proceeding. In all cases of such obscurities, (and they pervade all Scotland,) I have drawn the best inferences which the circumstances permitted, excluding equally, coloured records of alluvial soils, and blanks; and this in the case of the flatter secondary strata, as well as in the peculiarly difficult one which I have been here pointing out where the intermixtures of gneiss and granite produce such extraordinary difficulties, in addition to those resulting from the depth of the alluvial soil. On the latter occurrence, when in connection with the trap rocks, I must immediately make some specific remarks; and I will in the mean time point out the blanks which I have designedly left, and the reasons why; having preferred this to a useless entry of the superficial soil.

The blank near Kildrummie is the place of a deep peat bog, where granite, slate and red sandstone meet, and in such a manner that it is impossible to conjecture how it might be safely occupied with an indication of either of these rocks. In Isla there is a larger one left: although the stratification of the primary rocks to which the rocks in the neighbourhood of this spot belong, is a fact which generally leads to safe inferences; and that blank is thus left because the disposition of these is here very different from the usual course of things, and will admit of no safe conclusion as to their extension over a very low tract deeply covered with alluvia.

In Arran there is a smaller one; and the doubts are still more insuperable in this place, because of the great diversity of stratified and unstratified rocks by which it is surrounded. Nor can the truth be ever ascertained at this spot by any thing short of some change that shall bare the whole surface of this valley.

There is a similar blank near Campbelltown, and for similar reasons; while, especially, I did not choose to lay down the boundaries in this case under any of the usual modes of inference or conjecture, because of the singularity of this tract, and from its importance as an object of utility. Hereafter, doubtless, the pursuits of the coal miners will determine what could not have been conjectured with any tolerable security against error, be-



neath the flat maritime alluvium, further encumbered by peat and soil, which occupies this ground.

The last blanks which I have thought it right to leave, occur near Carse Bay and Southernness Point in Galloway; and the reasons are similar. Whoever may hereafter examine the country in these places will perhaps think that I ought to have done the same at the Locker-moss, at Tents-moor in Fife, in the ill-rescued land south of Stranraer, and in some other places which I need not here specify, as the enumeration would be far too tedious. But at the time I examined those I did not think there was any insecurity in inferring the nature of the rocks beneath; and a review of those recollections has not induced me to alter the opinions originally formed.

In proceeding to examine the case of trap under the same views, there are some peculiarities connected with this rock, in addition to the preceding remarks, which demand a separate notice, and which are also independent of those already made on its intricacy, its superpositions, and its veins. Together with the granite, but to a degree very far exceeding that, it constitutes the chief difficulty and labour in the examination and mapping of Scotland: while it is a difficulty scarcely known to England, and as absent from this portion of our island, most materially lightening the labour of a survey of this part of Great Britain. In this there is but very little granite, while it is abundantly conspicuous, and limited to a very few places; and the limitations of the trap rocks are even more narrow. Nor is it too much to say, that were it not for those two rocks, the survey of Scotland might have been completed in a fifth part of the time which it has occupied, or less; as the absence of the trap alone would have rendered the more difficult portions of this country a matter of extreme ease. They have in fact constituted the main part of all the labour; as they have, both, and the latter in particular, led to an extent and minuteness of travelling which might otherwise have been entirely dispensed with. There was not a spot of half a mile in extent, towards the north at least, where granite might not have existed, and also have been there undiscoverable, unless close at hand; while this is even more remarkably true of the trap rocks, if we turn to the south of Scotland. These were literally to be sought for every where, even when it was visible and certain that whole districts consisted of a single stratified rock, with this possible exception, and when they might easily have been mapped in a very few days, or when nothing more was requisite than to trace their boundaries. Of this, the present Map itself will give abundant proofs, in the scattered, insulated, and unexpected places of those which have been recorded; respecting which, very generally, it is plain that nothing but a minute research could have fallen on them, as in the case of the primary limestones.

It will be very extraordinary, therefore, if some have not been overlooked and omitted. The allotted time did not allow me to



examine every thing in this minute manner, over such a wide extent; and it was expedient to apply what was allowed, in ascertaining what could be seen to exist, rather than in searching after what might not; since the final result might have been a large collection of blanks, and an incomplete work: a work, of which the deficiencies might indeed have been pardoned by the Government, which marked the limit in time which should not be exceeded, but which would not have satisfied the public to whom that restriction was unknown.

Nor was this all of the peculiar difficulties that attend this division of the unstratified rocks, and which so much augmented the labour of investigating those portions of the country in which they exist. If the character of trap is sometimes so peculiarly marked that it can be known from far, so as to direct the course to its examination, this is very far indeed from being the fact universally. Its masses are sometimes rounded and its outlines flowing, and there are also many tracts in which it is both low and flat, so that no suspicion respecting its presence could exist, as even a closer inspection would often not discover that these tracts consisted of other than the secondary strata which it then accompanies. And not less remarkably, while producing equal or more trouble, it is not unusual to find its outline perfectly continuous with, and similar to that of the strata which it accompanies; no break or mark appearing to tell that the rock was changed under our hands, while such change occurs even on the declivities of hills of a continuous form and outline. "Qui ad pauca respiciunt de facili judicant:" nothing but that mixture of ignorance and conceit which characterizes the great majority of those who now aspire to the reputation of this, as of other sciences, will judge to condemnation in this, as in much more that I have here noticed; while, in the eyes of the enlightened and the judicious, it is their criticisms which will form their own condemnations.

If to what I have thus pointed out, there be added the great depth of soil by which these hills, and especially these junctions, are often covered, still less surprise will be felt at the labour which they have demanded, or at the errors of boundary which may hereafter be discovered; though it is most certain that no future generations, under any quantity of knowledge and labour, will ever give the true draughts of all these rocks. This depth of alluvia, often especially accumulated in the places of these rocks, from obvious causes, serves also to conceal entirely many of the minuter masses; as I have been repeatedly convinced by discovering some which had been detected by the cutting of a road, or a quarry, or even a common drain, and where no possible suspicion of their presence could have existed, as, but for such accidents, they would never have been known. It would be unnecessary to subjoin to all this, were it not for the sake of the utterly ignorant, and of those to whom these parts of Scotland are unknown, that these difficulties are enormously increased by the



cultivation and inclosures of the districts in which these rocks chiefly occur; because it is in those, and as produced by these very rocks, that some of the best and most fertile soils of this country are found. It is not difficult to traverse even the rudest and most remote mountain tracts, though there are no roads; but the roads on the cultivated ones impede examination instead of aiding it. It is impossible to deviate from them on horseback, and scarcely possible on foot, owing to the great height and strength of the inclosures; and the same character pervades all the inclosures of fields throughout almost every portion of this part of the kingdom; so that while no hunter could contrive to cross or intersect the country, he who attempted it on foot would spend an entire day in making the smallest progress, and ultimately, unless he were singularly fortunate, in doing nothing. No time was allowed for such work as this; nor indeed could it have been allowed: to survey Scotland in this manner would demand the entire lives of twenty men; whereas the limitation was to the very few summers, and often short ones, which were occupied in this work, often also but partially, and to a single observer.

I may now point out a few places, as examples of these facts, before I notice the expedients adopted to represent on the Map that which could not be definitely ascertained.

If, in the Glasgow district, there are very marked hills of trap, so are there very extensive tracts in which not the slightest indication of this nature exists, and where the rock, when ascertained, is found to be perfectly flat. Even coal is wrought by sinking through these: so that error easily arises by supposing, that where coal is wrought, there must be coal strata at the surface.

Near Comrie and Cortachy, the trap which every where else occurs in connexion with the secondary strata, is found in the middle of primary slate; where it would be easily overlooked, since there is no suspicion of its presence in such a connexion, and since it does not well display its characters at a small distance.

On this northern boundary of the red sandstone it also occurs skirting the slate, in far remote patches, where it is equally unsuspected and difficult to distinguish, unless the observer should have the good fortune to hit upon the very spot, so as, literally, to touch the rock itself. In such cases, it may therefore be easily passed without notice; since a shower of rain, or the deviation of a few yards for some other purpose, to examine probably something of striking importance, would render it invisible, or cause it to be overlooked. It is true, that after having once found things so unexpected, I have continued to seek for them: but it would be a singular piece of good fortune indeed if I had not overlooked some, amid all the accidents attending these investigations, and the short time allowed for examinations so extensive and minute, over a country of such extent. I point out, as before, these possible oversights, partly that I may direct others to what may require re-investigation, and partly that no



surprise may occur, in case they should hereafter be proved to exist.

The Sidlaw Hills offer a remarkable example of that continuity of outline and form between the trap and the associated sandstone, which, while it is very deceptive, leads to great labour, inasmuch as the rocks can scarcely any where be confidently distinguished without an approach amounting to contact. At the western end, the whole elevation of this ridge consists of trap; towards the middle, it only occupies small patches irregularly placed on the surface of the sandstone; and as the ridge proceeds eastward, the trap disappears. Yet the general form and character of this line of hill are very uniform; so that any surveyor who trusted to these general indications, and to that cursory or general examination which in some cases is sufficient for many rocks, would easily commit error, by prolonging the extent, either of the trap or of the sandstone, accordingly as he had satisfied himself of the one or of the other, by contact; accordingly, in reality, as he had commenced his investigation at one end or the other of the ridge, trusting after this to his general theory of the peculiar outlines produced by each particular kind of rock.

Near Machony, in Strathearn, there is, in this survey, a mark for a patch of trap, considerably exaggerated, for the usual reason. Of this fragment there is neither external indication nor change in the character of the ground, to afford the slightest conjecture, as the surface is also deeply covered. The accidental cutting for a deep road has brought it to light. No one can say that hundreds such may not exist, not only here, but throughout the whole of this sandstone district, as in reality there are such ones in Forfarshire. When these are used as quarries, they will be found, for the same reasons as the limestones are; that is, under a supposition that the country people in general are informed of them, which is not always the case: so that the surveyor who has not the fortune to meet with the actual quarrymen or road-makers to whom they are known, may remain ignorant even of such as are quarried. It is evident that the country might be traversed a thousand times without finding those respecting which there is no information, even though they should be apparent at the surface. Nothing less than to intersect ground as a pointer does for a partridge could detect such things as these, and many more; as they will be the omissions to find employment for the minute critics of some future day. And if I have not introduced a few, a very few indeed, which have been pointed out to me, it is that I have had ample reasons to doubt the accuracy of those reporters.

If I might easily extend examples of this nature, and of others somewhat different, I will content myself with noticing, lastly, the extreme difficulty of ascertaining, not only the boundaries, but the very existence of the larger tracts of this rock.

In very many of these, there is an interval between the last



visible signs of the trap and the nearest visible ones of the sandstone, which sometimes reaches to many miles; whether as this relates to patches of exposed rock or to the general characters of the ground. In this interval the boundary lies; but the covering is a deep alluvium, reaching, as I formerly remarked, to twenty, and onwards to fifty feet. A surface like this has, of course, no character; nor is it often that it has been penetrated, either by natural operations or human labours, so as to expose the rock. In general, there are few water-courses in the districts of this nature; and when there are, they do not penetrate through the alluvia, or, what is nearly universal, they form an alluvial deposit in their channels, from the rubbish they carry along, so as totally to obscure the solid bottom. And it is equally rare to find any assistance in quarries and roads. There is no temptation to quarry through rubbish so deep; and the roads of Scotland are now so well made, that the artificial covering is as effectual a concealment as the natural alluvium. It is fortunate, in such cases, to meet with an old neglected road, where the rains have bared the surface down to the fundamental rock.

But supposing that such detached spots should be found, whether those be protuberances arising from the forms of the subjacent rock, or the seats of water-courses, or whatever else, which serve for the prolongations and definitions of boundaries in most other cases; they are of very doubtful evidence to the same effect, in the investigation and assignment of masses of trap. They may be veins, or prolongations in the nature of veins, as I had formerly occasion to notice: while the circumstances already described render it impossible to decide what they are. Thus must a true definition of these masses be ever a matter of conjecture or chance: since no present labour can ascertain them, as no future one ever will. A specific line or point may indeed be altered, in consequence of some future and more fortunate research or accident: but he who may have detected this error, and thousands more after him, will still be short of the truth; since it is especially among those facts which can never be known, unless every atom of soil was removed, down to the bare rock.

A few examples must, as usual, here suffice to illustrate what occurs almost everywhere.

Throughout the Kilpatrick, Campsie, and Ochil hills, in many places, not only is there an immense invisible interval between the last visible trap and the sandstone, but the change also takes place near the summits or on the acclivities of hills of a uniform shape and flowing outline. There is ever a great temptation to define the trap by the boundary of the hill and plain. Yet this is sometimes proved to be wrong assumption; since not only the sides but the very summits of the hills sometimes consist of the sandstone, as in the Sidlaw just noticed, and elsewhere, but the trap in other cases runs far into the plain. Under this double



possibility, it is difficult to know what to do when all marks are wanting.

If to an extent of miles of such alluvial covering in the interval between ascertained trap and assigned sandstones, there be added high cultivation, trees, dense and lofty enclosures, a want of roads, and, beyond all, a bad geography in the map, the difficulties are enormously augmented. These are facts of perpetual occurrence in the south of Scotland, while, as usual, I may notice a few of this nature as examples, in illustration.

Between old and new Cumnock there is a very remarkable tract labouring under all these difficulties united, as there are many more all over that part of the country. For some miles, the only indication is a junction of the trap and sandstones not exceeding two or three yards in breadth; while nothing but the most minute research or the merest accident could discover that which is confined to the gutter of a dirty village. It is one of thousands of instances to enforce on a geological surveyor the necessity of an attention which must not be relaxed for even a yard, and of an attention also which must be for ever watching equally the distant and the near: every fracture of a road near him, and the characters and indications of the distant country at the same time.

In Haddingtonshire, a very extensive mass of assignable trap terminates on one side in a large space, entirely flat and deeply covered with soil and cultivation. The edges of this are seen to be sandstone; but there are miles of absolute obscurity between this and the nearest visible trap. The inference has, in the present survey, been drawn, and the boundary settled, from the evidence of the ditchers, who say that when they meet with a rock over this tract it is trap. It is the best evidence that can be obtained, and yet these masses may be nothing but veins. In a tract between the Glasgow middle road and Slamannan, the evidence of the northern boundary is here taken from some visible masses: yet there is no security that these also are not veins, while there is in this place, a very large space of that alluvial deep nature and total want of all character, which gives no evidence of any kind, and may be anything. About Paisley there are many wide intervals without even such doubtful evidence as this: not even an atom of rock appearing anywhere, there being no water-course, and neither road, drain or ditch, having ever penetrated to the rock beneath. In a country of uniform stratification like England, and in the assured absence of trap, blanks like this excite no doubt and give no trouble. They are laid down without investigation, and if with no doubts, so equally with little hazard of error; while there are thus hundreds of square miles which it is totally unnecessary to visit or about which we need not take any concern. In the secondary country of Scotland more than every square mile must be narrowly examined; and even when all this is done, to a yard, if that were often possible, we have no assurance of being correct.



If I might long multiply these specific examples, the present must suffice. With what has preceded respecting trap, they form the history of the country as far as this rock is concerned. It only remains therefore to state what I have done on the Map as to the representation of this most troublesome department of it.

In those first portions of it which were examined for the different purposes directed by the Ordnance, and when there was no intention of making a geological survey, either partial or general, as no idea of such a work had been then entertained, I was content with simply laying down such trap rocks as were perfectly assignable; using no efforts to extend their boundaries beyond the distinctly visible, by any inference from minute evidences. It was sufficient that the former was done: and thus the sandstones occupied spaces at the boundaries which, for aught that I could prove, might equally have belonged to the trap. The new survey, for the present fuller purpose, having taken me to some of those places again, I was induced to re-examine and correct them whenever such reasons for extension could be discovered: and was thence, partially at least, induced to adopt this latter mode of representation more generally, or to carry out the trap boundaries into the sandstone as far as the evidence justified. But where there was no evidence at all, and where therefore it was impossible to find any rule for a boundary, in an interval of some miles, I have not been able to avoid vacillating between the two modes, during the great number of successive years which have been occupied on this subject, and under the different views and intentions of those two very distinct periods. If the present more recent surveys have therefore also corrected the former one in many places, under these later views, there are others which I could not review in the same way, unless more time had been allowed.

Hence it will be found, on re-examining the ground, that in some parts the trap rocks are rigidly limited to the visible, while in others they are extended far beyond what is at least obvious: and hence an apparent discrepancy of representation which it has become necessary to explain in this statement; as essential to the right understanding of this Map, in some points, as the Key itself. And thus also, in as far as errors may, and must be discovered hereafter, they will be of two opposed kinds; since sandstone may be found where trap is indicated, as, reversely, the latter will be extended into the regions of the former. In each case also, but especially where the trap has been laid down in a detached manner, because it was thus only clearly visible, if the geography is at the same time bad, the errors must needs be considerable, as they will scarcely be corrigible to any purpose until there is a new map on which to re-survey the ground. That there are such, I have ascertained, and very strikingly about Dunfermline, where the total omission or perversion of



the forms of a most important tract of ground, as being the place of coal workings, has rendered it impossible to offer any correction of this Map, unless under a fresh application of time to it which could not be allowed, any more than to so many other parts surveyed in the loose manner formerly described, while pursuing the other and very different objects commanded by the Board of Ordnance. But all this must equally be trusted to future times and future surveyors: as I may now terminate this particular division of commentaries and explanations.

I must now notice two or three omissions arising from some other causes; while, if it is plain that I cannot name more than I know of, those which I do know should not have remained, if it had been in my power to supply the facts correctly.

Since I surveyed Caithness, there have been found in some place, fishes preserved in the usual marly slate: and these doubtless denote some fresh-water deposit, which, be it what it may, is at least interesting to geological science, though it can scarcely possess any other interest. But I have not been able to obtain sufficiently correct information about the place, to insert it: and the limitations of time for this survey did not allow me to return to so distant a part for so narrow a purpose.

Between Ballantrae and Girvan there is a small spot of serpentine, somewhat remarkable from the minerals which attend it, but interesting only to a collector of such minerals. I could not find a guide who knew the spot: being on that line in one of those tracts of bad weather which render everything invisible, and not being justified in waiting for so petty an object, at the hazard of neglecting what was of more importance, nor in afterwards returning there from a great distance, it remains unnoticed. I might indeed have entered it, on report, and perhaps nearly in its right place: but having never yet found anything that was reported to me, correct, when I came to examine it, I have preferred the omission to the probable falsity.

These are the only omissions of which I am quite sure, in addition to those formerly noticed. But I think it very likely that there may be others of a similar nature, relating chiefly to minute spots, and the niceties of boundaries.

To ensure correctness of record, in the only way in which this ever can be done, the necessary portions of the Map were always carried about; and the entries of outline, and generally of colour also, were made at the time of observation, and on the spot. Thus did those segments frequently receive much injury from wet and friction; as the unavoidable wear at the angles of the folds often interfered with the most intricate spots, numerous as these are over so much of the country. It was quite impossible to replace such a damaged portion with a new one whenever that might have been desired, though it was always done when it was practicable; and as the damage did not perhaps occur till weeks or months after the entry, and when the ground had been left far



behind, it was impossible to re-survey it for that purpose, and necessary to re-copy it in the best manner that was admissible and probable.

It was necessary further to re-copy the parts of this Map, sometimes to the extent of nearly the whole, repeatedly, partly from the cause just described, and partly from the corrections which fresh surveys of the same ground introduced. I find that even the great practice of the professional colourists does not enable them to do this with certainty, without the aid of an engraved outline, which I had not; so that some errors have probably occurred from this cause, in addition to all others. It is very true, that even the comparison of the copies does not easily detect them, else they would not have occurred; but they may still be errors as to the ground itself, when that is minutely compared with the Map. Under such an attempt at accuracy as pervades the latter portions of this work at least, and many portions of the former, early, surveys also, where the boundaries are closely referred to some geographical point or line, an error of the sixteenth of an inch in the colouring will throw the boundary a quarter of a mile out of its place, so that they who seek it on the ground may often be disappointed at discovering that it is not there, or by finding that it is on the wrong side of some road, or river, or house, or other solid object in nature. If under the two causes just described, damage and re-copying, there are such errors, as cannot fail to be the case, it is plain that they were among the unavoidable ones, and however to be regretted, not matters of self-accusation. Nor, like all the rest, can they ever be avoided unless, with a better geographical survey and a far larger scale, many persons were employed on such a work, with an absolute command of unlimited time, and every convenience that such persons could desire. And I may further remark, that above all it would be necessary to be unlimited in places of rest and accommodation; or to carry on the work, as much of a future geographical survey of Scotland must be, under a system of encampment; demanding of course far other numbers and means than those allotted for the present work, and to which it was confined. The enormous distances which intervene between places of accommodation in many parts of the country, render it often impossible to bestow the requisite attention on the intermediate and surrounding portions, even with the rapidity which a horse affords; as there are also many which cannot be traversed in this way; and I need not say that the nights cannot be passed on a Scotch mountain. He who will merely inspect the Map, may form a tolerable conjecture of all this, if he will at least measure the parts by a scale of miles, and if sufficiently acquainted with any one portion to estimate what the others are: but no one who has not gone over the ground itself can truly know what it is, while even the Map will deceive him as to its facilities. Very many of the roads laid down in the Map, are roads which were intended, but never made: many more have



ceased to exist, and there are still more, which, so far from being roads, as they are marked, are nothing more than the lines travelled by droves of cattle, which over immense spaces everywhere, are quite invisible, and known only to the experienced drovers themselves. And to add to all this deception, the new system of sheep-farming has entirely dispersed or destroyed thousands of houses and petty villages; so that where we expect to find those which are marked on the Map, we meet nothing but an absolute desert, not seldom extending over many hundred square miles.

I have thus explained as fully as the necessary limits of such a commentary permitted, the several reasons why this Map is not, and could not have been, a perfect work; if at least there is any one ignorant enough to suppose that a geological map can be what a geographical one is; that what can very seldom be seen, but must be inferred from a variety of obscure evidence, can be delineated with the same truth and precision as that which lies open to sight. But this would have been unnecessary had I been content to make this work such as all geological maps have hitherto been. I have assumed, not merely a higher standard, but one that I knew to be unattainable. Yet if thus also I have effected more than ever had been done before, so have I rendered more apparent that which was not done; sometimes because it could not, and never will, and at others from the different collateral impediments already pointed out. Of these, the one chief obstacle consisted in the want of adequate time and means, when compared with the intricacy and difficulty of the geology, the difficulties arising from trackless and uninhabited districts, or places otherwise difficult of access, where freedom of access was most needed, and those which were produced by bad weather; extremely prevalent in most parts of Scotland at all times, even in summer, unusually prevalent during many of the seasons in which this work was carried on, and, in this hilly country, having the effect of obscuring the whole ground, so as frequently to render invisible or unintelligible, everything which could not be almost brought within reach of the hand.

To the other leading obstacle to greater perfection I formerly alluded in relating the origin of this Map; so large a portion of it having been arranged in the best practicable manner from separate surveys, made without any such ultimate views, and, as being made without any command from that Department which ordered very different examinations, never attempted where it could have interfered, either in point of time or expenditure, with the work which was commanded; while to this I may also add that very large portion which was executed under *leave* from the same Department, without any expenditure of the public time or the public money. No work, thus executed, and thus finally compiled into one whole, could be other than the present one is: but it is the best which the circumstances permitted, and as such it is now presented to that Department of the Government which judged



it better that the whole should be finished in the best admissible manner, than that the original detached surveys should be lost.

If I had not desired that this work should not pass for a better or more accurate one than I know or believe it to be, and if I had not desired to point out the very deficiencies, in the hopes of such specific corrections as might lead to a future and better work, I should not have made this commentary what it is; but have followed the general usage, and also adopted the convenient one of using a map less crowded with geographical marks, since it is through these alone that errors can be detected. But for these reasons also, I need not have become the critic of my own work; being certain that very few of the errors and omissions which I have pointed out would ever have been discovered by others, and that it will not be known, perhaps for a century to come, how far the entire work is correct or incorrect.

If any corrections shall hereafter be offered, I shall gladly adopt them when they relate to visible and demonstrable facts: yet they must have other authority than such as has already been offered, though but in a few cases; since an examination of the facts has always compelled me to reject those suggestions, and consequently all others coming from the same and similar authorities. But there is no reason why I should receive as corrections, that which is matter of inference and opinion, any more than that I should adopt the suggestions of system and hypothesis for truth. It will be time enough to do this when I have found that such persons are more worthy of dependence than myself, and of more experience in the difficulties and the geological arrangements of Scotland. If in the only part where this Map enters into collision with geological maps of England, there is a want of agreement on the two sides of the common boundary, it will be for others to see whether they may not be in the wrong, where I have laboured to be right, and could find no reason for rejecting my own investigations.

In concluding, I think it necessary to inform that Department of Government which adopted the original surveys and completed the whole in its present form, that petty criticisms and corrections will be made by those who will find it abundantly easy to do this, by bestowing on a single spot, and perhaps at their own doors, under every convenience of place and time, the labour which I was compelled to diffuse in the same time over hundreds of miles, and under a privation of all conveniences. These will also be used to discredit the whole work: but the discernment of that Department, thus forewarned, will easily see that they ought not to have this effect, even when the corrections are unquestionable, as it is very certain that they will not always be such, and as they will be the produce of those persons who, already with ample leisure, through a long series of years, to examine the unknown parts of Scotland, have only employed themselves in re-examining what they were already taught by myself to see and know; much more often failing than succeeding in correcting anything of all



that which they could not discover, and dared not attempt, before it was pointed out. It is twenty years since this work has been in hand, in some manner or other; and since, in all that time, not one geologist has made a single contribution to the knowledge of Scotland, with the exception (I must repeat it) of Dr. Hibbert, the Lords of the Treasury will the better know how to value the impending criticisms of such men. They will the better know this also, being fully aware of the conspiracy which was originally formed against it, which has been unremittingly pursued throughout, and recently with unusual means, and increased energy.

But as all this must finally recoil on men and motives too unworthy to notice, far more to name, I request the Lords of the Treasury to observe, that I should not have indulged in these remarks but for the duty I owe them: that I may guard them, whether from their own suspicions, or the accusations of others, respecting this work, and the prudence of their proceedings in adopting that which was offered to them as a basis, and in conducting it to the present termination, through the present hands. Let it hereafter prove what it may, it is the first and only work of such a nature and extent that has been executed by a single hand, and with even an attempt after accuracy.



## N O T I C E

RESPECTING

THE GENERAL DISTRIBUTION AND CHARACTERS

OF THE

ROCKS OF SCOTLAND,

AS THEY ARE REPRESENTED IN THE MAP.

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THE purpose of this notice is to state some facts relating to the rocks of Scotland, which could not be represented in the Map, as they are matters which no map can show. With the other accompanying explanatory notices, this one will complete the plan which was intended, and which the nature of this survey seemed to demand, as to that it was properly limited. It is a needful sketch, but no more.

In a former publication on the Western Islands of this country, I have given a specimen of what a work on local geology ought to be; including, with the topographical details, and those also under great minuteness, all those philosophical views, and reasonings from the ascertained facts, which bear on the science of geology: as that work has also rendered geology a far other science than it was before I undertook this subject. Much of what it contains, both as to the facts themselves and the reasonings from them, will equally bear on the far more numerous facts which the continued survey of the whole country has brought to light; though there are many more which might have been detailed for the same and other objects, exclusively also of what will be found in my other various writings on the same subject. But my Lords Commissioners do not expect a work of this nature and magnitude: any more than they have ordered what could not be in their contemplation: while there are ample reasons, already alluded to in another report, why I should not undertake it on any other grounds. It will suffice if this sketch renders the geological structure of Scotland more intelligible than the mere Map would have done.

The total structure of Scotland differs considerably from that of England. It contains a much larger proportion of primary rocks; and while it possesses a comparatively inferior quantity of the secondary strata, so are these much more limited in kind. It also abounds in the trap rocks, as these form a very characteristic general feature belonging to it; while, in England, the limitation of these is very narrow.

If, for the present, I keep out of sight those very small portions of strata, from the coal series upwards, which are found on



certain parts of the eastern and western shores only, and in a quantity so small that they are scarcely visible on the map, it may be considered that the secondary strata of Scotland terminate upwards with the coal series. This is consequently the uppermost rock (or deposit), of Scotland, in geological order as well as in geographical position. Nor is it anywhere covered by superior strata, since it does not exist where the very limited portions of these occur. Thus may every secondary stratum above this, which is found in England, constituting so large a portion of this part of the Island, be deemed wanting in Scotland. Of the exceptions just noticed, I shall give the needful details hereafter.

If the primary strata, or rocks, display therefore every rock which is known, or at least truly ascertained to be a distinct species in geology, the secondary strata are limited, always under the preceding trivial exceptions, to the old red sandstone, the mountain limestone, and the coal series. It has been said, or thought, indeed, that the magnesian limestone, which is superior to the coal, occurs in this country. This is very possible, since it might as well be present, in detached places at least, as the fragments of the strata superior to it just noticed. It is equally possible that indications of the former existence of strata much superior, even to the very chalk itself, may be somewhere present, since it is very plain that the surface of Scotland has been widely and extensively degraded and removed. But such indications of the latter as flints afford, are questions for philosophical speculation, not matters for this Map, or for the explanations belonging to it.

As to other relics or evidences of superior strata, I have noticed them on the Map wherever that was possible. But I have never seen an unquestionable piece of the magnesian limestone. I do not dispute that it may exist, or may not even have been found and proved: but that which has been shown me as such was not; and I can have no respect to the imaginary authorities which see England wherever they go, because they know nothing else, and which equally represent the old red sandstone of Scotland as the red marl. The positions assumed by the mountain limestone and its associates among the coal strata are often very extraordinary, in consequence of the disturbances created by the trap rocks; while the influence of these is also such as to obliterate all traces of shells, and to entirely change the characters of the limestones, even to the conversion of them into white marble, and further, into rocks which are undistinguishable in the hand from the magnesian limestones of England. The geologists who decide on such limestones, must first learn to know Scotland, and their own subjects also, better; and I must also acquire a far other confidence in their knowledge, discernment, and love of truth in preference to hypothesis, before I can accept of their authorities, or of the authority of any man known to me for anything which relates to this country. They did not



even know the important facts respecting limestones, just noticed, till I pointed them out, as it has been my fortune to inform them of far more: of much which belongs to geology at large, and of everything which they know of Scotland: yet it was under this ignorance that they have decided on the characters of these strata. At any rate, let this, as a matter of geological curiosity, and of exceedingly insignificant moment at the same time, remain for future examination and decision.

I have said that Scotland gives striking marks of having undergone a great waste of its surface. Others may speculate on what has been lost, if they hesitate between the two suppositions, namely, that the superior strata of England never existed in Scotland generally, and that they have been removed. Such inquiries exceed my bounds: but I may note the chief places where there are conspicuous indications of the loss of the superior rocks, stratified or unstratified.

This is very remarkable in Sutherland and part of Ross-shire, with respect to the red sandstone, where the evidence can be traced, even in many parts of the Map, and in some sections formerly given in the work to which I have alluded. The detached fragments indicate a former much wider connection.

It is perhaps even more remarkable in the districts occupied by trap; the chief of which extends from the primary territory of the Highlands to that of the south of Scotland, as the smaller one is found to the south of this southern slate. The disjunctions of the masses, and the scattered small patches, bespeak a former far greater continuity, if not a complete one: while the reality, of the destruction at least, is proved by the presence of trap soils covering the sandstones.

But perhaps the most remarkable traces of extensive waste occur in Aberdeenshire. Towards the west, very generally, the mountains are high, as the schistose rocks rise to high elevations, and appear to conceal much granite which would otherwise be visible. In this eastern portion of primary territory, the same rocks appear to have been worn off to the granite; thus displaying considerable, and often very low tracts of that rock. Thence also does the direction of the stratification lose all regularity: and thus, if also from additional causes elsewhere noticed, does the investigation of this portion of Scotland become so especially difficult.

This may suffice as to the changes in question: as it is out of my limits to detail the alluvial condition of Scotland, with all of the various and interesting matter which belongs to it, while it is also matter for a volume: and for this reason, therefore, I make no remarks on the changes which have occurred, and are still taking place, on the sea shores of this country more especially.

In the following sketch of the details of the several rocks, I shall take them in that order which is the usage of geology, as far at least as that can be done where there is no constant order among the primary schists, and where there are some rocks which are guided by no rules whatever.



A glance of the eye will show where the granites of Scotland lie, and what is their extent. Except in Aberdeenshire, it is not very great in any one district. It occupies, indifferently, some of the highest and some of the lowest grounds; and this is equally visible on the Map. If sometimes found in considerable tracts or large patches, it also occurs in exceedingly minute ones, as I formerly noticed, and as the Map will show. In such cases, its occurrence is of course unexpected, and thus, as formerly said, must the discovery be often accidental. But it is equally unexpected in some places where it covers larger spaces; and this is perhaps especially remarkable near Comrie. Where the schists are bared down, as in Aberdeenshire, nothing of this nature excites surprise.

It occurs in contact with every primary stratum in the system; but the Map and the sections jointly show this in such a manner that I need not detail it in words; as my plan excludes the thousands of interesting geological facts which are found at those junctions. It is more remarkable, that it is immediately followed in a few places, both by the red sandstone and the lias series, as will also be seen in those records: while, as to these, I must also suppress equally the details that interest geological science.

It is not within my limits to point out its external characters and interior disposition in any place where it occurs, however different those may be. Details of this nature demand much room, and also much collateral discussion; and they cannot be adopted in one place, or for one rock, unless they were extended to all, with the consequent production of that large work which must not be produced. And as the general geological conclusions respecting this and all else that Scotland displays are stated in my System of Geology, as some of the facts are in other writings, this proceeding is the less necessary. If the details, indeed, of all these things would form a more full system of philosophical geology, so would they furnish the facts in evidence. But while this cannot be, the Map will at least form a guide to those facts; and they who are desirous, will be able to verify them.

It would be beyond the limits of any work to notice the mineralogical variations of these granites, and utterly out of the plan of this sketch. It would be the mineralogical history of granite; and of that I have given enough in my system of rocks; as I have shown, in other writings, its transitions into ordinary greenstones and basalts, especially remarkable in Aberdeenshire and Shetland. I must equally suppress the details of some facts which seem to distinguish the granites of Scotland into three principal mineralogical divisions: they are not suitable to this sketch, and would lead into inadmissible details. And equally, therefore, must I suppress the facts which prove the successive productions of these different masses and kinds, while also giving an insight into at least their comparative ages.

On the economical application of the granites of Scotland, I must nevertheless make some remarks, both as these concern their mineralogical nature and their geography under views of



commerce. But I shall, of course, limit these to what is practicable: it would be fruitless to give an account of things which their situation will for ever preclude from being objects of application to the purposes of life.

The red granites are more durable than the white, as a general rule. The granites which contain hornblende are more durable than those which contain mica; and those which contain white mica are more durable than where the mica is black. If the latter is also abundant, the chance of durability decreases. There is a variety of granite containing a felspar exceedingly subject to decomposition, apparently from containing an unusual proportion of alkali. The granites of Cornwall are frequently of this character, and are not durable. They even decompose extensively in nature, and the felspar forms similarly extensive masses of porcelain clay. Though beautiful to the eye, the perishable nature of these should cause them to be rejected, especially for bridges.

As far as I could trace and examine, the granites of this latter character are rare in Scotland; they occur, however, in the interior flat parts of Aberdeenshire, where they are also often exclusively decomposed into gravelly clays. But I could find none of these which even washing would render fit for the manufacture of porcelain, since they were all too deeply impregnated with iron, arising from decomposed hornblende. It is still probable, however, that such examples may be found: and they who intend to seek, will now at least know where to search.

Granite of a similar character occurs on the great ridge south of the Dee; but is far from universal. On the contrary, these rocks contain the most numerous and beautiful varieties, within a given space, that I have seen in Scotland, and with every promise of durability; as the texture of many offers also great facilities in working. It is for architects to judge of the value they may attach to mere beauty. It is for commerce to judge whether granite could be profitably transported from these spots to the sea, as might possibly be done by uniting that transportation with the rafting of the timber of those places. In the mean time, the vicinity of the present Aberdeen quarries to the sea renders it unlikely that more distant ones will be opened; as there are also some places which afford a grey, small-grained stone, leaving little to wish in point of beauty or facility of working; as the buildings of Aberdeen testify.

If I have observed, as a general rule, that the granites containing hornblende are the most durable of all, and that they are most so as the hornblende prevails, so have they other qualities, little noticed, which give them a great superiority to the others. It is a pure folly to inquire of the strength of a granite to bear weight, before using it in architecture, since the weakest will bear far more than is ever required. It is the tendency to decomposition which ought to be the object of inquiry; and no time or weather ever appears to make impression on the granites of this



composition. They are also the toughest kinds, and nearly among the toughest of stones: whence they are peculiarly fitted for paving, or, in defect of the even tougher traps, as materials for roads. But they have another very valuable quality as architecture is concerned. By the hammer alone they can often be broken into forms nearly as true as the pick would produce; and thus also, even flat faces of many feet square are often the consequences of the blast of gunpowder. The value of this quality in the saving of labour needs not be dwelt on.

Many parts of Aberdeenshire, especially in the open interior districts, abound with granites of this nature; they occur, indeed, so generally in Scotland, that there is scarcely a place where they will not be found; but, after the tract mentioned, they seem to abound principally in the granite district, of which Cruachan and Rannoch may be taken as the measure.

I need scarcely point out that the accessible granite of the shores of Galloway offers easy resources, in a great variety of this rock, and of very perfect qualities; since it is now brought near Builtte, for the uses of Liverpool. And if the Map will show where the other granites of Scotland are well situated for commerce, I need not extend these remarks on their qualities much further; since I have endeavoured to supersede the necessity of such enumerations, by a statement of the principles of judgment respecting them.

But I must note here the red granite of Mull, the general quality and aspect of which are well known from its use in the ancient buildings of Iona. On the northern shore of the Ross of Mull, in particular, it is distributed in such a manner, and in masses so large and so free from fissures, that it would be easy to extract from it columns of any desirable dimensions; to twenty, thirty, or forty feet easily, and I doubt not, to fifty or more: while its proximity to a shore abounding in shelter and readily accessible, almost even to contact, by small craft, would render the shipment as immediate and easy as shipment can well be. Should stones of this dimension ever be required, architects will now know where to find them, in a granite equal in beauty to that of Egypt.

I believe that I need not detail the other remarks which I made on this subject: since, of many, the commercial difficulties were too great; as this enumeration will also apply much more widely.

The gneiss of Scotland occupies a larger space than any other rock, primary or secondary, as it also forms the most extensively continuous tract. With this, and the showy colour applied to it on the Map, its whole extent will be immediately visible. It will also be seen that it is limited to the northern division of the primary rocks; no trace of it having been found in the southern one, even in the immediate vicinity of granite. But it is not always easy to delineate it truly, as I have elsewhere noticed, from its gradations and intermixtures: while, in some places, its



disposition is so contrary to expectation, that unless the Map should in these parts be supposed erroneous, the observer is always haunted with the disagreeable impression that he may not have discovered the truth, as these anomalies also lead to a great increase of labour in the investigation. The following sketch of its disposition will explain all this more fully than I could have explained it in a preceding notice.

The general direction of the primary strata of Scotland, when at all regular, is upon a line vacillating to the northwards of the north-east rhumb line: and such, of course, is the direction of the regular beds of gneiss. The geographical natural section of the land in which the Caledonian Canal lies, is a convenient reference for the course of the strata in this part; as the great slate belt extending from Arran to Stonehaven forms another convenient object of the same kind, though under a want of parallelism which, it must be believed, cannot depend on the Map, since it would imply a scarcely-possible geographical error.

Where this direction is regular, it is also, generally, but not universally true, that the dip is to the south-eastward, but under a great diversity of angles, independently of those peculiar and well-known disturbances in this respect which occur in the vicinity of granite. If I have not elsewhere mentioned the general average which might be assumed for these angles, pointing out the impossibility of representing them, even in a small number of places, as they really are, I may here say that they range most generally from twenty to fifty or sixty degrees, as they are also occasionally much nearer to the vertical.

It would be endless to enumerate the places in which the gneiss follows this consistent direction and dip, even where those were observed; while there is much that is inaccessible to this species of observation. Nor would it be of any use: it will suffice to state the facts in a general manner. Nothing can be more idle than these inquiries about position, unless in the case of workings, especially among the secondary strata: since they are so variable that a hundred records of lines and angles would often scarcely express the truth respecting as many hundred yards, especially among the primary strata; while there is perhaps not a thousandth part of all those rocks where any observation whatever of this nature can be made. To be thus anxious about such matters, is of the petty pursuits and follies of a speculative ignorance in geology.

If I except that portion of Aberdeenshire which includes Fraserburgh and Lochell to the Dee, forming its eastern and generally low division, and again draw an irregular line between Strathy Head and Loch Enard, the directions and the dips of the gneiss may be said to follow a regular order with tolerable consistency. Not but what there are occasional anomalies, even independently of the immediate presence of granite: though it is impossible here to enter on so fruitless and necessarily imperfect a detail. One



only I may notice in Glenco, where the strata are vertical, although the granite is somewhat remote; while this, and the peculiarities of mineral character in this spot, seem to depend on the abundance of porphyry veins.

But it is even in this regularly stratified division that there occurs the great anomaly to which I have just alluded. In most cases there is some parallelism, if not always very accurate, while never so prolonged as it is between the mica slate and the clay slate, defining the gneiss and the next stratified rock in the same class; or the changes of the rocks occur according to the order and repetition of the strata. But the Map will show that in some places this rule is broken; being that cause of surprise, and also at first of doubts, in those tracts, which it would not have been where the positions of the gneiss are irregular. The change from the gneiss to the mica slate occurs on the line of the direction of the strata; and while I here point out the district near Ben Nevis as a conspicuous example of this fact, the Map will show where else it occurs, both with respect to this substance and to quartz rock. In the eastern parts of Aberdeenshire, where it happens with respect to clay slate also, it excites no surprise, since all the primary strata equally have ceased to possess any consistency of direction.

The dips here are also equally irregular, both in quantity and tendency; there is no order of any kind; and thence the difficulty of investigating the places and the boundaries of that which, in addition, is also often invisible. Nothing can be inferred, but all must be examined and surrounded, with the same labour which the unstratified rocks require. There is little doubt that this distribution must be referred to the proximity of the granite. It is what takes place everywhere in those circumstances; but the visible space is unusually large.

In some parts of the north-western angle of Sutherland, and there at least most remarkably, the direction of the gneiss remains sufficiently constant, but the dips are reversed; the strata being nevertheless as regular as usual. Of course, vertical positions also occur between the western and the eastern dips.

But further south in the same quarter, all regularity disappears, under an utter confusion of dips, positions, and curvatures. And this character prevails very generally through the outer chain of islands; as also in Tirree and Coll; in which islands also it chiefly is, that we must seek those singular and extravagant curvatures which the gneiss of Scotland so often exhibits.

Besides the changes of the gneiss on the line of direction, it is subject to others which, as I already noticed, materially enhance the difficulty, first of ascertaining and distinguishing it, and next, of mapping it, even when it is ascertained.

It passes into quartz rock and into mica slate, according as it approximates to these. Such gradation is easily traced in separate masses or specimens; but that is far from being the case in nature, because the rocks about the places of these changes are



often invisible. There is nothing however in this, as far as scientific geology is concerned, which it is not prepared to hear; nor is aught more than the general fact of any moment. But it also is interchanged occasionally with both of these rocks, in sufficiently thin alternating strata, and often over large spaces, as might have been represented, at least under some exaggeration, by means of sections, since that could not be shown on the Map. Neither in this is there any geological wonder; and as to all else, the accurate determination is a matter of indifference. Such changes are of frequent occurrence in all the rocks of this division, not even excepting the limestones, where almost every other schistose stratum is found similarly alternating with the calcareous beds.

This is all which I think it necessary to notice respecting the position and the connections of the gneiss in Scotland, in addition to what the Map will show. I presume it is scarcely necessary to say, that it is followed in immediate contact by every rock in the series, down at least to the red sandstone; since this is sufficiently visible on the Map.

As it would be endless to detail all the varieties of gneiss which Scotland presents, I must limit myself to a general sketch of the leading ones; while the book already mentioned, founded chiefly on a collection of these varieties, as far as that rock is concerned, will give every minute detail which could not be introduced here.

Though I have made other divisions in that work, I need here notice only the granitic and the schistose; since they are the only ones in which either geology or statistics can take any interest, while the laminar ones may also rank with the schistose.

The granitic varieties are so universal over the outward chain of islands, including Tirree and Coll, that it would be difficult to find any other. They occur also, abundantly, in Aberdeenshire, and down to the border of the primary territory in this quarter. Generally also they may be said to predominate over the great western divisions of Ross and Inverness, as they are equally the most abundant in Sutherland. But if they also are found almost everywhere, there are one or two general rules under which they may be expected; as those rules include some places which I need not here distinguish. Wherever there are numerous and conspicuous curvatures, the gneiss is granitic: and it is the same, with little exception, where the positions are irregular. It is the same also, almost universally, where the beds are in the vicinity of granite.

On the contrary, extensive and regular prolonged beds are very generally schistose or laminar; as the strata also are of this character when alternating, and continuous, with mica slate and quartz rock. Thus it is, that the great tracts of this division of gneiss occur in Perthshire very remarkably, and very generally in that division of it which lies between the Caledonian Canal and the line which may be traced from Loch Awe along the



boundary of the mica slate, and the course of the Spey. But in this part also I should finally notice the very singular character of that gneiss which occurs about Glenco, and reaches along the borders of this mica slate: since it is not merely difficult to recognise on the ground in its visible masses, but unites to the mica slate on this line in such a manner that it becomes utterly impossible to define and separate them.

There is little to be said respecting the economical uses of gneiss: and I need not therefore do what I have just done in the case of granite. The granitic varieties are nearly unmanageable for any purposes of art, from the difficulty of shaping them; though there are some exceptions, in which their natural stratification would give two flat and parallel faces, and thus save labour. The finely schistose and laminar ones can be converted into heavy slates, and are thus occasionally used in the country, for want of a better material, or to resist high winds. But they can be of no general value other than as flags; and of these there is such an abundance in many more convenient rocks, that they may be neglected.

Yet there are many of the varieties of the schistose gneiss which well deserve the attention of architects; from the fact, first, of their possessing two natural parallel faces, under different degrees of thickness, and next, from the facility with which they receive the four other faces by the hammer alone. For dry, or unsquared stone work, this is among the best of rocks; while a very little additional labour with the pick, will also do for them what it requires much toil to perform for granite. And, in point of durability, it equals the granites, while exceeding them in variety. It will be for those interested in these arts and this commerce, to see whether those varieties of gneiss, where they lie commodiously for carriage, might not be rendered that object of utility which they have never yet been.

Respecting the hornblende schist of Scotland, there is somewhat more to remark than that usual connection with gneiss respecting which geology is fully informed.

For the greater part, it occurs in beds alternating with that rock, but always in a very inferior proportion; except in the single instance noticed in another of these Reports, where it forms nearly the whole of the mountain Ben Lair. But I have never found it as a bed among the great tracts of schistose gneiss, though portions are sometimes to be observed, in different connections, which are distributed in strata and laminæ, so flat and so thin, that it might be used as roofing slate. As a general rule however, it belongs to the granitic gneiss; while, as far as I have seen, it occurs only where that is a gneiss containing hornblende.

That it occurs also in what I have distinguished by the name of the chlorite series, is a fact which will be better noticed in the subsequent account of this singular collection of strata. And if it is further, though seldom, found as a modification of clay slate,



the circumstance is rare, as the instances are minute: while this is among those facts of a purely geological interest which I have determined to avoid.

The unalterable nature, and consequent durability of this rock, united to its convenient parallel forms, should render it a valuable material in architecture, but its colour is an objection. Its exceeding toughness renders it one of the best materials for roads; but I know of no place but Ben Lair where it might be quarried conveniently for such a purpose, and that is far too distant and inconvenient a position.

I have not thought it necessary to take any notice of the varieties of this rock; since they are very limited, and equally well known; while, occurring indiscriminately everywhere, no geographical places could have been peculiarly selected for them.

The relations of octinolite schist are nearly the same; since it is in gneiss chiefly that it occurs, and in a similar manner to that hornblende schist from which it so slightly differs. But it is so very rare in comparison, that it is very seldom found. I know of its existence in gneiss, conspicuously, only in Glen Elg, under a line extending to Eilan Oransa of Sky, as I have been obliged to remark already. It is not unfrequent also in the west of Sutherland, yet so dispersedly that it is easier overlooked than found. In Perthshire it is even more rare in the same connection.

If some complex hornblende schists occasionally occur in mica slate and clay slate, I have seen none which approach to that peculiar variety of octinolite schist which is found connected with mica slate in Perthshire, and which deserves to be noticed for its economical properties, though its position will probably for ever preclude its use. It is the only variety which I need notice, as it is on this account that I do notice it. It is a compound of octinolite and compact felspar, while the separate minerals are very distinct, and the parts large. The toughness of this rock exceeds every thing that I have seen: a hammer scarcely makes more impression on it than on iron. Could it be transported, it would form an indestructible material for pavements and roads; but, lying between Comrie and Killin, it is a hopeless subject for commerce or transportation.

Lastly, as connected with gneiss, I must here notice once more that compact felspar, before unknown, which I have erected into a rock species. I elsewhere mentioned that it could not be introduced into the Map: but in addition to its place in Iona, there noticed, I must here say that the chief other places in which I have found it are, North Uist, with some of the adjoining islands, Loch Maree, and Loch Greinord, while it is not uncommon in the interval between those two points. In each of these situations the gneiss itself contains compact instead of common felspar. Its extraordinary toughness would render it valuable for the same purposes as the compound just noticed, could it be conveniently procured and transported.



I may proceed to the mica slate: since, whatever irregularities there may be in its relations as to the order of succession in the primary strata, it is at least the most extensive rock in Scotland among those which might have contested for the priority of succession to gneiss.

Its colouring on the Map is so strongly marked, and the spaces which it occupies are for the most part so extensive, that very little attention is required to discern it on this work, wherever it exists. But that great tract of it which immediately follows the slate belt of Arran and Stonehaven, in proceeding northward, is the most conspicuous. In geological order, this portion is the next inferior rock to the slate: in other places the relations are often different; but he who consults the Map, and can at the same time examine the ground, will not require a statement of those in this place. It is to be regretted that the limits to which the publication of this Map seems to be limited did not admit of a corresponding and adequate set of sections, since there might then have been expressed in a small space, what even a volume of words could scarcely tell, and would not, even then, render tangible.

It might be expected, after what I have already said on this subject, that the positions of the strata of the mica slate in this great tract, nearest adjoining to the secondary territory of Scotland, was steady. And this is true, both as regards the direction and the dips. It is at least as true as it could well be under the accidents or influences to which it has been subjected. The general rule, both as to direction and dip, is infinitely predominant; and I will here notice only the principal deviations, since my necessary limitations exclude that minute account, which would occupy a great space, and, even then, conveying no information to add to the general facts of geology, would include none for any useful purpose.

Beginning at the westernmost part of this great tract, the circumstance chiefly remarkable is, that the strata are very frequently reversed in the peninsula of Cantyre, so as to present opposed dips on each side of a perpendicular. In Arran, the effect of the intruding granite has been, not only to destroy all regularity of position, but to apparently transpose the order of this rock and the clay slate, as traced from the eastward.

Near Loch Tarbet, and on the southern shore of Loch Fine, as also in some other parts visible on the Map, it passes into the chlorite series laterally, and here its positions become irregular, as those of this particular series are the most irregular and complicated that occur any where, not excepting even those of the gneiss, as already noted, in certain places. From Loch Gilp northwards, to its boundary at the trap of Mid Lorn, it passes into the chlorite series longitudinally, as regards its own position, whatever may be the case as to the utterly unintelligible disposition of this series in those parts: while I confess my inability to trace this connection in the interior country, so seldom



are the rocks visible, from the flatness and incumbrances of this country, and so utterly does the anomalous nature of the chlorite series prevent all inferences respecting that which, if it is not a solitary case, has never yet been noticed by geologists any where else. That the Map must on this point be therefore uncertain, and very probably defective, I cannot doubt: but I also doubt very much that it will ever receive more than partial corrections. If it might have been improved by a more minute research, this demanded a time which I had not to bestow on such a narrow tract and subject.

I need not here do more than merely notice the disturbances produced on the tract of mica slate in this quarter, by the porphyry on the south side of Loch Awe, and by the trap to the north of this lake. Geologists know that they ought to exist; and the details would be equally minute, useless, and inadmissible in this sketch.

On the northern boundary, confining this to the line from the River Awe to Loch Tumel, the positions and dips are not deficient in regularity, if I except the skirts of the Cruachan granite: but it is here that there occurs that wide alternation and intermixture, already slightly noticed in speaking of the gneiss, between a mica slate of the most irregular composition and structure, a quartz rock often equally anomalous, an ordinary schistose gneiss, and a gneiss which can often be scarcely referred to that rock or to any other, which render the just mapping of this tract as impossible as it is to ascertain in nature the places, extents, and transitions of these troublesome rocks.

Quitting this line, geologists would expect to find that the usual regular positions of this mica slate are disarranged in the vicinity of the granite which occurs near Comrie: but if this is the fact, the details would be as purposeless as the general result of these approximations is familiar.

There is nothing to remark on the southern boundary of this tract of mica slate, hence even to Stonehaven, except the gradual extenuation of its breadth, since it every where maintains a very consistent regularity to the eastern sea. But the northern boundary is a much more complicated subject, as it is far from being a very intelligible one. In general, the difficulty consists in that change of the rocks in a longitudinal direction, which I have already pointed out in some places in speaking of the gneiss. This is most remarkable in the tract which extends from Ben y Gloe to Mar, and towards Clova: in some parts of which, quartz rock adds to the general difficulty and confusion; as it is still more increased by those frequent alternations of these different rocks which aid in rendering an exact knowledge of the spaces occupied by them unattainable, and an accurate record of them impossible. Henceforward indeed, north-eastward, as far as the granite boundary, the joint limits of the gneiss and mica slate cannot be defined. There is the same kind of wide territorial gradation as occurs towards Rannoch and Loch Awe; and as



nothing but an occasional sight of the rocks can be obtained, it can never be ascertained whether the visible fragment of gneiss or of mica slate must be taken as indicating the establishment of the one or the other rock, or whether it is not, in either case, a casual bed of the one included in a real tract of the other. This indeed is among the things which no examination will ever ascertain, occur where they may: as it is likely that different observers will give different reports and delineations, since every one will naturally be guided by the particular facts with which he has chanced to meet.

The next most important tract of mica slate is that which reaches from Appin to Loch Ness, including Ben Nevis. In general, the positions of these strata are very consistent, both in direction and dip, though it is usual to find the angles higher, as the dips are also frequently opposed to the more usual one. But, excluding the influence of granite, as in the case of gneiss, the most remarkable fact prevailing here is that change of this rock to gneiss, in a longitudinal direction, which I already noted in speaking of that substance: and adding to this, the lateral alternations, occurring most remarkably on a broad and prolonged belt to the eastward of Ben Nevis, between the same rocks, a precise investigation, with a delineation equally accurate, becomes as impossible as in the tracts already named. But in no case is this of any moment, in any sense. To geology indeed it furnishes a fact, rather than proves an inaccuracy; teaching it that its definite divisions of rocks are speculations of the cabinet, not the truths of nature on the great scale, and that to define what she has not separated, is to construct systems, not to record facts. In every other view it is quite indifferent. If the different rocks could ever be rendered of use, they are equal in point of utility: and if they are looked on as the possible repositories of mines, each is the same in this respect: of which indeed there is here proof, in the fact that the lead and zinc of Tyndrum occur in one of these undefinable places, and, specially, in an intermixture of mica slate and quartz rock.

And on this subject, as concerning the statistical uses of this Map, I may make this general remark. The constructors of geological hypotheses, extending rules derived from a narrow territory, to the whole world, have named certain rocks as productive of metals, and others as never containing them; as they have also undertaken to point out some necessary connexions between certain rocks and certain metals; with more that I need not here notice. I have demonstrated the utter falsity of all this in other well-known writings on geology, and it is therefore sufficient to repeat it here: suffice it, that no one knows where to seek for metals, or for any specific metals: wherever one is found, that is a metalliferous rock; and should it be lead, or copper, or whatever else, it is a fact, and nothing more. For the remainder of this rock I may refer to the Map; and it is quite unnecessary to enter here on any detail of the varieties of



mica slate, as I purposely omit all those minute and peculiar facts which concern the philosophy of geology. While these varieties are described in my book on rocks, it would be purposeless, were it even possible, to state where they occur, numerous as are the varieties which are found in any given spot. For geology, it will be, generally, sufficient to state, that on the large scale, its leading varieties are regulated by the nature of the rocks with which it is associated; so that all will know where to expect its approximations to gneiss, to quartz rock, and to clay slate.

For the sake of the arts this is even less necessary, since its uses are very limited. It can sometimes furnish heavy and bad slates, as gneiss does; while they are of equally little value and of narrow application. It is indeed a very indestructible rock for the most part, as far as the action of the weather is considered, as it can bear any weight on its flat surfaces. But it cannot be squared by the hammer, even to the accuracy which gneiss admits, and still less can it be wrought by the chisel or pick. Thence is its use confined to rude or dry stone work, as it is also one of the worst materials for roads. It will immediately be seen, that if there be an exception in certain cases to this assertion, it is because there are some undefinable varieties in this rock, which seem equally entitled to rank with talc slate, and which I shall notice in speaking of that rock.

I have said elsewhere that I had made no attempt to represent the chlorite slate of Scotland on this Map, further than as it is included in what I call the chlorite series, under a general hieroglyphic; as the reasons were shown to be valid. But I must now give some account of it as it does exist.

In many places, far too numerous to name, and too minute to find if they were named, chlorite slate occurs among mica slate, as a transition or an incidental substance. Thus also does it occur in gneiss, even insomuch that there is a variety of gneiss which is characterized by interlaminations of this substance. I may point out the extremity of Sleat in Sky as the most convenient place for seeing these circumstances. And thus also does it form some of the thin strata occasionally mixed with clay slate in a very few places.

But if, when occurring in mica slate, its strata are of very unequal thickness and extent, and sometimes not unimportant in quantity, as in Cantyre and other parts of Argyleshire, though incapable of being represented on the Map, it is only on the line of Ben Lawers, including that hill, that I have found it occupying so large a space as to be deserving a distinct colour, could I have found one capable of representing it without the chance of mistake or confusion. But if it is thence necessary, as it is sufficient, thus to point it out, so is there very little to remark respecting it.

The courses and angles of the strata correspond with those of the accompanying mica slate, and it passes into that rock, longitudinally as well as laterally, through endless undefinable



transitions. Any attempt at a distinct representation must therefore, in a rigid sense, have been inaccurate or false. And of this mass I need only further remark, that it presents little variety compared to those which occur in the clay slate or the chlorite series, while the beds are also very generally curved or irregular, and the stone itself of no use.

As I must shortly speak of the chlorite slate which occurs among the clay slate of the remarkable belt already pointed out, it is sufficient that I simply notice the fact here.

The Map points out the places of the chlorite series, as well as it was possible to ascertain its boundaries: and if I have already shown where that difficulty lies, the obscurity of the connection between the mica slate and this collection of rocks will be still more striking when I have described the positions of these strata.

On the margins of the mica slate at these places, taken in lateral order, there is a gradual transition effected by the intermixture of that rock with the beds of the more perfect chlorate series; and here the usual regularity of the stratification is preserved. But very shortly this disappears; when there commences a disorder which continues throughout the whole range of the apparent breadth of this series, estimating that from the boundaries of the slate on each hand. The strata become thin and flat, as the rocks are changed at every few feet or yards; while they assume every possible position, from the horizontal to the perpendicular. Thus all inferences as to direction become impossible; or rather, there can be no such thing.

Thence, as I formerly noticed, it becomes impossible to conjecture what are the connections between this series and the mica slate, on that which is the longitudinal direction of the latter. The ground renders these invisible: there is mica slate at one place, and the chlorite series at another: but while the interval cannot be traced, so does this breach of all the usual rules of stratification prevent the usual inferences from being made.

I have however given so full an account of the positions of the rocks of this series, in my work on the Western Islands, that I need not dwell on them further here. In the same work I have also described minutely all these rocks; so as to supersede the necessity of such a detail in this place. It must suffice to say, that the leading ones are varieties of hornblende schist and chlorite schist, and that from these, this deposit derives its peculiar characters.

In this series alone, as far as I have seen, the chlorite schist is so flat and slaty as to be applicable to roofing, nearly as well as clay slate; and there are quarries for country uses at Loch Killisport and elsewhere; but they are not likely to be made subjects of commerce.

I formerly noticed that talc slate was so rare, and in such minute quantities, that it could not be expressed on the Map. It is found in Shetland, in Loch Hourn, in Scalpa, and in many other



places which I need not here name, since they are those at which serpentine occurs among beds of gneiss or mica slate; and the one will here be a guide to the other.

But there is an anomalous rock, more fitly referable to this than to any other, though it is a transition from mica slate, which I must distinguish on account of its economical uses. It occurs at St. Catherine's near Loch Fine, and in the hills south of Kenmore, if under some differences; and it has been used for building the castles of Inverary and Taymouth. It deserves attention as a building stone, from its indestructibility, and from the facility with which it is wrought, even by an adze or a saw. If not yet exhausted at St. Catherine's, it might there at least become an object of commerce.

If quartz rock is not unfrequent in Scotland, it occurs for the most part in such small portions that I can point out but two conspicuous and continuous tracts of it; as the Map will show where they all exist. The most continuous of these forms the principal part of the chain of Isla and Jura; and the other extends, if interruptedly, between Loch Eribol and Loch Assynt.

In every case of the occurrence of this rock, it is the most distinctly and regularly stratified of all the primary strata, as it is also free of curvatures and marked disturbances: but having never been noticed by geologists till I discovered and described it, in Scotland, as a principal rock in the system, its history is as yet limited to that which it there displays, or to the account of it in my own writings.

In the chain of Isla and Jura, and in the latter island most clearly, its strata dip eastward, at an angle of about twenty-five degrees, conformably to the other directions and dips on this side and place in Scotland. In Sutherland its dips are those already mentioned in speaking of the gneiss in that tract; and everywhere else, they must be determined in the same manner.

I need not here speak of its alternations with gneiss and mica slate, since it would be but to repeat what was said before: but in the chain of Jura, clay slate is also found in alternation with it, as I have represented a continuous belt of this on the eastern margin of all those islands, and elsewhere in Isla. And I need only further remark, that wherever, on the Map, it changes to another rock on the line of its stratification, this is probably the most frequent result of a disappearance similar to what occurs every where in narrow collections of strata, though the given record has probably also sometimes resulted from the impossibility of getting access to the prolongations, over flat tracts of encumbered ground. If it therefore often appears to occupy the summits of hills exclusively, the cause must probably be sought in this, as it never fails to be conspicuous in those places.

I have so often spoken of the irregular positions of all the strata in the eastern division of Aberdeenshire, that there can be no surprise at seeing its distribution in this tract of country: and if I did not make the same remarks on the mica slate of the same



district, in speaking of that rock, the facts and the reasons are the same.

If, occasionally, it is of a lead blue colour, it is white in by far the greater part of Scotland, though coloured beds or portions occasionally occur. I have, however, sufficiently described its varieties in the works already mentioned, so as to render it unnecessary to do that here. But I must add, that I consider it among the best of building stones, though neglected by architects, for the simple reason that it has hitherto been unknown. It is a much stronger rock than even granite; and, for the most part, so hard, that even the ordinary friction in the beds of rivers scarcely affects it, as the weather has no action whatever upon it. It is thus peculiarly adapted for the piers of bridges, or for wharfs. It is equally indestructible by fire, thus pointing out other uses. In very many places, moreover, while the beds are thin and regular, it possesses two parallel faces, so as to save that labour which even the sandstones require; as, in some places, the rock itself is the finest and most beautiful of sandstones, and workable either by the chisel or the pick. But very many strata also break out with faces perpendicular to the plane, as they can further be often sufficiently squared by the hammer; so that it would not be difficult to find beds applicable to the most accurate masonry, with a tenth part of the labour which must be bestowed on granite or sandstone. That a rock of pure white, often emulating white marble in its colour and surface, must be a beautiful building stone, I need not say.

It will be for architects to inquire respecting this, as it will be for Scotch commerce to ascertain whether the uses in question can be expected from this rock for extended purposes; and should it prove so, I may point out Jura as the place where it can most easily be quarried and shipped for an English market, though fully as accessible at Loch Eribol, and also near Loch Leven and elsewhere on that western shore, where there occur those small beds which required no particular description, while their indications can be seen in the Map.

The clay slate of Scotland occurs in a more dispersed and remarkable manner than either the gneiss or the mica slate: and it will not be difficult to see its larger tracts on the Map, though the minuter ones will require an accurate inspection, as there are some, such as that near Loch Eribol, and that which accompanies the serpentine of Portsoy, which I have scarcely succeeded in rendering visible, as there were many similar ones which I was obliged to omit under the same difficulties.

The principal tract of this rock is that which forms the primary territory of the south of Scotland, unaccompanied by any other primary stratum. Taking it as an entire mass, it resembles very much the similar tracts in Cumberland, the Isle of Man, Wales, and Cornwall with Devonshire: and it is visible that it follows granite without the intervention of any other strata.

It is evident that the general bearing of this great mass corres-



ponds with that of the primary strata of Scotland in general. But it is by no means easy to trace the individual directions of the strata, as there is a similar difficulty respecting their dips: these things arising, partly from the encumbered state of the ground and the small quantities of rock generally visible, but partly also from the nature of this slate, and evidently, at times, from actual disturbances of the general direction and dip; most of which occur near the granites and the porphyries, as might be expected, though some seem to be quite independent of such a cause.

It would be a vain and purposeless attempt to describe these vacillations of position, otherwise than as I may here point out the great and extensive irregularities in the neighbourhood of the great granite tracts of Criffel and Cairnsmuir. And it must suffice to say, that barring those and others, and however apparently irregular the positions may seem on a superficial view, or by carelessly confounding the fissile tendency with the planes of stratification, as is very commonly done, the great average direction is to the north-east, as the dip is to the south-east, under various but generally high angles; while in the districts about Hawick, and in many more, this fact is extensively visible. And where there are tracts of strata that interrupt the longitudinal continuity of this rock, as near Moffat and Sanquhar, these are plainly portions of the superior secondary strata which otherwise skirt it for the most part.

The general average character of this slate is considerably different from that which prevails in the narrow belt which skirts the Highlands, and in that of Aberdeenshire, those being the only two other tracts of noted extent. I have never found in it other rocks than fine slate and that coarse kind, under endless varieties, which has been termed graywacke, if I except the siliceous schists. But the coarser kinds are infinitely predominant, as the fine ones generally form but thin and casual beds in them. Still more rarely does it produce fissile slate, either for flags or roofing: while the few quarries wrought, near Peebles for example, near Loch Ken, and in a very few other places, are not situated so as to be the objects of a distant commerce. What future researches may affect over so vast an extent, and where so much of this slate bounds with the sea, it is impossible to foretel: but under all the views which a geologist can take, it would I think be decided that useful slate will probably prove rare in this great tract, and that the discovery of it is likely to be the result of chance far more than in the other slate districts of Scotland.

The next great tract of this rock requiring notice is that singular belt which so well marks the general direction of the primary strata of Scotland. This is perfectly definable on its south-eastern margin, as might be expected, but not always so well marked on the other boundary. It is not only that great tracts of peat and soil prevent it from being visible, very often for many miles, and most remarkably from Dunkeld eastward, even to the



sea, but that it demonstrably passes into the mica slate, often after a very considerable extent of intermixture, by a gradation of alternations. If in some places, therefore, the north-western boundary is sufficiently accurate, this is not always the case, especially to the eastward. How it is extenuated near the granite of Comrie, and near its eastern termination, how it skirts the northern shores of the Clyde, intersects Bute, and is stopped by the Arran granite, the Map will show.

This latter is the only place where its regular positions are remarkably disturbed, if I except the neighbourhood of Ben na Cherry and Loch Turrib, at both of which places this was to be expected. Every where else, while it is evident that the direction of the strata must be regular, so are their dips south-easterly, though under diverse, if generally high angles : although there are places affected by trap in the same manner as by the granites, and although in some others it is easy to mistake the planes of the fissility for those of the stratification.

Though this belt is laid down as if it were all slate, that is not always the fact, however impossible it was to note it otherwise on the Map, as any one can see in examining its structure. It must suffice that the far greater part of the whole breadth consists of slate ; and, very predominantly, of the finer kind. The coarser, or the graywackes, generally occur with the other, often anomalous rocks, that are interstratified with it ; as the whole of these also generally occupy a single portion of the belt. These comprise varieties of chlorite schist chiefly, but often of a very singular structure, with rocks that might perhaps be referred to some of the varieties of gneiss, and with mica slates ; but I need not here enter on these details. They are fully given by myself in the account of the Western Isles, and there is also a coloured section by General Imrie, which gives them with great precision in Forfarshire ; being the only accurate draught of any portion of its geology which Scotland has hitherto produced. These works may be consulted : but if any one desires to see the rocks themselves, I know not where he can more conveniently trace the whole than near Loch Cateran.

Slate of the best quality might doubtless be found almost every where along this long line : and the present accurate indication of its place and extent, hitherto unknown to Scotland, will probably prove among the most valuable of the economical applications of this Map and Survey, since a great deal of expense is now wasted on a land-carriage which might thus be superseded. If I have thus further discovered fissile and useful slate in many places hitherto unremarked, I know not but that the enumeration would involve nearly the whole line, at least on its southern margin, since it is there chiefly that the useful slate occurs : while I need not do this, when so many other circumstances must unite to render a slate quarry an eligible undertaking. Nor need I perhaps do more than name a few places where slate is now wrought upon this line, since these are things of general notoriety. Among



these are Arran, Bute, Luss, Benvorlich and Dunkeld, with other places, connected or intermediate.

The slate of Aberdeenshire is seen to possess that irregular extent on the Map which marks all the stratified rocks in this quarter. Its internal disposition is however sufficiently regular: while I do not think it necessary to enter on details that would only involve repetitions. That it produces workable slate at Fordlaw is well known, as it would assuredly afford it in numerous other places. The assignment of its boundary and place on the Map will therefore similarly lead to profitable knowledge in this populous country.

I need not here separate the deposits of slate which are marked on the Map in Isla, Jura, &c., and in the isles where that substance is so well known by the extensive commerce in slates which they carry on. In a geological view all these are analogous to those which can be traced on the Map in Knapdale, Appin, and other places, being portions, more or less wide, of collected strata alternating with the neighbouring mica slate and quartz rock. And thus may their dips be inferred, as their directions are visible. With respect to their economical value and produce, the quarries of Bdlahulish are as well known as those of Seil and Lunga: and there is no doubt that many more might be wrought in all these places and islands, were there any commercial expediency in competing with those which have so long possessed the market.

In Isla alone I desire to point out the valuable flags and beams which are furnished by the western portion of the slate, and which have hitherto been little attended to, otherwise than as the common people sometimes use the flags as walls for their smaller buildings. The beams are so long, and so well shaped, that they might even now be used as such for houses; as it is also not difficult to trim the less regular ones to a true shape by the adze alone. Architects may inquire what their value would be, as compared to iron, for fire-proof apartments.

If I have mentioned the slate strata which occur in gneiss, indicating on the Map those about Loch Maddy, and here naming those, less visible on it, about Loch Eribol, they are little more than geological facts to which geology may attach such value as it deems proper. I have not been able to find, in any place, that the slate thus associated will produce roofing slates.

It would be here impossible to enumerate the places of the primary limestones of Scotland by name, for want of references. They must be sought on the Map; where it will also require care to discern some of them. If I except one tract in Isla, another near Campbelltown, the island of Lismore, and that which runs along Glen Tilt towards Loch Tumel, there is not one spot of primary limestone of any notable extent; as even these are very insignificant in dimensions, compared to the great mass of the primary strata. Of all the others I may say, that they are the thin edges of casual strata, and if not soon exhausted



along their directions, ceasing to be traceable, from the circumstances formerly mentioned, when I also showed how greatly I was obliged to exaggerate, their breadths always, and their lengths very generally, that they might be at all visible on the Map.

It is superfluous to say any thing respecting the dips of these strata, since they are determined by those of the adjoining ones. And the only question respecting their directions is, whether or not they proceed much further than is now visible, and whether especially those portions which are now discontinuous on the Map are invisibly connected. There appears some probability of this, in examining especially those which range from Glen Tilt to Loch Earn over a somewhat wide space: but it would have been hazardous to have inferred what cannot be traced, when the exceeding tenuity of some of these beds is recollected, and when there are such incongruities among the apparent lines of direction of those which are here noted. What I have done, in ascertaining many before unknown, in prolonging the extent of others, and in tracing the probable connections or continuity of a great many, will not only lead to the more extended knowledge of this rare and equally needful substance in the primary districts of Scotland, but also point out to the natives where they may be sought. I discovered many myself in this manner: those who reside on the spots, and are also immediately interested, will now be able to do this far more extensively and effectually; and thus, I trust, will this portion of the Map become of an economical value much greater than they who do not know the wants of this country may imagine, and the impediments which the want of accessible limestone in particular throws in the way of the agriculture and improvement, with the further great loss which occurs from the distant transportation of what might often be procured near at hand. It is not easy for the peasantry to find these limestones; and they do not always recognize them when visible, so little do they resemble the more familiar rocks of this nature. Thus it is, that great tracts of limestone remained unknown near Rannoch and Blair, because these varieties have the external appearance of mica slate and gneiss: and thus was even the white limestone, or marble, of Glen Tilt used in building, under the belief of its being a sandstone. Thus also have I added the whole of this extensive mass to the old resources, since it had been unsuspected; as in other places, such as near Monterriarn, Cushiville, and elsewhere, I have substituted quarries on the very spots where the materials were required, for others many miles away, under a great expense of transportation.

Having, in the work on rocks, described all the varieties of this limestone which I knew, I need not repeat the enumeration here: and shall content myself with merely noticing those which, besides their usual agricultural and architectural uses, might be used for ornamental marbles. Glen Tilt is the chief deposit of



these; but its peculiar produce is now so well known that I need not describe it. The Gairloch Isles also contain ornamental breccias: but of the few other ornamental primary limestones that I have found or seen, there are none so conveniently situated as to admit of being profitably wrought. The white marble of Leadbry in Sutherland seems as scanty in quantity as it is inconvenient in respect to transportation. The quarry of Tirree is ruined: that of Iona exhausted.

In Scotland, there is no extensive tract of serpentine. All those which occur are very small, and often so small that even the minute spots by which they are noted on the Map are great exaggerations. I must request those who may examine this Map to look carefully for them, or else they may escape attention. If some are omitted, it is from a minuteness so extreme, that I knew not how to render them visible by means of their colour, strong as that is: as I have also avoided the notice of others reported to me, which I could not find; not less declining to record some, from well-grounded suspicion of the reporters.

The several serpentines noted amid gneiss are interstratified with it: and the same is true where it occurs with mica slate or clay slate. These are accompanied by more or fewer of the usual minerals: but I need not enumerate what is so well known, especially since the costly minerals of Scotland, as objects of mineralogy, constitute no part of these Reports. But none of these are of ornamental use, except that of Portsoy: while even that is not now wrought, as being an article not in demand. This well-known one is associated with a very small body of clay slate lying in gneiss: as the Map, however minute, will I trust explain.

The last circumstance deserving notice as to these serpentines is, that they occur as large nodules in Aberdeenshire, connected with granite alone, as if imbedded in it.

There was formerly a fact of geological interest, in a trap vein passing into serpentine, at Cluny in Perthshire: but the quarrying of the lime has destroyed the whole, so that it now is only known by a former record of my own, which they who may now seek for the spot in vain, might deem a fiction, if so inclined.

I showed, in another place, the difficulty which existed in distinguishing the ancient porphyries from those belonging to the trap rocks, and mentioned the places where I had intentionally coloured as ancient those which I knew to be modern. With this correction, the quantity of ancient porphyry on the Map is easily found, as it is very trifling. The most extensive mass is that which occurs near Loch Fine: the next, near Kirkcudbright. But neither of these possesses any geological interest to demand description here; as, in neither, did I find porphyries so ornamental as to be subjects of economical interest.

This is however the case, I think, with the island Devar. The green porphyries of this spot are ornamental, with the additional merit of novelty: the detached blocks require no quarry-



ing, and would easily be wrought into slabs : and the transportation is perfectly easy.

The crowd of porphyry veins in Glenco and in Cruachan, where there is no mass of that rock, is an object of geological interest, as is the fact I formerly mentioned, of the more than probably recent date of those which could be otherwise judged ancient. And this is all as regards these also ; unless I add to this, the probability that it is through the influence of these that the gneiss of Glenco possesses so singular a character, both in disposition and texture. And here I think that there are many ornamental porphyries which might be wrought with advantage, from the facility and power which the river affords ; though it must be for others to see whether a taste can be introduced for such a domestic manufacture, in competition with the favoured foreign produce of Sweden.

On the subject of the casual rocks, jasper, chert and siliceous schist, whether occurring among the primary or the secondary strata, I need add nothing to what I said in another Report ; since I am not here to discuss nice questions of philosophical geology, especially as I have elsewhere fully described rocks which had been always neglected or misunderstood, and which I have added to the ancient imperfect system of geologists. The jasper of the Burn alone, I have already said, might possibly prove an object of economical speculation or use.

I have taken no notice on the Map, of what I, and some foreign observers, have thought to be a primary red sandstone. What I know and conjecture about it, I have stated in my system of geology and elsewhere : and for the present it stands among the quartz rocks : since it will require much more investigation to know whether it deserves a distinct place. At any rate, it was a circumstance of no moment as to the leading object of this Map and its appended Reports.

I must proceed to the secondary strata and rocks of Scotland, as, of the former, I have already given a general sketch indicative of their number and limitations.

The red sandstone is the first of these. For the greater part, its extent and places, however remote and scattered, are sufficiently obvious on the Map. Yet not so universally but that I must direct the attention to some of these, since there is an interest attached to those fragments which does not exist respecting similar ones in the primary strata. Both on the sea shores and in the interior country, they mark a wasting of the surface which is an object of geological interest, though it should possess no other. But I must first note the principal masses, as the fragments in question must be referred to those : as it will also be the clearest method to describe the characters of each division separately ; since the differences, in different parts of Scotland, are very considerable.

I may take all of those sandstones which are found to the southward of the north-western boundary of the southern slate as



one, since there is tolerable evidence of some former connection more general.

The most continuously extended tract is that of Berwick and Roxburghshires. That of the valley of the Nith may be taken as one, though it is interrupted by a mass of slate, and it is continuously connected eastward with that which skirts the English border. The detached portions of this are so scattered, that it is needful to point them out here: especially as some of those noted in the Map, would, in nature, escape all but a very minute and discerning observer.

Westward, the most remarkable among these, is that narrow line which extends between the mouth of the Urr and Kirkcudbright: nor would it easily be recognised as such on the Map, but for this note: Applegarth and Moffat serve to mark two other detached portions, but much more conspicuous ones. But there are two spots on the Map near the former, and one between Tinwald and the latter, which will not easily be perceived on the ground, since they do not exceed a few yards in dimension; as the former presents nothing but the shale of this series: and they are noted on the Map for the purpose of showing that the extent of this sandstone was once much greater than it is now. They will also serve to show, as I elsewhere remarked of the slate about Loch Maddy in North Uist, the care with which this survey was carried on; since, in the case of this tract of slate in particular, the continued extent of the same rock which occurs without any variations, offers a strong temptation to follow the usual practice of geologists, and to lay down whole tracts by mere conjecture.

The portions of this sandstone on the skirts of the slate near Southernness, and all those which extend on the eastern side of the Nith in a similar position, as far as the Carter-fell, may be looked on in the same point of view. They are that portion of this rock which, following the slate, are covered by the coal series, and they are visible or not, according to the presence of this and the nature of the ground. Thus do they also here appear as if in the middle of the coal series, these being the places where that covering is absent. I elsewhere noted the impossibility of tracing every point of that which must contain the common belt including the boundary line of the slate and that of the red sandstone towards the coal series. There may therefore be deficiencies in the mapping of these few portions; which future observers may supply if they think fit to pursue that subject, so little important, on which I had no time to bestow. He on whom it fell to traverse every mile of all Scotland, and all its hundreds of islands, had other work to do than to spend days on so narrow a spot and so paltry a subject as this. If, lastly, I notice the fragments of red sandstone about Trendergarth, it is evident that these are the result of the intrusion of trap into this border.

The very minute fragment of this rock near Boonhill in Berwickshire was laid down for the same reason as those near Mof-



fat: as is that near the Aildon hills. They are rather indications that the rock once extended over these parts, and are, thus, simple questions of geological curiosity. It is quite probable that others may exist over this great tract of slate; as I suspect they do about its westernmost extremity, in that peninsula which terminates in the Mull of Galloway, from the frequent occurrence of heaps of the fragments of this sandstone. But I did not find what I sought for: as, in this and similar things, we must be indebted to good fortune where we cannot carry on a microscopic examination of every yard of ground.

The fragments on the eastern shore of Berwick are visible enough; and, in the Map, they represent the exact sizes and places: if they indicate nothing more, they at least show the action of the sea on this coast.

Of all this portion I may say generally, that the angles of elevation are low, while the variety of position is such, that all attempts at describing even what can be investigated would be vain. Of course, the higher angles will naturally be expected near the slate, as the disturbances will be near the trap.

This southern sandstone is of an exceedingly uniform character almost everywhere, both in the mass and in the details. The occurrence of conglomerates is rare, and there are none of those conspicuous masses which occur in the northern portions of the same rock. It also contains very little shale in comparison; while over great tracts, not the slightest indication of this can be discovered. Its limestones, as far as I know them, are noted in the Map. It is almost invariably red, and is rarely a very hard rock; though I know of no spot anywhere where it is not a very good building stone; while, of practicable quarries there is no end. Near Thornhill, its strata are sometimes so thin and flat that it is quarried and transported for roofing.

The Map in this part will show the inhabitants how much more widely they may quarry for this rock than they yet have done, and thus, in many places, save much expense. And the following remark I may here make once for all, as applying to the whole of Scotland where this, and indeed every other useful rock occurs.

I am not aware that any of those jointly practical and scientific persons in whom the ordinary road engineers, surveyors, and coal-viewers are included, have ever extended their views to the general geological structure of the country, anywhere. How far the superior class of engineers has done this I do not know, since they have not published their observations; while it is not improbable that their knowledge of this nature is confined to the districts in which they may have been interested. The applicable practical knowledge, as relates to quarries, therefore, lies generally, with a class of people even inferior in rank to the first set; with contractors, and quarrymen and masons, and the lowest rank of road inspectors. The acuteness, and the knowledge of these men is indeed very remarkable, as I have often been indebted to them for useful information; but it is confined to



their own narrow limits of observation. To them, therefore, the extent of their quarry and that of the rock is very often the same; nor could I find that any of them had imagined the continuous extension of such rocks, in the way that geology is enabled to point it out. And it is by them that the workable rocks are assigned, as their knowledge is naturally supposed to be the true point of reference.

It is from this want of geological information therefore, or of what is equivalent, sufficiently extended practical knowledge, that there arises the inconvenience, with necessary additional expense, to which I have more than once alluded, which follows from an imaginary confined locality of workable rocks; since it is often plain that the persistence in working a single quarry for a distant sale, does not follow from the work having been organized, or the market having become an usage; while it is further visible that many of those old quarries have become so deep and inconvenient that they ought to be abandoned in favour of new ones, and, above all, where the distance from the use of the materials renders the transportation expensive. The utility of this Map on the subject of the red sandstone alone will thus be seen to be as extensive as it is apparent; while there can be no difficulty, among a people like the Scotch peasantry, in extending all the useful knowledge of this nature which the present Map contains, by some form of publication adapted to their means. It is not a work to be confined to libraries and geologists: and though no cheap transcript can be very accurate, it may always be rendered useful.

But before dismissing this southern portion of the red sandstone, I must distinguish that narrow line near the Urr, already mentioned. The strata of this are so nearly horizontal that they may be considered as such; and it is a solid sandstone without shales, in beds of an especially convenient thickness, and remarkably free of destructive fissures, while sufficiently divided to render the quarrying easy. It is also, beyond comparison, the most perfect stone of its kind that I have seen in Scotland, as a building material, while its predominant colours are pale greys. In addition to this, it is already an open quarry of miles in length, skirting the sea shore to a considerable breadth, like a continuous series of a gigantic pavement. It may be true, that no lighters could lie near it at present, except in calm weather; but the very first working would form a dock, and that dock would cost nothing, since the excavated materials would be the saleable stone itself: while the flatness of the surface would form a convenient lodgment for any machinery. The engineers of the Liverpool docks have not been well advised in neglecting this rock, to quarry the granite of Builth at a far greater expense; when it is in every respect a superior stone, and affords blocks, almost ready squared, of nearly any dimensions, peculiarly applicable to works of that nature. Better known hereafter, it may become



the point of supply for uses of this kind to all the West of England.

I will not quit this tract without yet pointing out the singular redness of the slate about Eyemouth, in those parts whence the sandstone appears to have been worn away, together with the remarkable disturbances which it there exhibits. Geologists are already informed of the curvatures in the slate of this coast.

I will next take as most convenient, and as if it were one mass, this sandstone as it is bounded by the north-western edge of the southern slate, by the Forth and Clyde Canal, and by a line between Glasgow and Ayr. But I must appeal to the Map for its undescribable places, as one general description must suffice for the whole.

Appear in whatever manner it may at the surface, it must be viewed as the basis on which this great coalfield lies; concealed by that covering in some places, and displaying itself in others. That display, which interferes with the continuity of the coal field, is sometimes owing to the wasting of the superior rocks, at others to its undulations or elevations; while in some cases, though by no means in all, these are traceable to the influence of trap.

Thus, in some cases, it occupies low tracts of land, or appears in narrow lines, sometimes near the slate, as would be expected, at others near the trap masses; as, in other parts of this great coalfield, it is totally invisible in both these situations, and every where else; though some of the coal workings give evidence of its existence beneath. In other places, it is elevated into considerable hills, as in Hawkshaw-hill and Cairn-table; while if these display no other rock, the not less high land intervening between Muirkirk and the Irvine is extensively covered with trap.

It is a natural result that it must possess great irregularities of position and elevation. To all this indeed there is no end. Very little of it all can however be seen; and such is the uncertainty, that not a mile can be inferred. And as ten thousand sections, and a volume of description, would not include the whole, even as it is assignable, while even that is but the smallest portion, I need take no further notice of that which, could it be all known, would scarcely be an object of either use or curiosity.

Like the southern tract already described, this one contains very little shale, and is very generally a red rock, not often very remarkable for its hardness. And, in a similar manner, it is very deficient in conglomerates. Such varieties as may occur, it would be here superfluous to notice; since, having elsewhere described these fully, I have here chosen to limit myself to those which, from their places and qualities, are, or may be, objects of economy: but there is one not unfrequent fact which I must point out, because it so often interferes with the correct assign-



ment of the boundaries of those detached pieces of this sandstone.

It is evident in the first place, that the mountain limestone is often wanting between this sandstone and the coal series, and next, that this series follows the inferior rock in parallel order as well as in contact. It further happens that the rocks of the coal series are sometimes red, as those of the red sandstone are known to be occasionally white, or as it also happens, that, in some places, both sets are of brown, or other colours, in common. Thus there are many places, where the rocks are but partially visible especially, in which it is utterly impossible to conjecture which is which, since there is no guide of any kind. And if this is a frequent occurrence in Ayrshire, as it also appears to happen in the Edinburgh district, I may make the remark general as far as the boundary of this great coalfield; since it is evidently the case in Fife, which I might have included in this division, instead of associating its red sandstone with the great belt that follows the primary rocks of the north, to the southward. And to save a future examination of the same question, I may here state, that this is the case especially on that margin of the joint coal series and red sandstone which is bounded by the northern trap of Fife eastward. Different observers will probably judge differently as to the definition of these two rocks: in the mean time, under such a lack of evidence, I have taken the course which seemed at least as right as the other. It is not by assertions, most assuredly, and certainly not by those of the ignorant, superficial, vain, and arrogant intruders into this science, that the truth will be settled.

Thus further excluding Fife in this division, under a desire to unite all the red sandstone of the coalfield under one discussion, I may lastly point out two narrow lines which occur on the shores at Wemyss and Anstruther, a small spot at Denino, and another not far from Cleish. Whether these are the old red sandstone, or red portions of the coal series, seems very difficult, equally, to determine: but at any rate they are not parts of the red marl series.

The next portion of the red sandstone forms the most continuous and extended tract which Scotland presents. And I need not describe what the Map displays so perfectly. I need only guide the observer's eye to its outskirts and fragments on the shores and islands of the Clyde, and on the coasts of Cantyre; as, in many cases, sections might perhaps have displayed these more fully than could have been done in such a Map. It is easily seen in nature, and not less easily conjectured from the Map, how much of this is owing to the waste of the surface and the sea shores, and how much has arisen from the intrusion of trap.

This tract is not the flat country which might be imagined from the Map. The sandstone hills of the Sidlaw are high land, as is much of Forfarshire, and it is generally a kind of mountain



rock on the skirts of the slate; as the braes of Doune and other places also present hills of considerable elevation and extent. An observer will find but little guide in the forms of the land: and if, especially, he trusts to this near the primary boundary, he will be often greatly deceived. Definite as that line really is, there is not one on the Map which demands more labour.

It is equally a matter of course, that the positions of the strata vary over this tract; and the variations are even greater than in the southern divisions of this rock. It is as impossible to describe them, for the same reasons; and it would be equally purposeless were it done. But it is a general remark, that the strata are highly elevated near the primary boundary; being in some places vertical, as, in a few, they seem to have been partially reversed. In the lower districts generally, they tend to a horizontal position; but to this rule also there are endless exceptions, as the hilly tracts also do not always imply high elevations of their component strata. Some of the Forfarshire hills are formed from strata at no high angles: and at the low tract near Dunnotter, where the flatness of the surface would also lead to the expectation of low angles, the strata are vertical. This must suffice as to positions, in this great tract: local details must be entrusted, with the rest, to far other works than such a Memoir as this: as they may hereafter constitute the high fame of some aspirant who will appear to have discovered vast things.

This tract of standstones presents far more variety of mineral character than the preceding ones. There is scarcely an exception to the rule that the boundary with the primary rocks is a conglomerate; of great variety of character, and often of great extent also. But such conglomerates occur in many other places, often far remote from the primary rocks: and there is no more striking instance of this, than at Dunnotter, just noticed.

In the western division, this rock is so very generally similar to those already described, that the exceptions need not be noticed. It is generally red, not often very hard, and contains but little shale. Towards the middle, grey and whitish beds are not uncommon: and while some of these have been quarried for building, there are much wider resources of the same nature. In the more eastern portions, comprising Forfarshire, though the predominant quantity is also red and free of shales, there are extensive tracts of a pale grey, or whitish, as there are also considerable ones abounding in blueish or grey shales. Near Forfar, Carmyllie and Panmure, the intermixture of these shales with flaggy varieties of this sandstone, has led to the working of extensive quarries; as such might be opened in many other places were it necessary: and as there is scarcely a spot over this great extent which would not afford sandstone quarries. The remarks formerly made on this subject are equally applicable here.

The detached fragments on the shores of Seil, Kerrera, Oban, and Upper Lorn, with that near the bridge of Awe, were formerly



pointed out, lest they should escape the eye. They cannot be referred to any other mass: and the conclusions in geology to which they lead are the same as those which arise from a contemplation of the scattered lias of this coast. They have little or no economical interest.

I shall simply point out the patch at Kildrummie, of which the insulation is remarkable, and that which extends from Troup-head to Fyvie, with its accompanying fragments. These last at least, with the similar extenuated portions to the north, mark a once greater extent of this rock: though whether any one will be bold enough to infer the former connexion of the two, is what I do not know. Except that the portion of this rock at Kildrummie affords white sandstone, and is quarried, and that the other is a red rock most generally, similar to that of the south, I know not that these tracts admit of any remarks that are worth repeating: unless I note the conglomerate near Troup-head which is wrought for millstones.

I may take the great and scattered tract which commences near Speymouth, extends to Loch Lochy, and then proceeds north to Reay, under one view, reserving Caithness, as marked by some peculiarities. It is all sufficiently visible, except a small point near Cullen, which any one who chooses thus to speculate may use for connecting this tract with the one near Troup-head in former times. And if I add to this the independent spots at Ben Griam, the mouth of the Hallodale, and Tongue, they will equally serve to establish a speculative connexion between the eastern and western sandstones in this division of Scotland.

Though taken as one mass, under every appearance of a former more intimate connexion, the differences of character, both on the great and small scale, in different parts of this tract, are considerable. But as a geological treatise would be required to describe all this, I must confine myself to some of the most striking facts.

From the Spey to the Moray Frith, excepting on the primary boundaries, where the usual variety of conglomerates occurs, the general character is in all respects similar to those of the south of Scotland, and of the western portions of the great middle belt. These I need not repeat. And the same holds generally true of the great tract reaching from the Moray Frith to the Ord of Caithness. In a former place I pointed out the peculiarities of some of these junctions: but on these and the circumstances of the conglomerates which attend them, it is not my intention here to speak, as being questions of geological philosophy. I need only add respecting the conglomerates in this division, that they are often remarkable for their extent and general characters, especially in the great valley of Glen More, and its connexions.

Taking Caithness as somewhat separate, though still connected with the former by means of the insulated fragments just noticed, the character of its sandstone is so very different from what the



same rock displays everywhere else, that it demands a new notice. It is almost everywhere so flat that it is best referred to the horizontal position as a general rule. The Map will also show the great quantity of shale which is present, as of the nature of this entry I formerly spoke. And in some places, as is visible both in nature and on the Map, the extent and depth of the un-mixed shale is such that it seems to claim a place as a distinct rock.

This shale is always dark, and often black, though the sandstone should be red. The beds are thin and repeated. Near Thurso, it produces large and excellent flags, and is wrought; as it might be, far more widely.

In some parts the sandstone is often very deceptive. It is occasionally white or yellow, and might be thought a portion of the coal sandstones, on a superficial and hypothetical view, as I believe it has been thus mistaken. But it is not difficult to see that these are nothing more than the dark grey ones of this deposit, rusted, and often so as to affect whole beds, by the action of the weather or of internal water. It is a fact analogous to many similar ones which I have pointed out in the trap claystones.

I have lastly taken the great north-western tract of this rock as one division. It is much more scattered than the preceding: but as most of it is easily traced on the Map, I shall only point out in addition, a small spot in Lewis, and add that Rum is included in it.

Its disposition on the mainland is more remarkable than that of any of the former, from its frequently occupying the summits of the gneiss hills, far above the level of the sea: and these numerous detached parts, taken together with those in the interior of Sutherland just noticed, and with that apparent former connexion which one of the sections especially traces, bespeak such a loss of the surface in these parts, that I shall not dispute the speculations of any one who may choose to think that most of this country was once covered by a continued tract of sandstone. If the intermixture of this sandstone with the gneiss is often very minute and remarkable, it will also aid in showing the labour bestowed on this survey, as nothing less would have brought to light facts so easily overlooked in a sweeping examination.

It is remarkable respecting the positions of this rock in so mountainous a country, that the strata are very extensively at low angles, or nearly horizontal, while the subjacent gneiss is much elevated and also disturbed. It is in Sky and Rum most remarkably, and in the Summer Isles, that the reverse occurs; since the contrary is often visible, though the details cannot be given here.

With respect to mineral character, it is very generally a red sandstone, with little or no shale, and also a fine one. The conglomerates are apparently not extensive, and they occur where



they might be expected: and I may remark, as might also be expected, that the very insulated fragments, in the interior especially, consist solely or chiefly of the conglomerate.

Two portions alone have left doubt on my mind, and after all the examination that I had the means of bestowing on them, I must confess my inability to satisfy myself respecting their true nature. They will be fitting subjects for the future investigation of those who will otherwise be examining what is already clear, for the purpose of finding petty faults.

In the Summer Isles, this rock is often singularly disturbed and elevated, while in some of these, there are even strata at low angles placed on the edges of these disturbed ones. Under the general belief of geology, these ought to be distinct and distant deposits. There are persons who will assert that the upper one is the red marl sandstone. This may be; considering the singular positions and the neighbourhood of the lias series; but if I have laid down such a portion of red marl at Loch Greinord, I could not equally satisfy myself in those islands, since I had not sufficient time to spend on so long and difficult a labour as the navigation of so many islands often implies in this stormy climate. In the mean time, they are all laid down as the old red sandstone; while this annotation will suffice to point out a possible correction.

In the sandstone of Sleat in Sky, there occurs a quartz rock among the elevated portions. On the prolongations of this ridge to the Kyles, and also on its continuation upon the main land, the sandstone, if sandstone it be, is elevated and often reversed: it is the most disturbed stratification that I know of in Scotland. The flatter red sandstone of Sky is doubtless that now under review: but what is this? The action of trap might produce on it the effects which are visible. But it is more often pale or white than red. Under different examinations, in different years, I have doubted, and changed its indications. I have thought it a primary red sandstone; a quartz rock, on which the true red sandstone lies; and the red sandstone itself, elevated by the trap. Finally, I know not what to conclude: and if it remains as I first of all laid it down, it must also be left to future investigations to determine what it really is. But it is not so easy an investigation as a superficial geologist would imagine: although that will not prevent the first tyro who shall examine it from boldly deciding on its nature.

The remarkable elevations and disturbances of the sandstone of Rum may be accounted for by the trap. I may pass to the coal series: since I can add nothing of any moment to what I was elsewhere obliged to say respecting the mountain limestone.

This forms that portion of the geology of Scotland, which, while it was of the highest importance as a subject of statistics, has also demanded the most labour, from its extreme intricacy and difficulty. When I commenced this investigation, it was



said that the coal of Scotland formed one broad field extending from sea to sea, though no attempt was made to define its boundaries. It was known also that there was coal in Sutherland, that it had been wrought in Mull and Sky, in a trifling manner, as also that it was wrought at Campbelltown and at Canobie. But this was all. The geologists of Scotland had investigated nothing: and though the coal-viewers knew that the coal of Campbelltown and Sutherland differed from that of Fife and Glasgow, geological knowledge had not sufficiently spread among them to enable them to see where the essential distinctions lay. Nor had even these men, often remarkably able and enlightened, attempted to investigate any of the boundaries of the proper coal series: though it is to them that we owe all our information as to the details of that which it was their great interest to ascertain; as, among these, I must chiefly name the authors on this subject, Mr. Williams and Mr. Bald. And as it is not my intention to record matters of this nature, since they lay beyond the boundaries of my investigation, and could but have been compiled from the information of others, I must here refer to the writings of those two accurate surveyors for information which I need not abridge.

It was a consequence of this ignorance, that while the districts which might possibly contain coal were unknown and undefined, there could be no anticipation of the places in which it might be sought. But it was another, and had often proved an evil one, that coal-viewers, either ignorant or fraudulent, and sometimes proprietors of land equally ignorant, undertook to seek for coal where it was impossible that it should exist: as it is also well known that much money has at several times been wasted on these purposeless pursuits. And when I say that the wretched and scanty lignites of Sky, and more particularly of Mull, had thus been pursued under the belief that it was the proper coal series, and further, that considerable sums were expended in seeking for coal in the primary territory of Isla, it is a sufficient proof of some of the consequences of this ignorance.

The useful great result of the present survey therefore will be, first, to have marked all the places where coal may exist, though it should not be known, and thus to direct future researches; and, secondly, to mark the limits beyond which it needs not be sought, as it assuredly will never be found. Thus may the future waste of money be prevented: while if the settlement of this point should do no more than save the restless anxiety of proprietors of land on this subject, it will have effected a most valuable purpose: as few that are not extensively acquainted with those, can believe how widely this anxiety, with a belief or conviction of the possession of unknown coal, is spread among them. Every man may now at least see what his property is not, and cannot be, in this respect; though, in the opposed case, he cannot be sure of what it is. Yet, even here, he will



be satisfied that there is probability, or otherwise, and thus be guided by the joint amount of this, and of his desire and power in speculating on such researches.

Beginning at the south, though it was known that there was coal at Canobie, since it was wrought, and though borings had been made at Oikel and Ruthwell moors, and elsewhere in the neighbourhood, as the coal series was fully exposed on the shore at Ardbigland, it was not known that these were parts of an extensive coalfield continuous with another portion of the same beyond the Scotch border. I have ascertained and defined this coalfield as far as the summit of the Carter-fell, where it is lost.

But as the Map shows better all that I could say respecting its limits and bounds, and as I need not enter on things so familiar as the nature and position of this series, nor attempt to give lists of ever vacillating positions, I shall confine myself to the few following remarks: leaving it also to the coal-viewers to give their own details of the Canobie coal mines. Though the borings had not sufficiently ascertained it, as they are recorded by General Dirom, there is abundant apparent evidence that from Ardbigland as far as Hoddom and Middlebie, and probably even to near Langholm, the wear of the surface has left nothing but the lowest portions of this series remaining, if there ever was a greater depth of it, and that it is very unlikely to be a repository of actual and useful coal. In some places indeed it is so shaved down to the red sandstone, that but for the evidence of the borer, its existence might not easily have been suspected. And I have thus found great difficulty in representing it on the Map under a definition approaching to what may be the truth.

From Langholm through Liddisdale it forms a much deeper body of mountain land, though its lower surface, in contact with the red sandstone, is often visible in the vallies and beds of rivers. Yet though I have searched every accessible point here, as far as my other needful labours admitted, I have never found an indication of coal, and scarcely even of shale. It is a solid mass of white sandstone; and, at Langholm itself, is many hundred feet thick.

Yet it must not be pronounced that there is no coal in this portion; as there is in that near to Canobie. It must be for the great proprietor of this tract to inquire of this, if he thinks fit, through adequate coal-viewers: but the general difficulty, as far as a mere geological surveyor can go in such a work, seems to arise from the fact that the strata are commonly at low angles, and little disturbed; whereas in the central great coalfield of Scotland, the frequency of trap is ever bringing it to light, by turning up the fractured edges of the body of strata. Lastly, I need only add, that on the Carter-fell, this field thins away to a mere skin, in some places, of the sandstone, though in England, at no great distance, it contains coal. It may perhaps be better investigated hereafter by joining the examination of the adjoining English portion and this together. I do not find that the former



is very accurately known, and it was a work which lay beyond my prescribed boundary.

I need not describe in words any thing that respects the positions and boundaries of the detached tracts in the great central coalfield, since the tint that has been chosen for it renders it very visible; except perhaps near Girvan, whence I here note that small portion.

I have called it one coalfield, because thus at least will geology view it, though coal surveyors will divide it into separate portions, as they will also limit that term to the tracts in which coal is actually wrought. It must be viewed nevertheless as one great and single deposit: and whenever its portions are separated, it is either from the elevation, to the surface, of the inferior sandstone, or the waste of that surface, or the presence of trap, breaking up and dividing the strata in some places, and overwhelming them in others. The former remarks on the red sandstone supersede all that I might otherwise now have said on the first of those subjects, as the subsequent ones on the trap will do all else that is required.

On the positions of the strata in this great field, I need but repeat what I have said of the red sandstone. They are different in almost every place, they are especially discordant and irregular near the trap masses and veins, and nothing but a volume, after years of minute examination bestowed on that single object, could convey any notion of them, as even then the information would be extremely limited. But I may make one practical general remark; while I have not found, that as a leading fact, it is sufficiently known to the coal-viewers. As the intruding traps have visibly turned up the edges of the mountain limestone in many places, so, in turning up the whole mass of strata, do they render the coal beds more accessible. It is the peculiarity and number of the masses of trap in Fife that have rendered this county so remarkable for its coal mines. But for this series of violent posterior actions, accompanied by the incumbrances in working, of which the miners so often complain, and with apparent reason, it is probable that comparatively little of the coal of this coalfield would ever have been known or wrought. And thus also if the trap has destroyed or overwhelmed much, it has apparently far more than compensated that evil in rendering the remainder obvious and accessible. I need scarcely add, that coal-viewers will be thus directed to the points where coal is most likely to be found; and if they complain of the evils of intruding trap, they must also be content with it for the sake of the good.

If it is from this reason probably in a great measure, that the actual existence of coal beds over this large space seems very limited in proportion to the whole surface, so must it not be concluded that these beds are as partial as they appear to be. What they may be, in numbers or extent, or where to be found, no one can now conjecture: yet it might not be a very rash con-



clusion that they are very general over the whole, wherever at least the mass of strata is not bared down to almost the very surface of the red sandstone.

Thence, in addition to the speculative views which anxious-minded people may take respecting the exhaustibility or otherwise of the Scotch coal, there is a rational prospect opened, of boring for coal beds more freely than has yet been done, wherever the positions of the strata and the nature of the ground do not allow the edges to be seen at the surface. But if I cannot venture to say more on this subject, which must ever be one of economical speculation, I must here urge as a general rule, the folly of seeking for coal beneath the red sandstone in either of these coalfields, since it is a prejudice or practice not yet overcome, partly from ignorance of the true position of the coal series, and partly also from some false opinions, of geologists as well as of coal-surveyors, respecting the nature of the sandstone itself in some places. It is true, that coal does occur in the old red sandstone, as is the case near Dunbar, so as even to be partially wrought by the neighbouring country people, and as it once was in Arran. When it does appear, it may doubtless be wrought, if expedient: but it is never worth seeking for, and far less worth boring after; since it is always scanty, generally bad, and might not be found in one of ten thousand attempts.

The false opinion respecting some of this red sandstone, to which I have alluded, is this. Geologists unacquainted with more of Scotland than a casual journey, or the sight of a single portion of this sandstone could teach, looking at things superficially, very often incapable of correct observation where so many plunge into a subject for which they are in every way unprepared, and those above all who make England a standard for every thing, and judge from an hypothesis, which is not even their own, but borrowed from those who have ascertained nothing themselves, these persons have reported that many parts of the red sandstone of Scotland were the red marl; while, if such, it must have been superior to the coal series. The practical evil of this error is too great to allow it to pass without a censure which has been spared on all other similar errors when these related to nothing but the mere science of geology; and that it may be effectual as to those interested in the right and the wrong, it ought not to have been less marked.

I have examined all these sandstones, and traced their connexions in such a manner as to leave no doubt: as others may judge, whose decisions are most worthy of regard. And the conclusion is equally true of that red sandstone on the English border. The English geologists may inquire, if they please, into their reasons for deciding that the adjoining sandstone of England is the red marl; but if my own opinion that the Scotch portion at least is the old red sandstone, be not deemed valid, the appeal may be made to the miners of the Canobie coal, or to Mr. Bald; judgments, I imagine, which no one will venture to



reject or oppose; while their experience uniformly agrees in the fact that the coal is invariably above this red sandstone.

I have already said, more than once, that it is not within my limits or undertaking to enter on the question of the actual working of coal in Scotland. And this applies equally to the plans of those works, and to the details of the actual coal beds, in the series, of which it was my duty to give the superficial extent, and scarcely aught more. I could not have done more from my own knowledge: and as far as it is not already compiled from the experience of the different coal-surveyors and miners, it must be done by others, among many other matters of detail. It is not a work which a general geological surveyor could have done from observation; and had he attempted it, no one would have trusted him, and very justly: while, as it must have been compiled from reports, it will be far better done by practical men of sufficient connexions, devoted to this single object, as, in addition, they are the only persons on whom the public ought to rely, and on whom I should myself place any reliance. If any one imagines that a geologist can, on points like this, supersede a practised surveyor, he neither knows what geology is, or geologists are. It is for the same reasons that I here give no account of the ironstones in the coal series, or of the shales which may be wrought for alum. These cannot be anticipated by any scientific knowledge. They will be found by chance; and where they have been found, they are known to those who alone have any interest in them. And if I have seen alum slate in places where it was unknown, it needs not be said that there is more than enough of this material in the places where it is at present wrought, and that the state of this manufacture and commerce do not now admit of new undertakings in new places, and is very little likely to do so henceforward.

If the red marl sandstone is the next stratum of Scotland in the order of stratification upwards, I have left but little to say on the infinitely minute portion of it which is contained in this country. I have already named what is probably to be referred to this rock near Loch Greinord; as I have stated all that I know, and doubt of, respecting the Summer Islands. There is but one other place where it either does, or may, exist. This is in Arran, about Corrie. The portions of the otherwise united red sandstone which lie above the limestone at that place, may belong to this rock. But they may also be but a part of the inferior sandstone, since the limestones of this character, and containing the same fossil shells, often occur in this. It is a matter of infinite indifference what the fact is: and if a fanciful importance has been attached to it, it is by the very ignorant and hypothetical persons who have referred so much more of the red sandstone of Scotland to the red marl, under an utter ignorance of the country at large, and not a much greater talent in making distinctions on this subject; while, in lieu of this, deciding in a much more expeditious and less



laborious manner, under a previous hypothesis. All do not know what those persons are: he who does know them will know also how to value their opinions and decisions; as he also cannot fail to be aware that they who are incapable of observing for themselves, seek for a poor fame in controverting the decisions, and correcting, whether justly or not, the observations of those who have taught them even the little which they know.

Had I been merely writing on the science of geology, I should have spared this and other similar remarks; since Truth, in every thing, has ever had the same complaints to make, while emerging at length in all its brightness; and as he must be not only very inexperienced in science and literature, but very deficient in self-possession, who cannot exert that moral deafness to false criticism, under which alone he can experience peace. But the question here is of a far other importance; since it is not one of speculative opinions, but involves the very end and purpose for which the present survey was instituted; the terrestrial statistics and the consequent commercial enterprise of Scotland. Not to be thus pointed in providing against previously incorrect statements, and against that renewal of them which must be expected, would be a dereliction of duty: since it would be to leave an important economical question still open to dispute, or else to suffer enterprising persons to waste their means on vain speculations. He who may believe the red sandstone of Canobie and the neighbouring tract, or that of Hamilton, to be the red marl, may be there induced to seek what he assuredly will not find.

And, as I have no other opportunity of noticing this insulated fact, I may here point out the white sandstone in the west side of Arran, which is so entirely insulated, and so devoid of all specific character, that, in such a disjointed place as this, it may be referred to any thing. I am utterly indifferent whether it is referred to the old red sandstone, the proper coal series, or the green sandstone above the lias, since it might be argued in either way, and there is no evidence as to either. The contests of geological opinions are of as little value as the subject is without other interest than its utility: and this will not be affected by the decisions of those persons.

I have already said in another place, that there is no reason, in Scotland, for distinguishing the lias, the oolithe, and the green sandstone, in any other manner than I have done in the Map, if even that were possible; and I shall therefore here speak of the whole together, while I have not left much to say respecting these singularly scattered fragments of a deposit which occupies so little superficial space compared to its extent.

As far as the Map itself may render the finding of these often nearly microscopic patches of colour difficult, I have attempted to amend this in another notice, and I must now trust, that between both, their places will be found. I am very sure that they will be found in nature; and, as far as an inch can represent



four miles, in the exact places noted; since, from its peculiarity, this miserable fragment of the geology of Scotland was examined with even more care than it deserved. And all further that I need here say on its place, or rather places, is, that its extent, such as that extent is, reaches from Machrihanish Bay to the Shiant Isles, on the west, as, on the east, it is of no greater a one, under any indication, than from Cromarty to Nairedale in Sutherland. It thus skirts the western shores of a portion of Scotland, but under an extreme inequality; nor is a trace of it visible any where else: while I leave it to others to speculate, whether a series of strata so very conspicuous in England as to form a large portion of this part of our island ever occupied a greater extent in Scotland, or if they never were deposited in any other places. And any one, as well as I, can further speculate how far the position of these strata as they now stand, depends on their original extent, the effects of the intruding trap, and the waste of the land, separately or united.

The very slight description to which I must here confine myself will be rendered most clear by taking each portion separately, and I will trace the western side from the south.

At Campbelltown, or rather Machrihanish Bay, this series is wrought for coal; but that is a lignite coal of a very bad quality, and now, of very limited use.

The next portion occurs in Mull. The chief visible extent of the limestones is in the southern cliffs, and these strata re-appear under the trap on the north-eastern shore, in the place marked on the Map: though when I say under the trap, I should add that it has here partly disappeared, so as to leave the surface bare. It is also bared near Carsaig; and here the green sandstone is visible. Here it was that money was once expended in seeking for coal, but with no useful result. On the north-western side of the island, near Inch Kenneth, a considerable mass of the limestone is visible, but of no great extent, and Inch Kenneth itself consists of the green sandstone.

The Map shows though imperfectly, for want of sections, the manner in which this series occurs in Morven; but such sections will be found in my work on the Western Isles. The lias is especially visible on the shores, particularly about Loch Aline, where it might easily be wrought were there not better limestones in competition at Lismore and in Sky. Its singular position on the summits of some of the hills, is noted in the sections referred to, as not being well capable of entry on this Map; and it is apparent that it every where comes to light as edges of strata covered by trap. A little lignite coal occurs in these, on the hill summits: and I may remark generally, that in these southern fragments, none of the strata usually intervening between the primary rocks and this series are present.

This series occurs again in four distinct fragments, on the shores of Ardnamurchan, at Camusmore in Muck, and on the north side of Eig. Here it is visible only in the vertical cliffs,



and is interstratified with trap, as well as covered by it. One or two of the sections in the book referred to represent this better than words could do.

In the district of Shalts in Sky, the extent of the lias is considerable, while it also forms Pabba, and skirts the southern shore of Scalpa. It is here that the influence of trap has converted considerable patches of it into crystalline limestones of different colours. In some places, this is pure white, and one spot was partially wrought. It proved useless at that point, by being intersected with trap veins, and the search was not prosecuted. And as commerce knows that foreign marbles can be procured at a cheaper rate, those at this spot are not likely ever to become subjects of economy.

The point of Aird consists of the green sandstone, considerably calcareous in parts, covered in most places by trap, and intersected by trap veins, as a fragment also appears at Hunish point. The course of these strata beneath the trap can be traced on the Map along the eastern shore, and also at Duntulen; and some of the sections in the same work show a few of the remarkable disjunctions and positions. But the Map could not show, that at some points in the interior, northerly, fragments appear where the trap has been removed; rendering probable a considerable, if not a total continuity beneath. There have been found, in several places in this north part of Sky, fragments of lignite, and with the usual effect of exciting the hopes of coal. I need now scarcely say that there can be nothing here worth a further inquiry.

In Raasay, the quantity of visible limestone is very small, and lies on the south-eastern shore; though in the same sections, I have, for the sake of geological explanation, rendered it more extensive. And here also the red sandstone intervenes between this series and the gneiss. But the green sandstone forms a mass of enormous thickness, though generally covered by the trap porphyry of this island. And here the possibility of interminable quarrying equals the perfection of this material as a building stone, while, in summer at least, the shipment would be immediate from the quarries. It is for the proprietor, and others, to inquire of the commercial purposes to which this might be turned, if indeed the quarries of Arran would permit of a competition.

The last fragment of this series occurs in the Shiant isles, if indeed it ought not rather to be called an indication. But for a previous analysis of the whole of this most difficult piece of investigation, it could not have been suspected, though it had been seen. It consists in a minute quantity of shale, entangled in the trap at one or two very small points.

On the east side I may barely note the disjointed fragments south of Cromarty, giving the usual indications. The Sutherland portion is conspicuous. But it demands no other details here than the Map will indicate, while its economical description is unnecessary in this place, and also beyond my bounds. Mr. Williams's work can be referred to, as may a paper of my own



in the Quarterly Journal; as every thing which relates to this subject is also well known to the noble proprietor of this territory.

The last rock which remains for annotation, is the trap: and I have already indicated, in another Notice, the distinctions here adopted, as to these rocks and the older porphyries, together with the reasons for those, and for the general colour by which the whole, however different, have been here indicated.

With the exception of a few of the veins, which also I have pointed out in words, in the same Notice, the trap will every where be visible on the Map, with a little care; while, however scattered and unconnected it may often be, I must, for convenience, take it as if in three divisions.

The first of these lies to the south of the southern slate, the next is that which is so widely scattered over the space that intervenes between the northern and southern divisions of the primary rocks, and the third includes chiefly Sky and Mid-Lorn at its two extremities, while the Map will point out the intermediate portions. That which occurs in St. Kilda and the Shiant isles cannot well be united with this last, and I may therefore note these first.

St. Kilda is an entire mass of trap, divided pretty equally into an augit rock, and a syenite of a pale grey not exceedingly different from that of Ailsa, and sometimes resembling that of Arran, termed granite. The great mass of trap in the Shiant isles forms all those islands, with the exception just noticed, displaying great ranges of columns; while a more minute description of it will be found in my book on the Western Islands.

In the southern division of Scotland, the leading mass is that which is continuous with England under the same rock, including the Cheviot, and I have already stated all that seemed necessary respecting its characters and its difficulties. Nor do I find anything of importance, in addition, to remark respecting the various patches which are scattered about from Dunse to Tuendergarth. How far these may have been originally connected, it is not necessary here to speculate.

In the central district, the most remarkable circumstance is the great leading mass which commences at the æstuary of the Clyde, and which, though interrupted, may be considered as stretching eastward till it splits into the two divisions which skirt the north of Fife and form part of the Sidlaw hills; while at its western extremity it is continuous with a great mass which is marked by Strathaven and Loudon. The next which I may point out relates to the scattered masses which skirt the northern primary border, few as these are; and the interest attached to those which skirt the southern slate northwards is of the same nature. These, with the numerous masses scattered over the remainder of this great tract, seem to indicate a once much more wide and continuous connection, as there are persons who may speculate whether it was not once so universal as to have covered the whole of this district with trap. And why this trap, like the southern



one, should be especially connected with the secondary strata, and not give similar indications of having covered the primary ones, is another of those speculative questions which do not form an object in this Report.

The marks of great waste, however, are abundantly evident; while on the same eastern portion of the country, where the primary strata of Aberdeenshire exhibit the peculiar marks of waste formerly noticed, the trap seems also to have been more removed than to the westward.

Wherever occurring, the patches of trap, whether originally independent or the result of waste, are of very unequal magnitudes; while Fife, with the opposed proximate land south of the Forth, display this intricacy in the most remarkable degree, enhancing exceedingly the labour of investigation.

It would be equally tedious and unnecessary to describe the external features of these endless masses: the total history of the whole would occupy a volume: and I do not here intend to write volumes for geologists alone: while lastly, respecting this district, I need only further point out the outstanding masses, in the islands of the Forth and those of the Clyde, including Ailsa, lest any of them should be overlooked.

Respecting the mineral characters of the traps over this great tract, I can but notice some of the most striking circumstances, as the detail of the whole would be equally endless and useless.

I formerly said all that I can here afford to do respecting the peculiar traps of the Tinto and Pentland range.

That of Ailsa deserves notice from its singularity: containing but atoms of hornblende in a base of compact felspar.

In the Little Cumbray it is often a vesicular claystone, no way differing from the scoria of volcanos.

In Arran, the varieties are peculiarly numerous: presenting clinkstone, with various pale claystones and porphyries, besides the more usual blue claystone; as the former appear to be the produce of a partial decomposition. Here also is the chief repository of the pitchstones of Scotland; while for the minuter particulars of this and the other Clyde islands, I can refer to my book on the Western Isles.

Of other peculiarities in this great trap district, I may notice the exceedingly compounded greenstones about Glasgow, the greenstone with red felspar near the Queensferry, the claystones producing prehnite and geolites in the Kilpatrick hills and near Beith, the remarkable porphyry at Lentrathen, the not less remarkable rocks, including fragments and nodules, near Biggar and near Dirleton, the porphyries of the Ochil hills, and the rocks between Montrose and the Redhead. But as the minute details of all this are beyond my limits, I may conclude by saying generally, that the predominant traps where I have not made the greater exceptions in this district, are claystones of a dark colour, and greenstones, while the former very far exceed



the latter. The true greenstone, of hornblende and felspar, is, in Scotland, a rare rock. An original blunder, long persisted in, gave this name to augit rock, which I long since distinguished and added to the system.

In that which I have here separated as a third and the last district, I will first notice the outstanding portions, lest they should be overlooked in the Map. The two rocks at Loch Maddy, and an island in the sound of Isla, are the most remote of these: those in the small islands of the Oban coast, and those connected with Sky, will easily be found: if at least the copiers do not forget them.

Here, as elsewhere, it is left to others to speculate on the former unity or connection of these separate tracts: and with respect to the general characters and geological circumstances, the account which I have given in the work on the Western Isles is so full and minute, that it would be superfluous either to repeat or abridge it here, if even my plan admitted of such details. The only tract not there described is that of Mid-Lorn: and respecting that, I do not perceive there is anything left to say beyond what I was compelled to notice in the other Reports: as far at least as the plan of the present one extends.

The whole of this tract nearly, is a simple claystone, sometimes becoming a clinkstone: while some of its minuter peculiarities, visible on the sea coast, are described in the above-mentioned work.

Mull and Morven present little else that is remarkable: but, at any rate, the description of their rocks will be found in the same place.

In Canna, the most remarkable rock is the claystone porphyry containing glassy felspar; and in Eig, the columnar porphyry of the Scur, with the two pitchstone veins of the same island. Rum consists chiefly of augit rock; and its characters here are very distinct. It had always been confounded with greenstone, as I have just remarked: while it was by mistaking augit for hornblende that this name was invented, since it is a greenish compound. If I have now separated these, and made a new species of the present, so have I very widely extended the reign of augit rock, even to the exclusion of many imaginary claystones and basalts.

The same compound prevails on the north-eastern coast of Sky: which contains every known variety of the traps. About the Cachullin hills is found hypersthene rock, as it also is in Airdnamurchan; as yet not certainly known anywhere else, and added by myself to the former catalogue of rocks. The hills to the north of Strath are of pale and reddish claystones, porphyries, and sienites; as here also lies that rock which, in mineral composition, is a true granite, on which I have made many important remarks in my various works. The other varieties or species, as being of more ordinary occurrence, I need not specify.



Finally, I may point out the porphyry of Raasay as one of the most striking exceptions to the prevailing characters of the recent trap rocks.

Of the economical applications of these rocks it seems quite superfluous to say any thing. Nothing can be more familiar: and whatever confusion the working classes concerned with rocks may make in other cases, this is one which they never mistake. And though I might point out the varieties which are best fitted for the purposes to which it is applied, every quarryman can equally determine the best material among the rocks within his reach.

This completes all that I find it necessary to say in explanation of the Geological Map of Scotland, in addition to what is contained in the other accompanying Notices.



## N O T I C E

RESPECTING THE

## KEY TO THE GEOLOGICAL MAP OF SCOTLAND.

Sir,

THE colours used to express the rocks on the Map are eighteen. They are represented on the Key in their pure form, since they are on white paper. Hence they would be found to correspond with the same colours on sections, because these are equally placed on a white ground ; but their correspondence with the colours on this Map is much less perfect, with the exception of a few of the more conspicuous and pure, owing for the most part to the blackness of the engraving, and occasionally to the very small spaces which they occupy. Hence it will be useful, in case of the publication of this Map, to name the colours and mixtures which have been used ; as the colourists will thus more easily render the copies correspondent to the original.

GRANITE.—Burnt terra di Sienna.

GNEISS.—Gamboge.

MICA SLATE.—An olive, by a mixture of gamboge, Prussian blue, and burnt Sienna.

QUARTZ ROCK.—The purest green that can be produced by mixing Antwerp blue and gamboge, but tending to yellow. It is necessary that this colour be extremely bright and pure on the Map ; because the blackness of the engraving lowers its tone so much, as often to make it difficultly distinguishable, especially in small spaces.

CLAY SLATE.—The same colours, so apportioned as to make a blue green. This must also be kept very clear, owing to the same cause. In certain approximations with Prussian blue, used to represent trap, it sometimes becomes difficult to distinguish those two colours on the black engraving ; in which case the particular portion of this green in contact has been rendered more yellow by additional gamboge. They who may inspect the Map must recollect this circumstance, lest they might imagine that a different rock was intended.

CHLORITE SERIES.—The colours mixed for this tint are the same as for mica slate, but with a larger proportion of the Sienna, so as to produce a brown olive.

PRIMARY LIMESTONE.—This is pure ultramarine, and it ought to be that which has the bluest tone, as the purple one may be



confounded with the Prussian blue of trap, where the engraving happens to be dark. It must also be applied thick, that it may be conspicuous in the very small spaces which it occupies. I do not think that cobalt blue shows quite so strong, though the tone of colour may be the same: nor do I think that it can be trusted. This is intended as a caution to the colourists: as its superior cheapness offers a great temptation to substitute it for ultramarine.

**SERPENTINE.**—This is yellow orpiment. The spaces being very small, it must also be used in a good body.

**PORPHYRY.**—This is a purple, from a mixture of lake and Antwerp blue. Where the spaces are very small, and the engraving very black, as on the summit of Ben Nevis, it is necessary to make it very red, as it is otherwise invisible. Though it might be confounded on the dark Map, with the colour for red sandstone and that for shale, the geological connexions will prevent any error among geologists; as others may consult that science, in case of doubt.

**OLD RED SANDSTONE.**—Pure lake, considerably dilute.

**MOUNTAIN LIMESTONE.**—The same, made sufficiently strong to distinguish it from the former; but in the very few larger masses that exist, it must not be made so heavy as to deform the Map. In the greatest number of places, however, as it occupies very narrow lines, it must be made as full as the colour admits, without which it is often not sufficiently distinguished.

**SHALE OF THE OLD RED SANDSTONE.**—The same mixture as for porphyry, but bluer. Occurring only in Caithness, to such an extent at least as to have demanded a special notice, and in gradation with red sandstone, it cannot be mistaken.

**COAL SERIES.**—This is yellow oker. Over large spaces it may be very dilute; but in small ones, and on the dark engraving, it requires to be considerably strengthened. In all cases indeed, the colourist must use discretion in the quantity of colour, so as that the dark and light parts of the Map may, under any one colour, always appear as nearly of the same tone as possible.

**RED MARL.**—This is that burnt oker which, in most colour boxes, is termed light red. It occurs but in one place, forming two very small spots on the shore at Loch Greinord. I fear that it may be here overlooked; but perhaps this remark may suffice to call attention to it.

**LIAS AND OOLITHE, WITH COAL.**—This is the liquid verdigris used for staining maps. As it generally occurs in very narrow lines, it may be used strong. In Sky, and on the east coast of Sutherland, forming broader portions, it should be dilute, as it otherwise becomes too conspicuous, and deforms the colouring. It is however a very doubtful and suspicious colour, often fading after some time. I know not how this bad result can be remedied: but there was no other sufficiently conspicuous colour in my power.



GREEN SANDSTONE.—I could find no spare, unoccupied, colour applicable to this rock, from the exceedingly small spaces which it occupies, rendering all degraded tints undistinguishable. I have therefore repeated the yellow oker, as maintaining a sort of geological, or rather mineral analogy, between this and the coal sandstones. But the proximity of the lias will always be sufficient to distinguish the intention of the yellow; or, wherever the oker tint is attended by that of verdigris, it signifies the green sandstone.

TRAP ROCKS.—This is a Prussian blue. The tint should be low, at least over the larger spaces, as it becomes much darkened by the engraving; and being also generally near to the yellow of the coal series, produces a very heavy effect by the contrast. Where it is used to denote small spots and veins, it is scarcely to be discriminated from the similarly small touches of ultramarine used to distinguish primary limestone. Nor have I been able to find a remedy for this, on so contracted a scale and so black a Map: it is one of the evils inseparable from a work executed in so heavy and dark a manner.

DIALLAGE ROCK.—The colour selected for this is vermilion; and being in approximation with the orpiment of serpentine, may easily produce an effect of offensive splendour, unless both are carefully managed; but as it occurs in Shetland only, it will not be found in this Map.

It is the usage, and an unavoidable one, to engrave a slight line on the plate, as a boundary to each colour, for a guide to the colourist; but in nature many rocks are not so defined: either they pass into each other by a slow transition, or else the incumbrances of the soil prevent the boundary from being ascertained. On the original Map, therefore, both those circumstances are attended to, as well as it was practicable. Hence the colourists who may copy it, must be careful not to make definite boundaries where they do not exist, but to blend the neighbouring colours into each other, or to wash them off at the edges wherever this occurs in the original. They must also observe that there are in this Map five uncoloured places; one in Isla, another at Kildrummie in Aberdeenshire, another in Arran, and two on the shores of the Solway Firth. These are not forgotten spots, but intentional blanks; because the alluvial covering prevented the rocks from being seen, and the occurrence of different rocks at the same place prevented them from being inferred.

In the choice of colours for this Map, if I have not succeeded as I wished, I have laboured to do the best which the circumstances permitted, nor was it without many calculations and trials that the present system of colouring was adopted.

The number of tints distinguishable on so very dark an engraving was found on trial to be so limited, that it was finally impossible to produce the eighteen which were indispensable, as



I have just shown. The extremely small spaces occupied by many produced another unfortunate restraint, as did the fact that colours so perfectly distinguishable as "light red" and burnt Sienna, became confounded in many places, owing to the blackness of the ground. Thence the disagreeable approximation of colours between the red sandstone and the coal series on this Map, since it was found that where granite was near, the more eligible light red could not be trusted. And, not to dwell on these and other difficulties, it has frequently occurred that the colour which was not only most eligible, but indispensable in one approximation, was inconvenient in another; while, if this evil was removed from one place, it was but to transfer it to some other, and generally at a greater risk of disagreeable effects and of confusion.

Under all these circumstances the following plan was adopted as the best which seemed attainable.

The importance of the coal series demanded that it should all be seen and recognized at a glance, and thence was a very clear and striking colour used for it; while that tint also bore such a resemblance to the actual colour of the predominant rocks, as to approach to the fact itself.

The same plan was pursued as to the red sandstone and the trap, by choosing the colours which were most nearly analogous to those of the rocks themselves, within the admissible limits; as thus also the very important distinction between the trap masses and the accompanying coal and other secondary strata was rendered striking.

This plan could not be pursued in the primary strata; and the next best expedient was therefore resorted to, in associating all the principal ones under green, with pure yellow as the starting point. Limestone alone was distinguished by a powerful blue, on account of the small spaces which it occupied; as I was compelled to resort to a similar expedient for the lias series, and for the same reasons.

For the other rocks, such as granite, porphyry and others, no expedient remained but to select among the remaining visible tints those which would best display them, when the spaces they occupied and the necessity for distinction was considered.

I need only add, that in looking at a single tint over the whole Map it will be easy to perceive that it is very unequal in strength, and sometimes also in tone. This, which might appear carelessness, was designed, because it was necessary. The same quantity of colour did not show the same tint on all parts of the Map, nor did it show alike or effectually under all its different extents and approximations. It has been attempted to remedy those evils in this manner; or by changing the tone or the intensity, in such a way as to prevent any chance of error in consulting the Map.

I trust that, in case of publication, the colourist copiers, thus forewarned, will attend to this, as to all else which I have here



noted for their instruction. But I cannot hold myself responsible for the accuracy of the copies: experience has long shown me how very uncertain those are, even to gross mistakes or utter obscurity. The original must remain the point of appeal in cases of doubt or criticism.

Let me finally offer this remark on the subject of colouring the copies which must be made, should this work be published by my Lords Commissioners of the Treasury. The colours are not a mere object of show, but are the very Survey itself. If the copies are not the most absolute transcripts of the original Map, so that it shall become impossible to distinguish each individual from every other and from the original, they are not the same work, nor are they the Survey which I have executed. If there is any one person who may hereafter possess an erroneous copy, that copy is, thus far, to him, not my Survey. Nor is there any remedy for such errors or misfortunes to be found in words—description is inapplicable, even to correction. Expense in colouring must not therefore be regarded—it were better that this Map were not published at all, than published at a price insufficient to command the very best colouring that can be procured in that market of labour:—it will be worthless, and will be a fraud on the purchasers, although not an intended one. As the Surveyor is concerned, it is as if false or fictitious books, or books abounding in error even to falsehood, were to be published and attributed to an Author who has had no concern with them, and thus published under the sanction of his name backed by the highest authority.

I have the honour to be, &c. &c. &c.

*J. MacCulloch.*

To the Hon. James Stewart,  
&c. &c. &c.



## N O T I C E

IN AID OF THE

## KEY TO THE GEOLOGICAL MAP OF SCOTLAND,

AS THE

COLOURS ON IT ARE USED TO EXPRESS THE NATURE  
OF THE ROCKS FORMING THAT COUNTRY.

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THE colours used to express the rocks of Scotland are limited to eighteen, as I have observed in the preceding Memorial; but while this number of colours will not express every rock which occurs in this part of the Island, using the term rock in its absolute sense, it becomes necessary to assign the reasons for that limitation, and also to explain what the Map itself could not, by showing the exact purpose for which each of these colours is used, in addition to that general explanation already given in the Notice respecting the Key.

The chief reason for this small number of colours is, that the rocks of Scotland are less numerous than those of England, for which part of the Island a more extensive system of colouring is necessary: a fact which I shall have occasion to point out more particularly in another Notice. It is another reason, that the spaces occupied by the more rare of these rocks, such as jasper for example, are so extremely small, that they could not be represented by any colour, especially under the peculiar circumstances in which they exist; while to this and more, I must add, that the extreme blackness of the engraving, united to the smallness of the scale, has rendered it impossible to find a sufficient number of tints capable of being distinguished on such a ground: whence arises that violent contrast of tints equally violent, by which it was found indispensable to regulate this Map. And the last reason is a geological one. It is believed, or known, that certain rocks occur only in small quantities as subsidiary to others, and that some which possess marked mineral differences of character are but variations in a single species: as it is also the usage, and perhaps an unavoidable one, in the unstratified rocks especially, to give but one name to the families or species, although subject to such variations of character that the individual varieties, considered as mineral bodies merely, are exceedingly dissimilar, and considerably numerous, as is particularly the case in those of the trap family.



Under this last reason the details are of such a nature, while they comprise almost every rock, that it will be necessary to enter on a somewhat wide description of the rocks in question as they occur in Scotland: while the result will be such, that a further Notice in addition will suffice to comprise all that needs be said respecting the geological structure of that country, and in aid of the Map itself, under the restrictions to which it has been judged right to limit these Reports.

There is but one colour used for all the granites of Scotland, nor could it have been otherwise, from not knowing where to stop amid the endless diversity of those, and from the impossibility of distinguishing them by any mode of colouring. Of this, however, there can be no complaint; since such is the universal usage. The further Notice on this subject will explain, as far as is needful, what those diversities are.

It is the same with regard to gneiss, and for the same reasons; as the needful explanations will also be given in the Notice which follows this one.

No colour has been appropriated to the hornblende schist; nor could it, though that is a principal rock in the system. In whatever manner it may exist elsewhere, it occurs in Scotland, with one exception, only as a very inferior stratum, alternating with gneiss most generally, but sometimes also with a numerous set of rocks, including chlorite schist, which I shall describe hereafter. Its relation to the gneiss, both in proportion and disposition, is similar to that which the shales bear to the sandstones: and if, in each case equally, these inferior substances could not be distinguished in any manner, so is it the usage not to make such distinctions.

The exception to which I alluded, occurs in the mountain Ben Lair, near Loch Maree; and as far as I now know, it is also a solitary or rare occurrence. This tract is nearly all composed of the hornblende schist, to the equal exclusion of the gneiss; but the space which it occupies on the Map is so small that it would have been fruitless to have appropriated a separate colour to it; as in this case also it would not have been easy to know where to stop in making the same distinction, while, if pursued, it must have been under so outrageous an exaggeration of the extent of this rock, that the result would have proved a greater falsity than the total omission. In the mean time I must trust to the present explanation, and to further ones which will be given hereafter.

The same reasons apply to octenolite schist, but in a far greater degree; since it is an extremely rare substance: and, whenever it occurs, is in quantities so very minute, that only a very narrow research can discover it. The only very noticeable bed of it which I could find, extends from Glen Elg towards Sky, yet is not traceable far without interruption. To describe it accurately, would be easy, though it cannot be represented on the Map; but such description would be the object of that work on Scot-



land, under the minute and peculiar views of geological science, which if I once intended to give, I have resolved to suppress, for reasons, the force of which will be apparent from some remarks in the Notice respecting the Map. That knowledge which it would be worse than fruitless to make public, must die where it exists.

If the micaceous schist is delineated under a single colour, there was nothing belonging to it that admitted of distinctions: further than I shall immediately have occasion to notice under chlorite and talc schists, where its intermixtures are chiefly engaged; since any notice of its varieties was as impossible as to have noticed those of granite, gneiss, or any other rock similarly variable in structure and composition. A work which I have already published on the distinctions and characters of rocks will suffice for this purpose, as it will equally prove the impossibility of making such distinctions on this Map: and with that, he who would desire additionally to understand this subject and to know what the rocks of Scotland are, in all their details, must be content.

If nearly the same remarks are applicable to quartz rock, equally represented by a single colour, I need not prolong this detail by repeating them.

I was much more doubtful how to act respecting chlorite schist, but at length resolved not to distinguish it from mica slate in the colouring. The only doubt I entertained related to the ridge of Ben Lawers, where a considerable tract of it occurs, tolerably distinguished from the mica slate for a considerable space. But this notice must suffice respecting a tract which it seemed inexpedient to distinguish, even had it been easy, when so many more of smaller extent must be suppressed for the usual reasons, and when, above all, it was utterly impossible to distinguish the far better defined chlorite slates which occur in what I have called the chlorite series, and those which are intermixed with clay slate throughout that singular line which traverses Scotland in a north-easterly direction. And since chlorite schist, as it occurs in Scotland, is really very ill distinguished from mica schist, whether in place or mineral composition, while in both ways for ever passing into it, the adoption of the present plan seemed as unavoidable as it was conformable to the usual practices of geology.

That which I have just termed the chlorite series, now demands a special remark. It consists of many different rocks, as I shall notice in another Report; but these are so numerous and so intermixed, that the substitution of a yard for an inch in the scale would not suffice to represent them. It also constitutes a geological group so new and so peculiar, that it demanded to be distinguished from the neighbouring mica schist with which it is nevertheless always associated, and into which it graduates: for which reason it is indicated by a peculiar colour, though that ought no more to be defined with respect to the colour of the



mica schist, than the different substances themselves are in nature. Respecting talc slate, though one of the rocks in the general system, there could be no doubt. It is an extremely rare substance in Scotland; and the specimens, rather than strata, of it, which do occur, are exceedingly minute, as they also pass into the neighbouring mica slate. In the place also where this rock is most conspicuous, near Loch Fyne, the far larger portion is so intermediate a substance, as happens also near Loch Tay, that it was quite as justifiable to confound it with the mica slate on the map, as to have given it a separate indicative colour, even had that not been impossible or inexpedient, for the reasons already more than once assigned.

All the clay slate has been represented by a single colour. Geology had made a gross mistake in distinguishing it into clay slate and graywacke slate; as I have fully showed in former published works, and need not repeat in this place. I have, in conformity to this correction, represented it as a single rock; and though it had been desired to distinguish the coarse kinds from the fine, this could not have been done, any more than I could have distinguished the varieties of any other rock, so minute and frequent is the intermixture. And even the quarrymen need not be told that workable slate cannot be distinguished from that which is not workable, by any means short of absolute trial: while it was not within my limits to note every quarry in Scotland, any more than every coal-pit and mine; as, if I had even desired this, it could not have been done on this Map.

If these remarks apply to the slate of Scotland universally, that which occupies the singular north-eastern belt already noticed, demands a separate one. I shall hereafter show that it includes a great variety of distinct rocks, many of which also are of a very anomalous character. But since these were undistinguishable in the Map, as much so indeed as the strata in the chlorite series, and since the predominant rock was clay slate, producing also, in many places, workable slate, it was equally expedient and inevitable to distinguish it by one colour, as has here been done.

On the primary limestone and the serpentine I need add no remarks here to those made respecting their minuteness, in the Notice respecting the Map; since they are uniform substances.

The porphyry requires considerable explanation; and as, on some points, this rock involves the case of the trap rocks also, I must disturb the usual order by here taking these two substances together.

The joint ignorance and hypothesis of geology has hitherto made porphyry an utterly distinct rock from those other unstratified ones which it confounds under the general term trap. But unless there be some other character united to the porphyritic structure, there is no such distinction in a geological point of view. The porphyritic form and character occur among the latest trap rocks, and the same continuous mass often unites



this peculiar character with others quite dissimilar; as, further, the porphyritic distribution of the parts is found in many rocks of very different composition and materials.

It is plain therefore that porphyries like this, or rocks of this character, being of later origin than the secondary strata, and connected with the most recent ordinary traps, cannot be distinguished from these, unless we were equally to distinguish in the colouring of these Maps, all the modes and varieties of trap, and further, all those of granite, since the same facts apply to both. There is no geological ground for making the distinction; and it would be mechanically impossible to distinguish the whole, as will immediately be shown.

But if it can be ascertained that there are porphyries connected with the primary rocks alone, and never interfering with the secondary ones, a division should be made, on the ground of age, and thus there should be a colour for such porphyries, distinct from that which is applied to the traps. Such porphyries rank with granite, to which they also often approach in character: and if this be not done, then the granites which become greenstones and basalts must also be coloured as traps, and separated from the other granites, to the utter confusion of all geological distinctions. It is in fact but a portion of the universal geological question, whether rocks are to be distinguished by their geological characters or their mineral composition; since, if adopted in one case, the principle must be followed in all, while the consequence then would be to confound many more of the rocks of the system, such as quartz rock and the secondary sandstones, shale and clay slate, and much more.

But admitting this principle, namely, that the age and connections, not the mineral character, are to regulate the names of rocks, and therefore that some porphyries must be distinguished from others, the difficult practical question remains, how this is to be done in every instance. The obvious evidence is, that such a porphyry is ancient, or demands a distinction and colour for itself, whenever it interferes with the primary rocks, and does not interfere with the secondary ones: and reversely, that in the latter case it must be referred to the traps.

But the practical application of this rule is by no means so certain and easy as it appears. Though the secondary strata are absent, it does not thence follow that a given mass of porphyry is of a date higher than that of their production. They may never have existed in that place, or they may have been removed under the usual progress of waste. In the former case, though the porphyry had been of the most recent date, there has been nothing to give evidence of its age; and, in the latter, that evidence has disappeared. Nor do the mineral composition and characters give that evidence which cannot be found in the former circumstances. This indeed has generally been maintained: but I have proved that it is not the fact.

The general result of this brief discussion therefore is, that we



can obtain no absolute evidence on the date of a porphyry, from negative circumstances, or from its non-interference with secondary rocks: though the reverse fact, or the positive knowledge that it does interfere with those, is sufficient to settle its modern nature, and consequently to give it a place with the traps.

Under these views and difficulties, I must now therefore explain how I have acted in the case of this Map. But though I made the best inferences which I could, I am by no means satisfied that they are all just: for which reason I must here enumerate the spots themselves, that they who may examine the work may be more fully informed than they could be by a mere inspection of the colouring. It is scarcely necessary to premise, now, that the colour chosen for the porphyries supposed to be of ancient date is a purple, as the decidedly modern ones are united to the general traps under the colour of Prussian blue.

The great mass of porphyry near Loch Fyne sends veins through the mica slate, and is therefore more recent than that rock. But there is no secondary rock so near as to be reached by these veins: whence there was no resource but to view it as an ancient porphyry, though under such negative evidence there can be no certainty.

Near Kirkcudbright another extensive tract of porphyry sends veins through the slate, but not through the line of sandstone which here skirts the sea shore. For the present it must therefore stand as an ancient porphyry: but if any one shall hereafter find a vein penetrating the sandstone, it will be necessary to remove it to the traps.

A small mass of porphyry in Banffshire must remain as it is noted, for similar reasons; and so must the great veins noted in Mar, and near Blair Atholl and Loch Rannoch. So must that on the summit of Ben Nevis: respecting which there is no chance of discovering any other connection than the present.

The porphyritic veins of Glenco, so numerous as to have demanded a very marked record, have been noted as if they were ancient. There is no evidence to the contrary at present: but the following remarks on the analogous veins of Cruachan, may throw some doubt on a conclusion which I was nevertheless not justified in altering. Every one, including myself, had hitherto believed them to be ancient porphyries, since they traverse granite and mica slate, and also possess that peculiar mineral character which belongs to those esteemed most ancient. But the neighbouring trap, which covers the red sandstone, is also traversed by veins exactly resembling them in characters, number, and magnitude; whence it seems a safe inference that the whole are connected, or that the latter are the prolongations of the former, though the intervention of the deep valley of the Awe, renders it impossible to trace any vein on one side into another on the opposite one. Nevertheless I have coloured, equally, the veins on both sides, with the colour of the ancient porphyry. On the Cruachan side this is probably wrong: on the Tyanuill



side it certainly is. But it was important to record this fact, and there was no other means of representing these veins, at least on the side of the trap, since a blue line would not have shown on a blue ground. The present note will prevent any error.

Now it must be left to future researches to inquire whether the veins of Glenco are not of the same date. This will be proved if a vein can be traced continuously through Glenco and Cruachan: though the difficulties are so great, from the distance and the nature of the ground, that it is little likely to be done. In the mean time I have not, myself, been able to do this; so that the whole must remain as it now stands, under the present explanations in addition to the coloured record.

These are all the cases in which I have here represented porphyry as an ancient rock by giving these places the tint of purple; if I except Campbelltown, including the rock of Devar. In these there commence a set of doubts which prevail widely in the south of Scotland, and which render this explanation in aid of the colours which I have adopted, peculiarly necessary. The porphyry of Campbelltown does not touch the secondary strata, though sometimes quite close to them; and hitherto I could find no veins penetrating these. Devar, being an island rock, affords no evidence of any kind; but whatever may finally be concluded of the one will be true of all. In the mean time, the purple must stand: though as a subject for future correction.

In Raasay, with the sole exception of Duncan hill, the entire mass of the unstratified rock is a porphyry which, as a mineral specimen, would be classed with porphyries, and not with traps; while they who were ignorant of the ground would also suppose it an ancient one. But it lies above the lias and green sandstone; so that it was necessary to give it the general colour of the traps, unless it had been possible to have distinguished every variety of these.

The same reasoning extends to Sky and to Arran: the facts being identical in the former case, and analogous in the latter: while I shall hereafter have occasion to extend these notes so as to give all the aid that can be given by them in enabling the inspectors of this Map to distinguish among the several varieties of trap to which the general tint of blue was compulsorily assigned.

Whatever other porphyries may occur in other places than those which I am now about to note, coloured as traps in the Map, they are comparatively insignificant in quantity; as it would be equally endless and purposeless to describe the places, since they could scarcely be found, and would produce a long catalogue of names and descriptions difficult to verify on the Map or the ground. It must suffice to state the general fact: and the observer will be sufficiently prepared by these statements, whenever they may occur in his researches.

It is in the line which is marked by Tinto and the Pentland hills that the first very remarkable and extensive masses of por-



phy occur, in proceeding towards the southern division and border of Scotland. And they are so very remarkable, and so unlike the ordinary traps, that this annotation is especially necessary: since, for the preceding reasons, they could not have been distinguished by a specific colour.

I could not specify every place and every change, without a detail of the notes made on this subject, which while it belongs to that scientific geology into which I do not mean to enter, would be infinitely tedious, and, for the present limited object, as purposeless as it would be difficult to make use of it in the verification of the ground. But the remarkable fact is, that on this line there occur great tracts or masses of a porphyritic rock, or of an analogous rock without imbedded crystals, which must sometimes be ranked as a compact felspar; at others as a clinkstone, and at others again, as a hard claystone. And it is also to be noted, that these rocks are very extensively reddish or brown, or of some grey tints very unlike the ordinary dark hues that prevail among the trap rocks. But their date is unquestionable, because they are more recent than the coal series, as the ordinary blue claystones and other traps also occur among them: and thence has the single and usual colouring of trap been adopted for them.

I have been in doubt what to determine respecting the Aildon hills, but have finally entered them under the colouring of all the other traps of the south of Scotland. The present note will at least explain the facts; and he who thinks this particular entry inexpedient, or may discover that it is wrong, can easily obliterate the present colour and substitute the purple. It is true that the rock is far more analogous to, or identical with, those last named than with the more usually esteemed traps, and it is not less true that it lies in slate and does not come into contact with secondary strata. But many of the insulated traps of this district touch the slate on one part and the sandstone on another; so that the removal of this latter portion, to happen undoubtedly at some day, would lead to a false conclusion as to the age of such a mass. It is equally true that the superficial sandstone has often been extensively removed, leaving the evidences in detached portions and fragments. There is such a fragment at the edge of the Tweed near the Aildon hills: and it is from these circumstances that the present inference has been drawn. With an explanation of this nature in addition, the mode of entry is of little moment: but others can judge as they think fit.

The great tract of unstratified rock which extends between the Tweed, the Cheviot and the Carter-fell, and of which, fragments, or what seem to be fragments, are widely dispersed along the ridge which includes Fanna hill, presents the last of these difficulties; while under all the circumstances of the evidence, I have concluded to colour it as trap. If some portions of it cover slate only, others are connected with the red sandstone,



and others again with the sandstone of the coal series which occurs on the Carter-fell. Yet the far greater portion, though not the whole, consists of rocks similar to those of the Tinto and Pentland range. It is evident indeed in some places, that there is more than one date for the whole, because there are veins of one kind penetrating the masses of another. But unless it could be proved that all those portions which are connected with the several sandstones were different from those connected with the slate, we could not conclude that there was here a primary and secondary rock both, or a porphyry to be coloured with purple and one to be coloured with blue: while the evidence, as far as it can be found, lies the other way, or proves that the same mass interferes with both, although there are masses of different dates.

With this statement in addition to the present entry on the Map, there can at least be no error, though doubts may be entertained of the truth of the general conclusion as far as the whole tract is concerned. But the opinions one way are of no more value than those on the other side: whence, as in so many other cases, it is a question that must be left to future investigations or casual discoveries: as I shall pay no attention to the suggested corrections of those, who, as the great dealers in opinions and hypotheses, are also the worst of observers, and, from every cause, the least to be trusted, though always criticising and correcting, with a confidence equal to their ignorance, and the surest mark of that ignorance.

But those fragments which are noted near Fanna hill, Westerkirk, and elsewhere, are still more likely to be disputed. There is no sandstone near them, or they lie entirely in and on the primary slate. Yet I have coloured them as recent traps, and on these grounds. They are masses nearly worn out, and fast disappearing, as, in many places, they are both very narrow and very thin, while in others they are evidently nothing but veins proceeding from a principal mass. Hence that difficulty in finding them under the incumbrance of peat in this obscure and trackless country, which I noticed in the account of the Map, and which convinces me that the delineation here given must be very imperfect. Now if the veins are veins from the great mass already described, they are recent of course, though traversing only primary rocks. And by tracing the first set of these fragments from the Carter-fell along the north of Fanna hill, it is almost demonstrable that they are the remains of a continuation of the same great mass once covering this country far more widely: whence I have extended the same general conclusion to those which are situated more remotely and in a more detached manner. The portions marked near Westerkirk are undoubtedly very far separated from the rest: but if any one does not choose to coincide in the present inference, he can change the tint and adopt his own views. The whole difficulty is a matter of no great moment, even in geological science: since there is abundant proof of porphyries of different dates, and since it is the



general fact alone which concerns that science: while as a question of utility or statistics, it is absolutely indifferent, inasmuch as the consequences would be exactly the same whether these rocks were primary or secondary, of an old or a recent date, coloured with purple or coloured with blue.

The continuation of this explanation, including all else that belongs to these unstratified rocks, relates to those traps which are demonstrably secondary, and which it has been agreed to class under this general term, though so numerous, and so widely differing in character and composition as they do.

For the distinctions and characters of these I must refer to my own work on Rocks, since that information is not to be found elsewhere; but I must here give at least their names, as the impossibility of distinguishing them by colours would not otherwise be appreciated. They are the following: hypersthene rock, augit rock, greenstone, syenite, porphyry, amygdaloid, basalt, clinkstone, two qualities of claystone, and tufo; to which I must add pitchstone, as being akin to these, or rather a mode of them. And if to these thirteen rocks I were to add that syenite of Sky, which is a true granite in mineral character, though a recent secondary rock, it is plain that it would require fourteen colours to distinguish the traps alone.

Now, in this Map, though eighteen colours are entered on the Key, I have not been able to produce more than seventeen altogether, that would have been distinguishable on this black engraving, so that the yellow ochre is twice used, and for different rocks. Thirteen others, in addition to the blue used as the colour of trap generally, were therefore unattainable: while, could I have adopted two or three, or any number much less than the whole, it would have even more misled the reader, under a more deceptive statement, than in thus generalizing the whole. It is further true, that though some of these specific rocks, in some places, might have been defined, from their marked characters and the large spaces which they occupy, it would have been far otherwise as to the whole. The porphyry of Raasay might have been thus distinguished, as might the hypersthene rock of Sky and Airdnamurchan, the augit rock of that island and of Rum, the syenite of Ailsa, and more: but in the far larger portions of all this extensive body of trap, pervading so much of Scotland, if in separate divisions and fragments, such distinctions would have been utterly impracticable, from the frequent and often minute intermixtures of the different kinds. I must here remark however, that I did make and enter these several distinctions in the surveys and memorials whence the general Map was reduced and constructed in these parts, by adopting separate draughts of the geography on a larger scale, and applying separate keys and systems of colouring. In this independent manner there was no difficulty: and examples will be found in the published maps of my work on the Western Islands, where separate keys are used for each, and where there was thus neither



want of space nor of colours. But, as I have already said, the entire Map as it now stands, did not admit of this, and thus was I compelled to adopt the present general expression, in the blue applied to the whole of these rocks: since there would be no limit to the separate publication of the hundreds of enlarged maps of separate tracts which would be required, if the reverse system of such enlarged and multiplied parts of maps had been adopted, and if all which demanded this enlargement and detail not less than the trap rocks, had been included in that plan.

To a certain extent therefore, this explanation will suffice to show under what light the blue colour adopted for trap must be viewed. In the future remarks on the rocks of Scotland, I shall specify the most conspicuous places where the principal varieties occur; and thus will the geologist be furnished with all the additional information on this specific subject which the plan of these Reports admits.

The expression used for the red sandstone may be deemed to require some remarks of a similar nature to those passed on the simpler cases which preceded this of the traps. Geologists indeed will not require this, since they have agreed respecting this rock, as designated by position, be its mineral characters what they may. But they who may regard the mineral characters alone, and they especially who may view this rock as an object of use, would have wished for distinctions which, for all the same reasons, it was impossible to make on a map of this nature; such and so intricate are its variations, so numerous are its varieties, and so impossible was it to distinguish these by any mode of colouring. A few general remarks here, added to those which will be found in the general view of the rocks of Scotland, will do all as to this subject which is necessary or possible.

There would have been no end to an attempt to distinguish the conglomerates from the finer sandstones, and still more would it have been impossible to have distinguished the endless varieties of those. If their places had always been the lowest, or the nearest to the primary rocks, that might have been comparatively possible: but this is not the fact, since they occur in many other ways, as near Stonehaven for example, conspicuously, and since the fine sandstones often occupy the places where the conglomerates would have been expected, while they are also intermixed in many ways and in minute portions.

In Shetland, and elsewhere, this sandstone cannot be distinguished as a specimen, from quartz rock; as this also happens over very extensive spaces; while its colours are frequently white or dark grey instead of red. It is a very different rock for purposes of economy; but it is the same geological rock, and as such it must be coloured. If it thus also varies from its nominal colour in many places, and very remarkably in Perthshire and Forfarshire, while there also becoming a peculiar object in the views of a quarryman and an architect, still there is no resource but to follow the general rule.



In this latter county in particular, there is a still more remarkable and important variation. The shale which geology considers as but a part of the same rock, and classes with it under one term, predominates so much in some places, as near Forfar itself, that, as a separate substance, the rock is truly a shale and not a sandstone; as there are many varieties connected with this, being flaggy sandstones. It is easy for a separate, or a county map, to make this distinction, because it will possess room and resources in colouring; and a map of this nature ought to make this and every other distinction, already and hereafter noticed, which I was compelled to pass over; because this is the very duty of such maps, and because it is here that such statistical and economical details will be sought, as they ought to be found.

But if even this more remarkable variation was incapable of being specified in the present place, in this particular spot and in some others, I have departed from the usual proceedings of geology in doing this for Caithness; though in but a general manner; as being the only thing which the obscurity of this deeply covered county permitted. The shale of this district, connected with the red sandstone, forms whole tracts without any intermixture of the latter rock, so that it not only admitted of distinction, but seemed absolutely to require it; and thence the places of the former are represented in the best admissible manner. If in certain parts of this tract or county, the record is not so accurately true as could be wished, it is because the rocks are not so perfectly distinguished in some parts as in others. If in some places nothing but red sandstone is visible, in others there is nothing but shale: but, in many, they are intermixed in a manner that cannot be accurately known anywhere except on the sea shores, from the immense spaces covered with a peat so deep as to render every thing equally invisible and un conjecturable. The rule which I have therefore followed, is to lay down as shale all those tracts where it appeared to be predominant, as well as sole: while I have done the same as to the sandstone: whence it is plain, that in this county, when practically and accurately examined, shale will often occur where sandstone has been denoted; and the reverse.

The coal series, as laid down in this Map, demands similar remarks, even more imperiously, from its economical importance, and from the limited manner in which the coal occurs in it. Geology has long ago defined it, collecting many things, namely, sandstones, shales, clays, including ironstones, and limestones more rarely, together with beds of coal, into a single series, or "formation." And thus it lays down with one colour what it defines, as indeed it could not easily act otherwise. Of course I have conformed to the usage, nor could I have departed from it had I wished to do so. But it does not follow that there is coal present in every portion of such a series; while nothing can be much more uncertain and irregular than the presence of the



substance which constitutes the chief importance of this series, whether in the places of these beds, or in their numbers and repetitions. It is moreover true, that the places of such coal can never be known but by experience. It may be traced at the surface, but the traces are commonly very limited: it is only after being investigated by actual mining beneath ground, that it can be estimated and assigned. But if, in England and Wales, very generally, it can thus be assigned very widely, that is not nearly so true of Scotland, where the coal field, or fields, are so separated and disarranged by trap rocks, that calculations to a similar extent, from partial knowledge of the workings under ground, cannot be safely made.

Now it is plain, that in as far as the very limitations of a geological Map are, to lay down the rocks at the surface, it could not notice the coal itself as a distinct object in that series; since the very small quantities visible at the surface would not form more than a few microscopic points on the Map. And as no reasonable conjectures respecting its existence beneath could be formed at any places where it was not actually known, not even a conjectural inference could be recorded: so that the whole series was laid down, as I have just said, under the ordinary usage and in one colour. At the commencement indeed of these examinations, I attempted to denote, by some marks, the places where coal was actually wrought. But finding, first that the geography was too incorrect to admit of the places of coal-pits being truly entered, and seeing that falsity of position must be the frequent consequence of such an attempt, while these marks would have been invisible on so much of the Map, without such exaggeration as would have confused the records of the rest, and especially of the trap rocks in which the coal is so often entangled, I was obliged to expunge what was done, and abandon this design. And on reflection it appeared as superfluous as it was impossible. There is no secret respecting these things, as it requires no geologist to discover them. Every person knows where they are in his own neighbourhood, and it is for that neighbourhood that he will chiefly consult this Map: while the future geological surveyors of tracts or counties will find no difficulty in entering them in their proper places, as it will be their object to do so. And even to have given a verbal list of these places, here, would have been to do imperfectly what is better sought in Mr. Bald's printed accounts of this subject.

It is lastly true of this series in Scotland, that it is believed to contain conspicuous limestones independent of the mountain limestone beneath it. It will be for future observers, versed in geology as well as in coal mining, to determine what the value of this authority is, or, what will be really necessary, to determine the facts by a proper examination of all these reported spots. My time did not admit of such minute, and generally



underground examinations, for such a purpose: but from what I was enabled to see, I had reasons to doubt the conclusions of those coal-viewers, finding that such as I could examine were referable to the mountain limestone, and perceiving that the assertion in question had sometimes arisen from not duly estimating the extraordinary disturbances of these strata produced by the frequent vicinity of trap.

Future and more minute knowledge will correct the general entry which I have made of all these limestones, should I in any instance prove to be wrong: but it will be even then but a question of geological science, since the economical object will be as well accomplished in the present way as in any other. Every secondary limestone connected with the coal series has been laid down as the mountain limestone, with a single colour: while, of the far greater number at least, I ought not to doubt the correctness of this determination, partly from their positions, and partly because they include those fossil shells, which are considered among the distinguishing characters of this rock.

But I have also done this where no coal strata are present, and even where the limestone is decidedly subjacent to some of the red sandstone strata, if not to all; as in others it at least appears to be so. I know not that it is worth while for geology to distinguish between the separate and great beds of lime occurring above the red sandstone, and the smaller ones which occur in it, since it is but a fact analogous to many more in these associations of stratified rocks. And being so, these beds are parts of the mountain limestone: while of some of the instances thus represented on the Map, it is true that they present the same evidence in the identity of the fossil shells contained, be the value of that evidence as perfect as it has been esteemed, or otherwise. But the Map itself will at least show where these cases are: so that any one who may not be satisfied can re-examine them. At any rate, I should scarcely have given them a separate colour, though I had thought otherwise: since the distinction is a trifling one, and the economical purposes are equally well served on the present plan.

I need not separate the lias, the oolithe, and the greensand, in the consideration of the expressions which I have been obliged to use for those in this Map; while the lignite coal occasionally included will equally find its place in these remarks.

With scarcely other exceptions than those of Sutherland and Campbelltown, the fragments of these limestones are so small that they could not be represented on the Map without exaggeration, as I elsewhere noticed. And this is equally true of the green sandstone; with the still inferior exceptions of Raasay, Strathaird in Sky, and Inch Kenneth. If I have therefore noticed this rock by the same colour as the coal series, for want of another, yet showing that it can be distinguished, because it is then attended, in contact, or near at hand, by the colour for



lias, I have been compelled to omit it in some other cases, because its colour could not have been introduced without disturbing the others.

But I found it as impossible to separate the lias and the oolithe, as it was to find colours for the two, that should be visible in such minute spaces; while, on the former grounds, no notice is taken of the actual existence of coal. Nor can this be of any moment. These two limestones may almost safely be united into one series; and if it were not so, there would be no remedy in the present case. In some parts there is lias without oolithe, as there are limestones with the green sandstone and without it; in others there seems to be oolithe without lias; and in others again, nothing more than the shale belonging to one or other or both of these rocks. Such is the joint effect of the minuteness and dispersion of these fragments, and of the action of the trap rocks on them. One general expression for the whole was therefore indispensable, while it has been extended even to the merest fragments of shale, as in the Shiant isles, that the very singular dispersion, and therefore original connexion of this deposit, might be visible, under the interest which geology may feel in this fact, but in which economical statistics can take no share.

As to any thing else which geology may require respecting this strata, it may be sought in the additional Notice explanatory of the rocks of Scotland.

Of diallage rock I need say nothing, further than that I was compelled to omit, on the Map, some fragments of strata, if they can even be called such, not amounting to a yard in dimensions in any case, which occur in a few places, accompanying serpentine, as usual; but which are in general so extremely minute that they might rather be considered as occasional minerals than portions of rocks requiring geological record.

Pitchstone, as a separate rock, could not have been made noticeable on the Map, since, with exception of the Scur of Eig, if that rock ought to be thus ranked, it occurs in very small veins only, and in a very few places: limited, as far as yet appears, to Arran, to Eig, and to Sky, while, in the two latter, occupying only very small points. Nor, if practicable, did it seem necessary, when this rock is safely ranked with the traps.

I have discovered that compact felspar is a distinct primary rock, not connected with any formation of trap or porphyry, but with gneiss. But the quantity is, any where, so very small, that I could not notice it by any colour: while in Iona, where one of the larger masses occurs, any attempt to do this would have confused the whole island. If the limestone has been also omitted in this island, I know not that I ought to have marked that, of which nothing but the place remains.

I have noted jasper, chert, and silicious schist as distinct rocks, in the system which I formerly drew up, as I have described their characters, relations, and origin. One or other, or all of these, are of perpetual occurrence wherever sandstones, slates,



shales, or limestones occur near granite or near the trap rocks: since to the influence of these on the several strata they owe their origins. In almost every case, not one of these could have been represented on the Map, since their limitations are to within a few feet of the contact, even had there been colours remaining to do all this. I might indeed have represented the hard slates which often assume this character very perfectly, in Galloway and elsewhere: but it did not seem essential to distinguish them from the general mass to which they belong, as indeed I could have found no expedient to do this, from the same ever-recurring cause, the want of adequate colours.

But the whole of these facts have been made known to geologists, generally, in my own writings, as many of the examples have been pointed out. They now know where to seek them and how to account for them; and as no economical purpose could, as far as I can foresee, be served by such a record on the Map, this compulsory omission will be of the less moment. I must only notice here, that there is near that house named the Burn in Forfarshire, a mass of jasper lying in the slate, which ought to be distinguished in this place, but could not be noted in the Map: because of its small extent, and as it is of a nature susceptible of ornamental uses; which, as far as I have seen, is not the case any where else in Scotland. The jasper of Dunbar, with some analogous ones in other places, lying in sandstone, and converted from it, is a geological curiosity, but could not have been entered on the Map.

The deposits or strata of clays in England are of sufficient interest and conspicuity to have demanded an entry among the other strata of this part of the Island. There is nothing of this nature in Scotland, as far as my observations could make out: with perhaps that exception of the place in Caithness where fishes occur in marly slate, and of which I have already declared my ignorance, and the reasons for it.

All the clays which I know in Scotland are to be ranked under the following heads; and as such, the plan of this Map, and my own views as to these facts, did not either demand or permit a coloured record.

The traps and the granites, and more rarely the gneiss, are often so widely and deeply decomposed as to form great bodies of clays, of different characters; and this occurs most widely I think, in Aberdeenshire as to the latter, and in Sky as to the former. They are all coloured in this Map, together with the rocks from which they derive. And the same is true of the slates. When these clays occur beneath the same rocks, as is sometimes the case, it is still more plain that the Map ought not to have distinguished them, if even that were possible.

I elsewhere remarked that immense spaces over the red sandstone and the coal series are often covered with alluvia, which are clays of different kinds, to an enormous depth. This is not less true of the trap rocks. Entire masses have evidently disap-



peared; and in these spaces we find great beds of clay which are their produce, as is very often proved by imbedded nodules that have not yet undergone entire decomposition. It is plain that the attempt to represent any one of all these several clays would have been to abandon the representation of the subjacent rocks, as it would have been an easy expedient well understood by the constructors of some geological maps, to get rid of the difficulties of investigating these most difficult portions of Scotland. Whatever of this nature may be required must be left to a map of the soils, not of the rocks of Scotland: and it may perhaps occupy hereafter the joint knowledge and labour of an agriculturist and a geologist.

The clays of the coal strata are as necessarily represented under the geological hieroglyphic of that rock as the shales of the same series, nor do I know that they are any where separately distinguishable at the surface, beyond very small spaces.

The remaining clays are the alluvial deposits of rivers, or of rivers and the sea conjointly, or of lakes that have been drained or filled. Viewed as mere alluvia I have already assigned reasons for not recording these, to the obscuration of the rocks beneath. It is true, that in such tracts as the Carse of Gowrie and that of Stirling most conspicuously, some geologists might choose to arrange these with their fresh-water formations, under the usual confusion which they have hitherto continued to make on this subject. But under such a rule as this, every flat part of every coast which has repelled the sea is equally a fresh-water formation, and would claim, not only a separate distinction and colour, but separate sets of colours to denote each deposit of clay, sand, marl, and so forth. But neither would my geological views allow me to adopt such a system as this, nor could I consent to extinguish such large tracts of rock from the Map of Scotland. All such alluvia are therefore unnoticed; and the subjacent rock, as determinable by the best procurable evidence, is substituted for such blanks as this practice would produce. In any view, a record of such alluvia would be a map of soils, not of rocks; and to some such future map must entries of this nature be trusted.

The sands of Scotland demand the same kind of remarks, although they occur in some places very conspicuously. They are deposits by rivers, or by the winds, or are the produce of decomposed rocks. They are nearly all formed of blown sand, and there are extensive tracts of it in the outward chain of the Western Islands, as also in Coll, and on the shores of Moray, Fife, Sutherland, and Aberdeenshire. In the whole of these I have omitted the sand, and represented the subjacent rocks. At Kildrummie and elsewhere, the sandstone rock has become sand by decomposition: I have acted in this case as with the clays produced in the same manner. The alluvial sandy tracts formed by rivers admit of the same remarks as those already made on the similar clays.



I have been obliged to follow the same rule as to the filled, or partially diminished lakes; though these are often economically remarkable for containing beds of marl, as is the case with Restennet and many more. It is the idle question of misarranged fresh-water formations, once more. There is not a lake in Scotland which has not such a "fresh-water formation" as Restennet moss, on some part of its margins; that of Loch Tumel is of great extent. All the great flat peat bogs, such as Locher moss and the moss of Inverloch, come under the same head, and there is scarcely a flat bog in the Highlands which has not been a lake; or at least has not contained one; while beds of shell marl, as well as clays and sands, are found in most of these, whenever they come to be excavated; though in every case, excepting that of Restennet, where the circumstances were such that the presence of the marl could not have been overlooked, the discovery of these marls has been a matter of pure chance. A remarkable instance of this nature occurs at Auchtergaven, between Perth and Dunkeld, where a tract, once almost utterly worthless, has been converted into a valuable estate by the chance which, in removing the peat for use, displayed the subjacent bed of marl.

This subject is so important in an agricultural view, especially in a tract so deficient in limestone as is the far larger portion of the Highlands, where also calcareous manure is of great value, and must generally be transported, both by sea and land, at a great expense, that I must be excused for offering some further remarks on it; though somewhat misplaced in a Memoir which is not an economical one, but only a needful explanation of the system and the restrictions under which the details of the coloured Map have been regulated.

A very little observation, united to much less knowledge than that which geologists claim as their own, has taught, or may teach, every farmer, or every peat-digger and roadmaker, in such a country as the hilly portion of Scotland, that if the sea is repelled, and the land extended, near the æstuaries of rivers which terminate in the ocean, the same is true wherever that termination is in an interior or fresh-water lake, be the dimensions of that lake and the size of the entering streams what they may. In the larger lakes, such as that of Tumel, already quoted, in Loch Lomond, Loch Maree, and others beyond enumeration, the flat tracts, first commencing as subaqueous banks, then becoming marshes, and finally peat bogs, or meadows, which occur at the entrance of the main stream, are known to every one; while not less obvious are those lateral flats, proceeding in the same course, which attend the entrances of the smaller subsidiary streams. In a similar way, it can scarcely have escaped any one's observation, that a single original lake has thus been separated into two; of which, in Scotland, I may quote the case of the lakes Rannoch and Tumel.

Now that which occurs on this great scale, and is so very



obvious, takes place also on a much smaller, and even on a very minute one, where it is by no means so easy of observation, and, under the predominant circumstances, is very easily overlooked. This is especially the case when the whole operation has been terminated: when the lake has been obliterated, and when a tract of flat peat generally, but sometimes of meadow land, still gives passage to the stream by which this work of extending the terrestrial surface was effected. If geologists have overlooked this, it is not surprising that it should have remained unnoticed by the neighbouring agriculturists; of which also, the far greater number, in those parts of Scotland to which I here allude, are without education, however acute they may be, and are also restrained to daily and limited labour by their poverty. The disappearance of such a lake as Loch Ore could scarcely be overlooked, from the nature of the present ground, even were the recollection of its recent and artificial drainage obliterated; but it is not always easy to trace the similar ancient state of a tract respecting which there is neither recollection nor tradition, whether the change has been the result of a natural drainage under the deepening action of the issuing stream, or the deposition of alluvia by the entering one, or by both united.

But that which is sufficiently difficult, even in such a case as that of Auchtergaven, above-mentioned, becomes far more so in those cases where the original lake has been very small, or where even the term lake is scarcely applicable; such collections of water deserving no better name than that of pools. The western shore of Sutherland still abounds in such pools, of every imaginable dimensions; and I here quote them in illustration of what many other parts of the Highlands, and indeed of every mountainous tract in Scotland, must have been in former times.

Now it is in such obliterated pools, as well as lakes, that marl will be found; not always, possibly, but very widely and generally, as I have proved in several places. The shell fishes of fresh waters have inhabited them in former days, and their remains are the marl in question. This fact I have pointed out, on several occasions, to the farmers in the neighbourhood of such places: but, in spite of such examples as those of Restennet and Auchtergaven, with no better success than usually attends the first efforts to introduce new practices; of whatever value the possession of a calcareous manure might be, and whatever saving might have followed from substituting such manure for transported lime.

In other writings, I have also desired to teach those who are interested, how conjectures may be formed of the places where such beds of marl ought to exist, sufficient to justify the very small expense that would attend an excavation in search of them, though that should fail of success; as, with due care in the selection of a right spot, could not very often happen, unless indeed the former existence of shell fishes in such waters should be much more rare than is generally supposed. As to the ex-



pense indeed, even in case of failure, I scarcely know how it could occur, unless the places were very distant from the farms, or habitations of the people. Since peat must be raised for fuel, it may as well be procured in such places as elsewhere; so that, except in the case just named, the labour of trial will pay its own expenses, at the very least.

But it seems incumbent on me to notice some facts with respect to the usual digging of peat; as the correction of the common practice is essential to the expected discovery of what may exist beneath it. In a notice of this nature, a detail so irrelevant to the primary object of this Memoir will be excused; as the neglect of it might neutralize all the other suggestions here offered.

In many places, the mass of peat is so deep, while the quantity accessible at the surface is so great, that there is no inducement to work down to the bottom of the stratum, whatever may be the case where the beds are thinner and of less extent. In addition to this, it is an economical practice, very usual, and founded on sound principles, not to remove the entire stratum, and, further, to replace the turf of the original surface on the new and bared one; that a progressive growth of the same plants may take place, with a continuous increase of the peat stratum, or a replacement, for future, if distant uses, of that which has been taken away.

Another cause leads to the same practices. This is, the accumulation of water in the pits formed by the workings. It is not worth while to be at the labour of draining these, when the object in view can be attained by continuing to work along the surface: and if ever such strata are wrought to the bottom, it is where the form of the ground admits of a natural drainage,

Now these are the very places where marl is not to be expected, because such tracts of peat have been produced on declivities, or at least have not replaced the situations of lakes. It is in those very spots where lakes have been, or are likely to have existed, that the natural drainage of an excavation cannot be expected; as it is therefore in those that the peat is seldom if ever wrought out, or down to the terrestrial soil. But, in addition to this, and to the causes above stated, it is the usual, I should say the universal practice, to cease when the earthy soil has been reached, supposing the circumstances favourable, and the intention to remove the whole stratum, existing. Nor is this unreasonable, when peat is the only object desired, and when no further gain is expected from continuing the excavation.

But although marl may be present in such places, it does not follow that it will lie immediately in contact with the peat, and thus make its appearance as soon as this is removed. All such waters, be they lakes or pools, are subject to the influx of the overswelled streams, which bring down clay, sand, and gravel, so as often to form a new bottom in a very short space, and thus to cover a bed of shells, should such be present: a fact of which



there is abundant evidence in the frequent alternations of strata of such earthy substances with shell marl. Thence arises the necessity, should the search after such marl be intended, to continue the excavation into the earthy soil, until satisfactory evidence of its absence be attained: a work of very small labour, since deposits of this nature can never be very deep.

I may lastly repeat what I have elsewhere written on this subject for the information of agriculturists; since it cannot, or ought not to be, required by the most minute geologist; and it relates to the indications of the probable existence of former lakes or pools, where the surface is at present a solid mass of peat, or of peat covered with soil.

A tract of this nature which is of a perfect level, may always be suspected; and when connected with an existing lake, can admit of no doubt. If there is no connected water, the same inference may be drawn if there should be water in the vicinity, separated from it by a prolongation, more or less perfect, of similar land. But the case of minute or small masses of water formerly existing, where all around is now dry, is a more difficult one; while drained pools of this nature, whether containing marl or not, abound all over the mountainous parts of Scotland. He who can examine Loch Spey as it now is, will easily see what it will hereafter be; and thus perhaps form a better notion respecting the marks of a former and obliterated lake, or pool, than from a suggestion like the present. But if there be a tract of peat, be it large or small, which is of a water level, and occupies a basin, it may be suspected to be the place of a former pool; and that suspicion will be rendered a certainty, if it still gives passage to a stream. Such a tract, having a rocky boundary, or a hilly one, on most of its circumference, will be a still more obvious one to ordinary observers: and thus, with a little attention to the suspected ground and to the circumstances of existing pools and lakes, be a guide within the reach of almost every one who may be interested in such a search. I need not prolong this economical notice; but I will not terminate it, and, with it, the Memoir to which it is, thus, somewhat irregularly appended, without repeating at more length, remarks which I have been compelled to make elsewhere.

If so remarkable and so often discussed a case as that of Restennet should be admitted into this Map, as should equally that of Caithness had I known where to place it, and on the ground that these have acquired the imposing modern name of fresh-water formations (one of the magical terms of the day), then must I have equally reserved a space and colour for every analogous deposit, on the shores of all the seas of Scotland, on the margins of every lake, on the borders of many rivers, and in places innumerable over every mountainous portion of this country, as well as in many parts of the flat interior districts: while, if noticing them only in as far as they were marls, so must I have indicated, and, in justice, under a separate colour, those



terrestrial marls formed of land shells actually existing, which I have discovered in different places.

But, to have done this, would have deformed the Map with hundreds of spots of colour, unconnected by any common bearing, and often so minute as to be almost invisible, without great exaggeration of space, and further, to have defied the utmost care of the copiers. Nor would this be the only evil; since whatever was thus noted would have excluded any record of the subjacent rocks, and, still further, have so broken up their connexions on the Map, as often to have destroyed all the geological inferences, or even to have produced a patch-work surface, so dazzling as to have rendered it a chaos of unintelligible colours.

That a map of this nature would however be desirable, I am not about to question; but whenever it shall be executed, it would demand a separate record. It is true that I might have done much towards it, but by no means all; since it would have demanded a separate set of entries and a distinct work, as it would also have called for an investigation very different from that of the rocks themselves, which also was, at no time, within my plan or the limit of my orders, especially during the first portions and years of this survey.

But if I thus consider its execution as desirable, I know that it can never be done by one man, nor, to any purpose, on a map of this scale and structure, were that even more perfect than it is. Such a record ought to be the work of many men, and of men, as I have elsewhere suggested, uniting agricultural with geological knowledge. It might be done on county maps, and on those it ought to be done; while, whenever executed, it must needs be a work of time. How far a record of alluvia, be their nature what it may, could be united to one of the agricultural soils, on a common basis, I need not here inquire; while believing that each would demand a separate map; though, on one or the other, there might also be noted, as an object of pecuniary economy, the useful, existent, or probable, quarries or quarriable rocks, be those limestone, sandstone, granite, or aught else, the coal beds as far as they have been traced in the coal series, the places of the actual workings of these beds, and the situations, recorded or known, of mines, or of metallic minerals holding out the prospect of future mining operations.



## N O T I C E

RESPECTING THE

## MINES AND METALLIC MINERALS OF SCOTLAND.

IN most countries, that popular opinion which may safely be considered a vulgar one, attaches the chief interest which it may take in a geological survey, to the record or the discovery of mines; or to that of metallic minerals, under the expectation of future undertakings of the same nature, and future profit. In mining districts, this is not unnatural; but a similar prejudice, with similar anxiety, is very general in countries where few or no mines have ever been wrought, and especially in mountainous ones; being those with which the notions of the presence of metals are very widely connected.

This at least has been very generally the case, with even the better educated; though now much less prevalent, under the greater diffusion of scientific knowledge, under greater experience of deception and imposture, and under juster views of the real wealth of a territory, and of the most profitable application of capital and labour.

But independently of any views of this latter nature, it must be recollected, as it is now I presume, obvious to most educated persons, though but moderately imbued with science, that even on purely geological and mineralogical considerations, to trace and assign metallic veins forms but a very small part of the interest belonging to such a survey, or of the pursuits demanded from a surveyor under this subject. As far as geological science is concerned, the history of metallic veins, obscure though it yet be, and desirable as it would be to understand that which has hitherto eluded all theory, forms but a small portion of what is expected and demanded from geology and mineralogy. And though, under questions of statistics and economy, or of utility, the knowledge and assignment of metallic veins, or of such minerals as may lead to the working of mines of this description, is of high importance, it must be recollected that it forms but a certain portion of all that to which minerals or rocks are subservient for the purposes of life; though the predominant ignorance respecting geology has hitherto been unaware of the light which it might throw on the knowledge of the several non-metallic substances used for the purposes of life, and of the assistance which it might afford to their discovery, selection, and application.



It ought also not be forgotten, that if the determination of metallic minerals or veins, the research after possible mines, or the further investigation of known ones, were the only objects in view in the geological investigation of countries, there are many tracts in every country, and even vast territories every where, that would present no geological interest whatever, and would therefore demand no examination, and deserve no record: as, in any case, every record beyond that of metallic appearances would be superfluous. Thus, if even a survey of this nature, proceeding on the hopes of such discoveries, could be defended, the record of it would be worthless, for all purposes of utility at least.

This would be to abandon the whole subject, unless in as far as philosophical geology is concerned; but if it is true that there is an extensive interest, not as to science, but to public economy, implicated in the statistics of the naked and fundamental earth, in the knowledge of the rocks of a country, and, above all, in our own, to that of the coal series, more valuable by far than the metallic minerals of any country have ever proved, so must it be recollected that the fundamental proceeding, even as to the investigation of metallic minerals, in a country previously unknown, most especially, consists in ascertaining the places and natures of the several rocks of which it is constituted. Geology has discovered that there are certain rocks in which metals may occur again, because they have previously occurred, that what is productive of metallic veins in one country, or in one portion of any tract, may be the same in another: as it equally concludes from experience, that there are certain others, the nature and position of which it can always determine, in which it is in vain to seek for them or expect them, since they have never been found in such associations and positions. Hence the assignment of the places and qualities of the rocks of any territory serves to exclude what would lead to a fruitless pursuit, as it gives ground for rational research in other places; thus marking the bounds of the probable and the impossible, and thence limiting hopes, and, with that, checking vain expense or imposture, as it confines both hopes and labour to a rational direction.

The present geological, or mineralogical, Map of Scotland has done this, if it has done no more. It has marked the places of the admitted metalliferous rocks, and it has equally noted where metals cannot be expected and will not be found. In this it has done what it has for the coal series; as the researches on this collection of strata will serve to illustrate its utility respecting the possible metals of that country. No one needs now seek for coal in Scotland, where the carboniferous strata are not here laid down: he who makes or proposes such a search in the districts where the primary rocks come to the surface, is either in a state of ignorance which requires to be informed, or is a wilful deceiver who can now be detected by any one who will inspect this Map, even had he no



geological knowledge. Thus it is as to the hopes or expectations of metallic mines: they may possibly be found, though this has not yet happened, in the primary rocks, in the mountain limestone, and in certain of the trap rocks; but excepting the iron stone of the coal series, they will scarcely be found any where else: I need not note here some very rare exceptions to this general rule.

Nor could this Surveyor well have done more than has been done; or this Map, or its Memoirs, recorded more on this subject than the little which will be shortly noted. The search for metallic minerals forms a very different pursuit from the assignment of rocks and their boundaries. It is almost a microscopic pursuit: it is at least a very minute one. Over such a country the lives of hundreds, occupied for centuries, would not discover what exists, should aught of this nature exist, or, reversely, decide that the pursuit of metals was worthless or hopeless. The very smallest space easily selected might occupy the entire labours of one man; and assuredly no labour could well be worse applied. Every discovery of this nature in an unknown country, or in one not previously known to possess metallic minerals, is the result of accident, and can seldom be otherwise, even in scientific hands: while no one will be induced to search, without guide or hope; least of all, thus to waste time on which there are abundant other demands. In a land of such minerals, in tracts above all where mines have been wrought, such a pursuit would be more rational, while it may sometimes succeed, as the result of a design founded on some kind of evidence; and more especially where veins can be followed or sought under expected prolongations from known ones, or under other known modes of examination which I need not here detail.

But nothing can well be less tempting to such pursuits than the condition of Scotland in respect to mines and metallic minerals, as far as it is yet known. There is scarcely a guide or an indication to tempt any one to an examination, even of the few miles to which he may have access on every day of his life. To the geological surveyor, fully employed in wider pursuits, requiring a very different kind of attention, and to the distant far more often than to the near, there is not only none whatever, but it is nearly impossible that he should combine both, so diverse or opposed are they: it would be an utter impossibility, not merely an inapplicable and censurable waste of time: under one narrowly limited, as in the present case, it would be to leave much of the intended and fundamental work undone. If he should find any indications of a metallic vein not known before, he has no more merit in the discovery than the most ignorant would possess; since it is not his science which has led to it; though the knowledge of minerals would doubtless, often enable a geologist to see what others might overlook, especially were the indications minute, or the mineral devoid of ostensible metallic characters.



In truth, discoveries of this nature must be the result of pure chance: and how little likely such chances are to occur in a country so barren of metallic minerals as Scotland, I need not say. The merest shepherd who traverses the mountains in his daily range, has also a better chance than the geologist, from the minuteness of that range and from the time which he is occupied on it. This at least is true wherever the mineral has a metallic aspect; in other cases, the mineralogist would, of course, possess the advantage.

Nor are these very observant persons inattentive to such subjects. An expectation of the existence of metals in Scotland had been excited early in the last century; it was much increased at a subsequent period, and fostered especially by the visit of Mr. Raspe, and of some others, not always very honest, whom I need not name. It has therefore not slept in the memories of the rural population, however the pursuit may have cooled: while there are few among the shepherds, quarrymen, road contractors, and others, who have not an eye capable of distinguishing an unusual mineral, though they should not know its name, and though they might be suspected of want of discernment by the geologists who find that they possess so few names for rocks.

I have accordingly never failed to cultivate the acquaintance of all these classes, as I have occasionally received specimens from them, of whatever nature, and been conducted by them to the places of their imagined discoveries and hopes: convinced that this is the best plan which a surveyor can adopt on such a subject. How very little I have gained in consequence, I need not say, since it has proved to be next to nothing, and without value: while if it has been my fortune to chance upon a few indications of metallic veins, or on metallic minerals in some form, the result, trifling as it has proved, is even more than I had a right to expect. These will be noted with the rest, in the appended catalogue: though it is quite unnecessary for me to distinguish, on every occasion, between what I have myself noticed, and that which had been previously known, as it has been printed at several times in different popular books. Had I not supposed that such a list would be expected, and its omission deemed an unpardonable negligence, there is very much that is undeserving of being reprinted or noticed, from the doubtful nature of the evidence, the obscurity of the places, or the impossibility of now tracing any indications of what was asserted to be, or to have been. A work on pure science, which such a Memoir as this cannot be, would not have condescended to notice things resting on doubtful evidence, or on ignorant and popular tradition.

Whatever mines may have been wrought here in former times, of which some were rather attempted than pursued, there are but four, as far as I can find, actually working. Of these, the mine at the Leadhills is the only one which is returning any profit, as far as my information goes: though I must speak with some hesitation respecting the others; since, within the period



of my own knowledge and examinations, one, if not more of these, have been wrought and again abandoned, and that at Tyndrum, I understand, resumed. I do not know whether Strontian has been re-established since my visit, now of many years date, but I am informed that it never produced any profit. Latterly, I understand that this is also the case with Tyndrum; or that this, as well as a very feeble attempt, equally on lead, near Newton Stewart, is barely sufficient to carry on the expense of working. It is difficult however to procure the needful information on subjects of this kind, since it is confined to the proprietors or lessees, not very likely to afford it, even were they known to me; nor is it an essential part of a Memoir of the present nature.

I may now say, that neither these mines, nor any others of those which are recorded, in print or in tradition, afford any basis on which to proceed in making further researches than those which have been already made on the probable or possible courses of the veins in which they are wrought. I mean, however, in this, to say that they would not justify any further researches from a geological general surveyor than such as could be made under a small expenditure of time, in the course of his proper work. Such a pursuit belongs to the proprietors, and it is for them to see whether they would expend money on such subjects, under the employment of professional miners.

What the actual state of public feeling in Scotland may be on this subject, I have not been able to discover; while, as far as I have seen, it has somewhat vacillated within my own memory, and is so different among the proprietors that I have known, as to lead to no general conclusion. High, and even extravagant expectations of the possession and of the value of mines in this country, were entertained by landed proprietors during a portion of the last century; while, during no inconsiderable period, many trials were made, and some money fruitlessly expended. There was an excitement of hope, which some contemporary writers considered a mania: and it is well known that these hopes were encouraged by impostors who found their interest in so doing, to the entire falsification of the facts, in making reports of metals that never existed, and even, as is common in mining countries, in secreting specimens within cavities or workings, whence they were afterwards produced as evidences.

But if I have seen rightly, there has been no small revolution, for some time past, in the public opinion; which has also, as is not unusual, been carried to such an extreme as to consider Scotland peculiarly barren in metallic minerals. Those who think in this manner strengthen their argument also by the cases of Cumberland, the Isle of Man, Wales, and Cornwall, in which metallic minerals occur or abound; countries not very distant, and the two former in particular, intimately connected with at least the south of Scotland, by geographical position;



as the whole consist chiefly of the same rock which constitutes the larger portion of this division of that country.

This assumption is at least a rash one: it is, at any rate premature; while the same argument might be used for the opposite conclusion. It is premature, as long as Scotland has not experienced the same attention which has been bestowed on the tracts in question; and if the slate of the south has already produced the mine of the Leadhills, it is a fact which maintains the general analogy betwixt all these districts, sufficiently at least to prevent the renouncement of all hope. Metallic veins do not often appear conspicuously at the surface: discoveries of this nature are, notoriously, more the result of chance, than of research for such specific purpose: and if Anglesea has thus given to light its Parys mine, there is no absolute reason why similar discoveries may not be made in Scotland, not only in the slate rock in question, but in many others.

In the mean time, there seems nothing to be done but to wait for similar accidents. Such, any discoveries must almost always be, in whosever hands; nor will a hundred such surveys as the present ensure one discovery, though casualty may fall on a few. The conclusion therefore to be drawn, is, that it is at present fruitless to expend time or money in the search after metallic deposits in Scotland, as far at least as the mineralogical experience hitherto attained is concerned, although geological principles are far from destroying our hopes respecting their existence.

If this be the conclusion of mere science, I conceive that it is strengthened by other views. Every sound economist will, I imagine, consider it bad policy that Scotland should expend its capital on such pursuits, when that which it possesses is so usefully and profitably employed. It has yet lands to reclaim and plant, roads to make, and far more of all that must tend to the improvement of its agricultural territory and produce: while it may still extend, from the same fund, that system of manufactures and commerce in which it has lately been making so rapid a progress. All can see what it has already gained by these applications of its activity and capital: and few, I believe, will think that it would have done better, had even the smallest portion of these been diverted to mining speculations. That which has hitherto been a right proceeding, will also probably be the most prudent one for a long time to come. It ought not, if I am right, to regret at present, that it finds no mines; nor ought it to pursue those indications which it already possesses. It will be time enough to do this when, like England, it overflows with capital which it cannot apply: and, when that time arrives, it may possibly become that mining country which it is not at present, to whatever conclusions mere science may have come on this subject.

I must not thus judge however with respect to a proposal which was made some years ago, and which, in the present state of British capital, may possibly be renewed. I allude to that



endeavour to establish a mining company, which was made some years since, but which was abandoned in consequence of the refusal of Government to grant this portion of the Island a charter, as it had done to Ireland. In such a case, the subscribed capital would probably be chiefly English, as it was in the former one; while the minuteness of the shares could cause little inconvenience to any person, though no profit were returned, or even though the whole should be lost; and, while whatever might be expended on Scottish labour, could not be considered as absolutely wasted.

To these general remarks I may lastly add, as connected more especially with my own pursuit, that I took occasion to examine every spot, the seat of present or ancient mines, or merely of metallic minerals, to which it was possible to get access; since there were many which could not be found. Of these, some which had unquestionably been either wrought or tried, seemed to have been exhausted, or abandoned from their poverty: the places of others had been forgotten by the country people, or else had become so obscured by the usual changes of the surface as to be undiscoverable: while of many that were named to me, or recorded in print, I had reason to doubt whether they had ever existed. In no instance did I see anything which could tempt to a further expenditure of money, except where I have noted such in the appended catalogue of places: and, of many, to which I was particularly directed under great assurances, it was evident that the popular reports were false; the result of traditions exaggerated by the people, under the usual feelings of mining countries. The reports of silver mines were especially numerous, while they carried improbability on the very face: and having examined, in particular, the two principal spots thus pointed out, I found reason to conclude that these had been merely lead mines, doubtless yielding some silver, but which never could have produced much, even of the baser metal, since the workings had been very confined, and seemed to have been abandoned after very little labour had been bestowed on them.

I must now give a general List of the metals which have been found in Scotland, or which it is said to have produced, before I proceed to the Catalogue of the places which I have collected: since the falsity of the reports as to some of those, requires that they be noted in a separate list, for the purpose of excluding those which could not appear in a catalogue of places, and might therefore seem to have been overlooked.

But I must previously observe, that in everything which I have yet said, I have excluded iron. If found, in some countries, in situations analogous to those of most other metals, this is not the case at least in Scotland, with a slight exception hereafter noticed. In the form of ironstone, accompanying the coal strata, it is sufficiently common, and it is thus, on every ground, excepted from these general observations; while, to



seek or find it, is almost a matter of course. I need not therefore name its places in the general Catalogue.

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*Catalogue of Metals, proved or asserted.*

**GOLD**: alluvial.

**SILVER**: in lead ore only.

**QUICKSILVER**. This is said to have been found once in Isla, in its native state, and in a single place. It has never been found since, nor any of its ores. This, with the fact that the metal was produced by the asserted finder, in a quantity of some ounces, forms a combination of circumstances sufficiently suspicious: as those are increased by knowing that the proprietor was both opulent and liberal, so as to have been the prey of pretenders or impostors, some of whom persuaded him to mine for coal in mica slate and quartz rock.

**COPPER**: in many places, but never wrought to any result.

**LEAD**: in several places: in one at least, largely wrought.

**ZINC**: not wrought to collecting.

**ANTIMONY**: in one place.

**TITANIUM**: in two ores: common, but scanty.

**ARSENIC**: in the lead mines of course.

**IRON**. Iron stone, abundant. Pisiform hematite, in one place. Traces of chranat in all the serpentines, but as yet no veins or distinguishable masses: except in Shetland, which is not included in this Survey. Bog ore, not uncommon. Pyrites very rare.

**COBALT**: reported to have been found near Alloa: not now to be found, and no specimen existent, to my knowledge.

**CHROME**. The oxide: almost invisibly, and very rare, in serpentines.

To these I may add **BLACKLEAD**, as a nearly metallic condition of carbon, while popularly viewed as a metal.

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*Catalogue of the Places, as far as known or asserted, where the above-named Metals have been found.*

**GOLD**. This is known to have been found in the river alluvia of Crawford moor, in ancient times, and is reported to have abounded sufficiently for the purposes of coinage. It may still be procured by washing in the usual manner; but, as the people in this part inform me, will seldom yield more than a third of the wages of common labour. A nodule of considerable size was found, not many years since, near Helmsdale in Sutherland, which I have seen in the possession of that noble family.

**SILVER**. The places where this metal was found, combined



with lead ore, are the following, as far as I know: of which I have examined the first two; no one having been able to point out the places of the others.

In the trap and limestone hills between Linlithgow and Bathgate: marked as silver mines in the county map: several workings resembling quarries: no attainable report of the produce: abandoned from a time which no one seems to know.

In the Pentland (trap) hills, not far from Pennycuik: called Silver holes: seem to be marked in the present Map by the word Silver burn, though the geography is here uncertain: what I saw resembles the working of quarries. As in the former case, no attainable record of the produce or the date: long since abandoned.

*Ecclesmachan.* Said to have been once wrought: but no report of time or produce. The place now unknown to the country people to whom I applied.

*Alloa.* Said to have been wrought in the trap of the Ochils. I was unable to procure information respecting the spot, and can find no record of either the produce or the times of working and abandonment. Some printed reports are evidently the extravagance of popular tradition.

**COPPER.** The reports of the finding of copper, or some traces of it, are numerous; but there are only a few instances where it is said to have been wrought. Many of those reports are so vague as to admit of considerable doubt respecting their veracity. Of many others, I am compelled to say that I could get no information respecting the exact spots, or that when I did so, and was even attended by the pretended guides, I could find nothing. Of the few that are said to have been once wrought, I could never find that any one knew of their produce, their dates, or aught else; nor do I find that marketable copper ore can be proved to have been produced. If that has happened, the records must be locked up in the papers, or existing in the memories or traditions, of the proprietors, and it would be a fruitless task to seek for them: at least the information could be of little value, under all that has been proved respecting the former mining, real or pretended, of this country. I must note these places as I best can: lest I leave as an obvious blank, what when filled, is seldom better than a blank as to science or economy.

*Applecross.* No place specified in this wide district.

*Airthrie* near Stirling: not to be found through any information that I could obtain: no produce recorded.

*Ord of Caithness:* mere traces.

*Clyth,* Caithness: the same.

*Kilmartin* in Knapdale: not to be found; by me at least.

*Binny,* near Linlithgow: no place pointed out now.

In the parishes of *Longformacus* and *Lauder.* I could find no one acquainted with the spots, nor hear of former workings.

*Alloa:* reported to have been found and wrought in the same



mine with the silver-lead already noticed, and with cobalt. Admits but of the same remarks as the former of these metals, already given.

*Hoardwill*, in Buncle, Berwickshire. Said to have been wrought: not now known, from any inquiry that I could make.

*Morven*, near Sanda: marked in this Map. I could not find it, nor ascertain that it had ever been wrought.

Near *Stair* in Ayrshire: said to have been wrought, together with antimony: no other information to be procured.

*Logie*, in Perthshire: said to have been wrought. Equally obscure, and apparently forgotten.

Near *Dunkeld*. The presence of copper pyrites had been here noticed. The vein, as I investigated it, is in mica slate, and some feet thick. I caused it to be wrought by two men during one day, and there were produced thirty pounds of ore, within a few feet of the surface. This is a highly promising indication: and as the vein is soft, and could be wrought a considerable way by a common drift, it well deserves a further pursuit. The expense of the very little labour bestowed on it was far more than repaid. The exact place is well known on this estate.

LEAD. I need not repeat the same general remarks on this metal: they are no other than what I have made respecting copper.

*Ben Ledi*. Traces have been found.

*Skinnet Hill*, Caithness. The same.

At *Sandside*, in the same county. The same: and similar traces have been observed in other parts of this county. Of such as I have seen, here as elsewhere, I may say literally, that they are but traces: being very commonly detached grains rather than masses, as the apparent constituents of rocks, and leading to no hopes of metallic veins.

*Clunie* in Braemar. I here found a considerable vein of fluor spar with traces of lead. It might deserve some further examination by the proprietor.

*Chapel of Gary*, Aberdeen. I observed abundant fragments of lead ore imbedded in the rocks: but could see nothing that indicated a vein, or could tempt to any expensive examination.

*Tinto*. In the trap (porphyry) of this hill, there are numerous veins of sulphate of barytes, with indications of lead. I did not hear that they had been observed by the people, or that any attempts to examine them had been made in former times. Whether deserving it or not, I had no means of ascertaining.

*Coll*. I examined a vein of lead ore in this island, which has long been known, but never wrought. It is very narrow, and lies in a very tough gneiss: I doubt if it would justify aught but a very superficial trial.

*Ballater*. I also examined here some veins on which a little money had been fruitlessly expended. The rock is most refractory, and the veins very small and very poor. I imagine that it belongs to the same set of appearances, or traces, of which there



are so many in Scotland; and that it holds out, now at least, no temptation to a further expenditure.

*Isla.* If I am rightly informed, the lead, which here lies in primary limestone, did once produce some profit, while the excavations are not inconsiderable. I am disposed to doubt the fact of profit, where no statement was produced, because the proprietor, at the time of my visit, was equally enlightened, opulent, and anxious for every kind of improvement, while these mines had been offered to speculators in vain. The present proprietor can afford more correct information, should this statement be wrong. It is not, at least, a favourable a place for deep mining, as it would be expensive to drain.

*Alloa.* Whatever might be said of lead here, has already been noted under the head of Silver. I may say the same of the tract between

*Linlithgow* and *Bathgate*; and also of  
*Ecclesmachan*, and of the silver holes of the  
*Pentland Hills*.

*Traquair*, near Peebles. I could obtain no specific information respecting this place. Nor of

*Westwater* and *Broomholm*, near Langholm.

*Inverneil* in South Knapdale. The lead is said to have been once wrought here; but there was no one to inform me of the facts.

*Glen Shira.* A lead mine is here marked on the Map. I could find no printed information respecting it: my guides could not point out the spot, nor did any one seem to have heard of its history. At any rate, it is not wrought now.

*Glen Nevis.* No one in the neighbourhood now seemed to know of this place, which I imagine to have been noted by Mr. Williams. To be thus forgotten, seems a sufficient proof of insignificance.

*Inverscaddle*, near Fassafarn. This admits of the same remarks.

*Kembuch Point* in Fife. I have read of what I could not here find, and no one seemed to know.

*Cairndrocm*, near Killin. Lead is said to have been wrought here. What the trading mineralogist of Killin, a person of great acuteness and research, did not know, I could have no hopes of finding.

Near *Ardoch*, on the road between Fettercairn and *Loch Lee*. I was assured that lead mines had formerly been wrought here to a great extent, that the miners had secreted the ore and become very rich, with more which I need not record. I narrowly examined this place. There are remains of lead ore scattered about, but no marks of extensive workings, nor any trace of a vein to be seen at present, though such may exist, obscured by the soil and fragments. It is in Lord Panmure's power to re-examine this spot: but the reports bore strong marks of absurd exaggeration.



*Glenlyon.* I was informed by the late Duke of Atholl that this valley contains two lead mines, and that they were once wrought; while they ought to have been of some value, or promise at least, since, in selling the land, he had retained his right over the minerals. No papers in evidence were however found, nor could the exact spots be described to me. I could gain no information in the neighbourhood, and consequently sought for them in vain.

*Cumberhead hills, Lanark.* I merely read that lead had been found here.

*Lead-hills.* It would be superfluous to make any remarks on a mine so well known: while I can only conjecture that the lead said to be found at *Crawford John, Glendorch, and Gilkerscleugh*, belongs to veins of the same general description, though probably insignificant, as no one could point them out to me.

*Tyndrum.* The mine working: in an alternation of mica slate and quartz rock; I believe to little profit.

Near *Castle Wig, Galloway.* I was informed that lead ore existed here, offering some temptation: but not having heard of this till I had quitted the country, could not institute any examination.

**IRON.** To what I have already said on iron I can add nothing. I did not find the spot in Ayr which produces pisiform hematite, and as to the bog iron ore, it is as worthless as it is diffused, though rarely in large quantities in one spot.

**TITANIUM.** Rutile abounds in the hills north of Killin, being in quartz veins, of which the detached fragments strew the surface very widely.

It is however but a matter of mineralogical curiosity to point out this mineral; as, independently of the limited use to which titanium is applied, it is not here in such a state as to be extracted for use. It is even more a matter of such curiosity to name SPHENE as common in the granites of Scotland; being abundant in Glen Tilt, for example, and far more so in Criffel.

**ZINC.** I know not that this has been found any where but at Tyndrum. The ore, brown blende, is not very abundant, and is thrown away, as it deserves.

Lastly, BLACKLEAD has been found in Glen Elg, in Strathpeffer, at Stair in Ayrshire, and at New Cumnock, at which last place its remarkable mineralogical relations are well known. Here it has been wrought for pencils: I knew not that it has been applied to that purpose, from any of its other situations.

If I had thought that it was a needful or fitting portion of this Report to give a catalogue of the earthy minerals occurring in Scotland, I might easily have done so; while I can refer to one which I formerly published in one of the Scotch scientific journals, and which requires but little addition to be completed to the present state of our knowledge on this subject. But this neither belongs to economical utility nor to the other objects of



this Survey: it is a mere matter of curiosity, or of interest to the collectors of minerals.

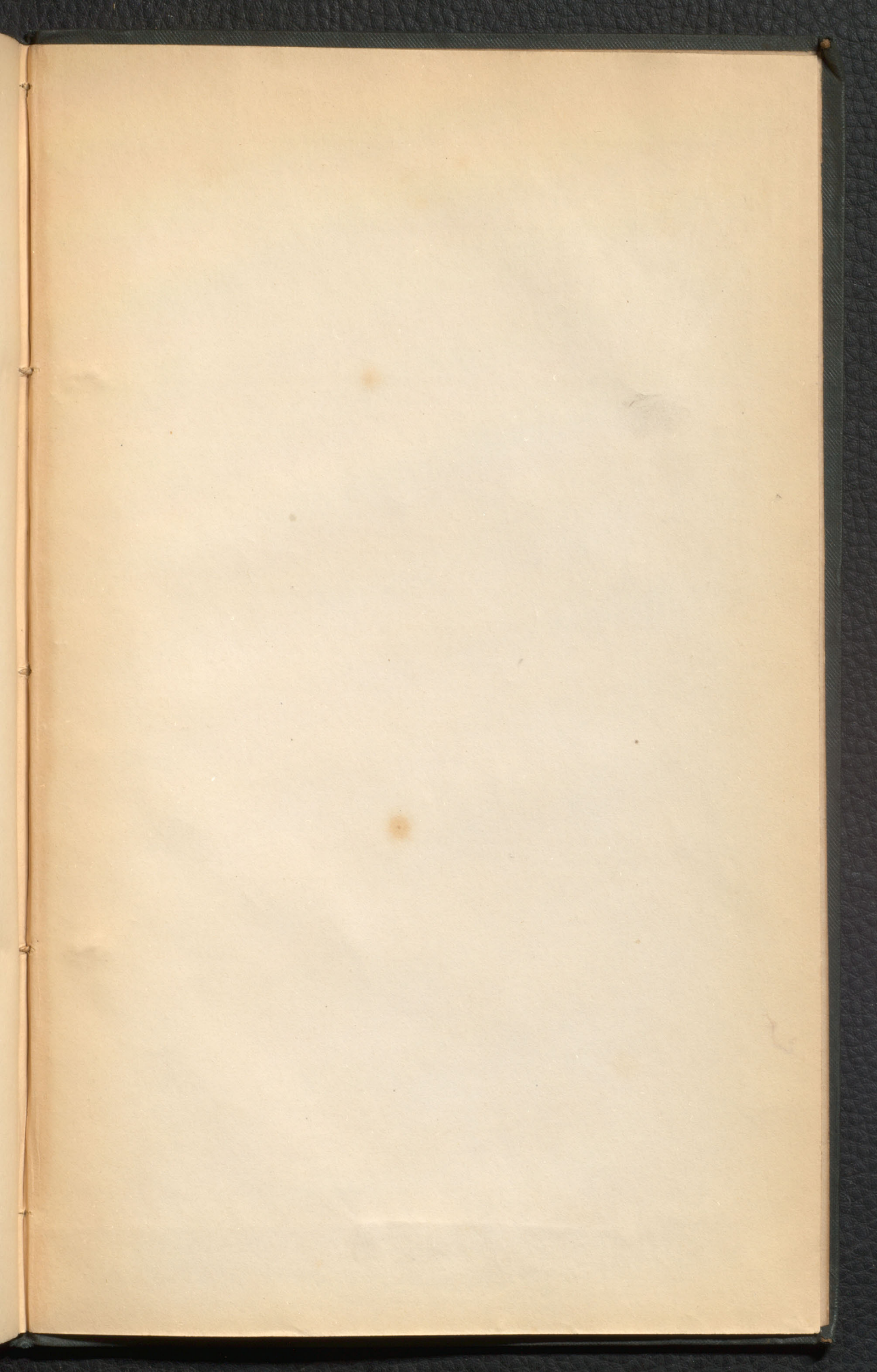
I must finally add, that I have made no attempt to represent the places of mines or metallic minerals on the Map, though referring to some which the geography has recorded. Those which are wrought are so well known that it would have been superfluous to mark their places by a hieroglyphic, few as they are: as indeed the names in the Map form a sufficient indication. There is not evidence enough as to some, to note them as facts: of others, as has been shown, the places could not be found; while, of the remainder, the minuteness and inaccuracy of the groundwork did not permit a true record; and while, moreover, although all this had been otherwise than it is, marks so necessarily minute as they must have been, could not have been found on such a Map, had there even been colours for them, remaining unoccupied. The Catalogue will suffice for all the required purposes; while the names thus given will be at least as good a guide as such an entry could have been, and with even less tendency to mislead an observer or inquirer.

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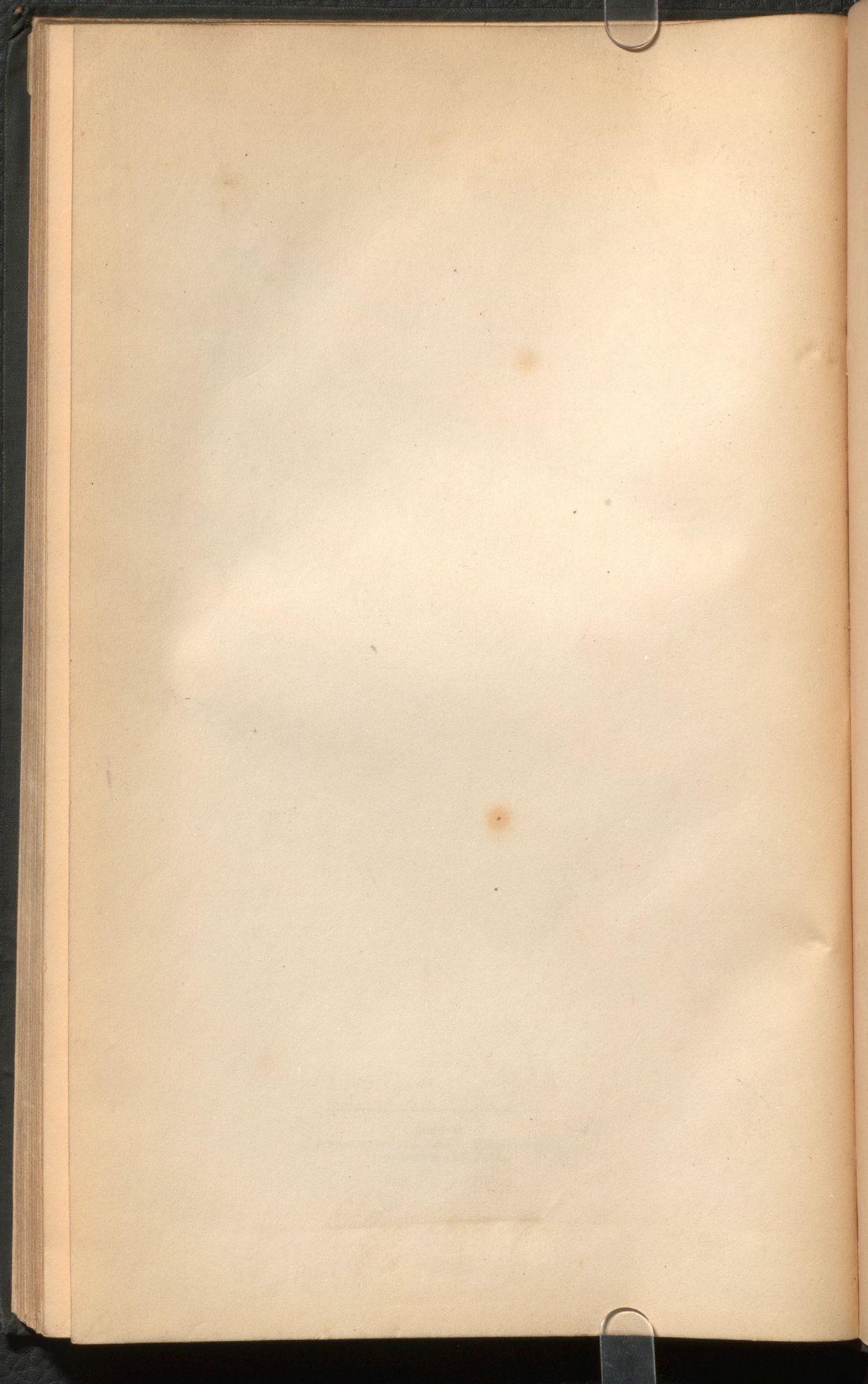


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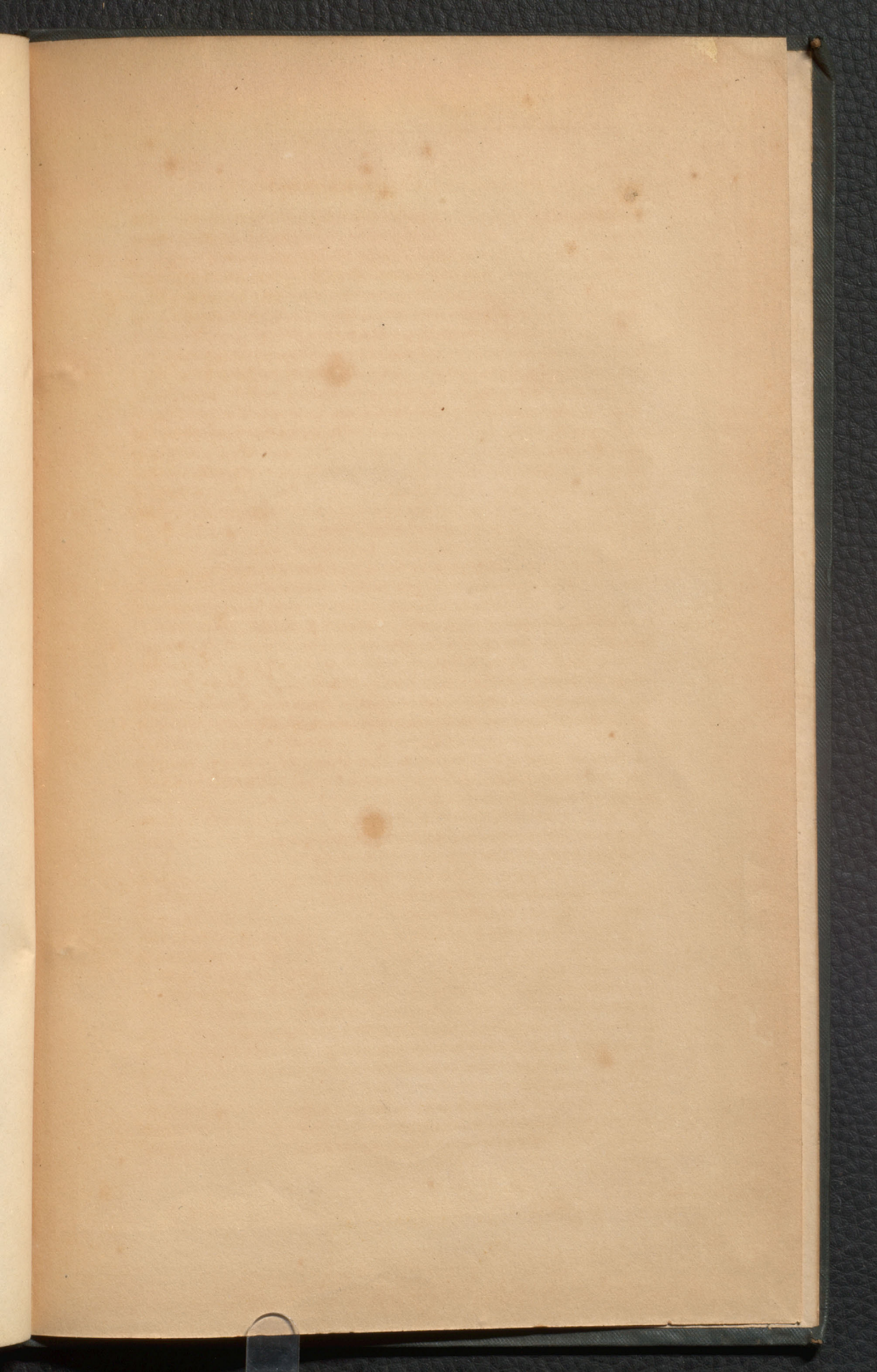




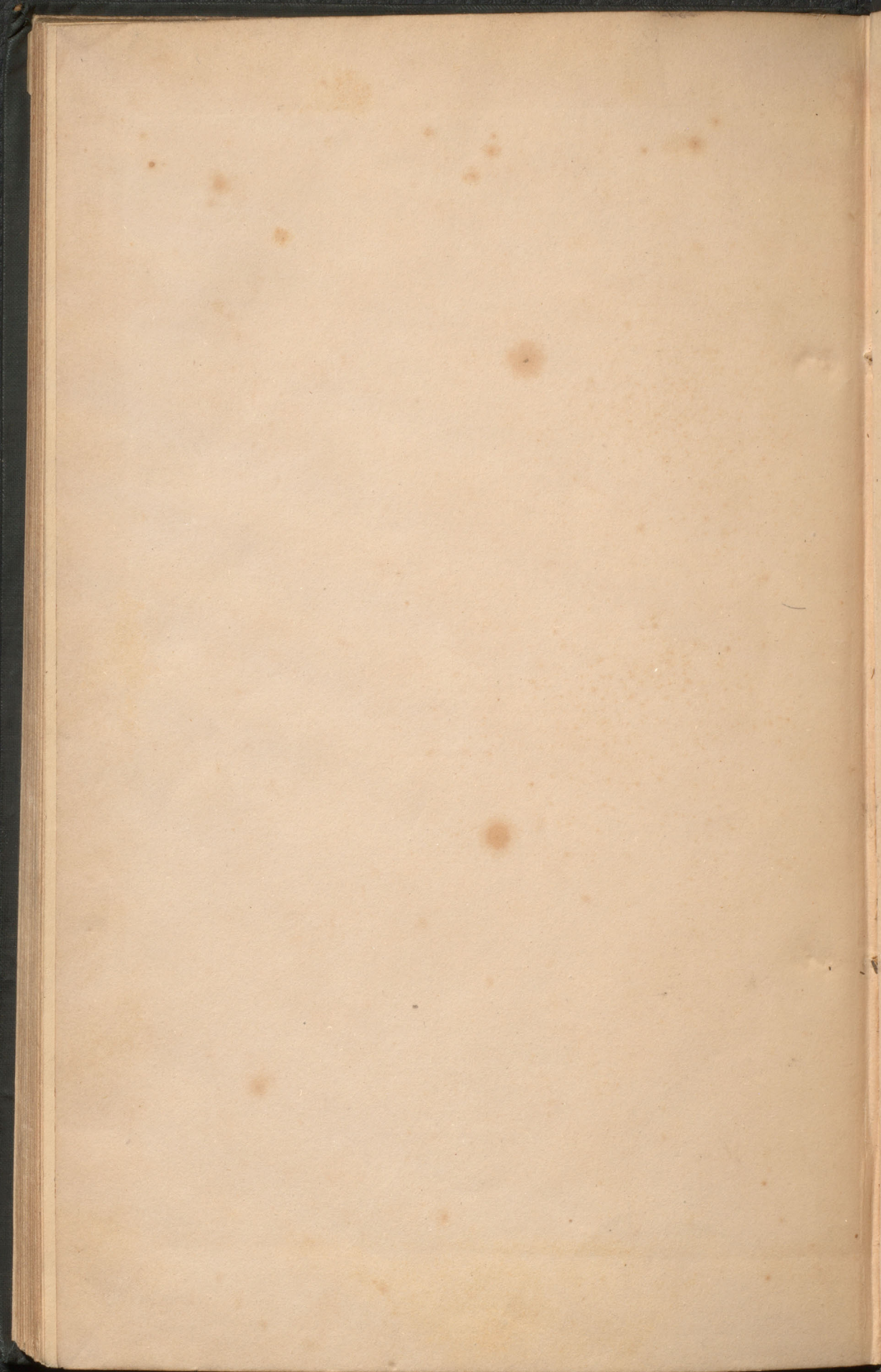














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