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ASIATIC SOCIETY.

Report of the Mineralogical Survey of the Himmalaya Mountains lying between the Rivers Sutlej and Kalee. Illustrated by a Geological Map, By Captain* J. D. HERBERT, *Superintendent.*

To some of our Indian, and to many of our European readers, it may be necessary to explain the circumstances which gave rise to the following report, and those under which it has so long remained unpublished.

Captain Herbert of the Bengal Infantry, Deputy Surveyor General of Bengal, and Superintendent of Kemaon Surveys, was appointed by the Government of India, then under the Marquis of Hastings, to undertake a Mineralogical Survey of that part of the Himalya Mountains, which form the British Frontier to the North-West; but it would appear that this was not fully executed, though much was done; and the elements of much more which might have been accomplished at a small expence were already collected.

Captain Herbert, after editing for three years the valuable Gleanings in Science, the parent of our Journal, was appointed Astronomer to the King of Oude, whither he proceeded, but enjoyed for a very short time his post, dying of an apoplectic attack in 1833.

When our present Curator of the Museum of Economic Geology, Mr. Piddington, assumed temporary charge of the Museum, he found 12 cases filled with what were well known by the Assistants to be "Captain Herbert's specimens," but beyond this fact, not a line of Catalogue, Journal, or Note relating to the specimens could be discovered; It became then an object of great importance to the Society, and to Science, to trace out, if possible, any records which could throw light upon this valuable collection, and after a persevering search of eighteen months by the Secretary and himself, their labour was rewarded, first by the discovery of five volumes of Captain Herbert's Notes, which had been carried into KEMAON! but fortunately left there in the care of a zealous friend to Science, and a valuable associate of the So-

* See Introductory Remarks.

Geological Map of the MOUNTAIN PROVINCES

BETWEEN THE RIVERS

SUTLUJ AND KALEE

By

CAPTAIN J. D. HERBERT.

Sup.t Min.l Survey Himalaya Mountains.

1826.

Published to accompany Captain Herbert's Report

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A Granite
B Gneiss
C Micaceous Schist
D Chloritic Schist
E Argillaceous Schist
F Limestone
G Hornblende Schist.
H Newer Red Sandstone.
I Diluvial Beds

REMARKS.

The Straight lines indicate the direction of the Strata. The Arrowheads the quarter of the Dip. The figures annexed the inclination.

Scale 16 Miles to One Inch

Copied in the Surveyor Gen.l Office February 1827.

Printed by P.S. D'Rozario & Co.

ciety, Mr. J. H. Batten of the Civil Service; next, by that of the report now published (to which Captain Herbert's paper on the Mineral Resources of the Himalaya in the Physical Transactions, Vol. XVIII. is a sequel,) and through the report, by the knowledge that his geological map, and plans of the river basins of that part of the Himalaya, exist in the records of the India House. It is needless to add, that no time has been lost in requesting copies of these valuable documents from home.

It remains but to add a word on the lacunæ which it will be perceived occur so frequently in the first pages of the MSS. These are owing to some corrosive liquid having so far destroyed the manuscript that it has been sometimes necessary to fill it up altogether conjecturally, but at other places there are enough of words or letters left to assure us, that we were not far from the very words used by Captain Herbert. It will be noted, that all our emendations are distinguished both by italics and by brackets.

INTRODUCTION.

1. It has been my intention to give, in the accompanying paper, such a general sketch of the geological features of the mountain tract between the Kalee and the Sutlej Rivers, as the series of partial and scattered observations which I have yet been able to make will allow. In the absence of every thing like information, such a sketch, though necessarily imperfect, and even premature, will not be perhaps without interest. It will at least serve to exhibit to the Government, who have so favorably distinguished me, the nature and extent of my labours since entering on this duty, and also to mark out the train of investigation which they have suggested to me.

As such I offer it, but with diffidence. Geology, as a science, has not yet attracted in India that attention which its importance merits, and it would be futile in me to deny that, till selected for this duty, I had but a slender acquaintance with the subject. While exploring the local phenomena of this tract I have been in reality studying the principles of the science; an advantage in so far as I may hope to have escaped the trammels of system. But on this account I have also laboured under some disadvantages, inasmuch as a premature account like the present, of an unfinished survey, may be expected to lie under some imperfections, which a little more technical knowledge on my part might perhaps have removed. "But a survey that shall accomplish every thing, must be a work of time, nor will any thing be contributed towards it by

him, who fearful of being wrong where as yet it is impossible to be always right, and unsatisfied with the best he is able to attain, delays the record of his observations to the period of perfection." Should it be considered as redeeming in any degree the pledge of industry and zeal, which my acceptance of such an appointment must have held out, I shall consider its chief end answered.

3. Hereafter, when a more enlarged field of observation shall be attained, I trust I shall be able to make it more worthy the attention of the scientific geologist. Having once put on record what has been done, and digested it into something like a regular form, it will be easy to add to it as my researches extend and become more particular. One part will throw light on another. A particular fact carefully observed, may sometimes lead to a happy generalisation, and in this way many deficiencies will I hope be supplied which must necessarily attend so early an effort. In the meantime, imperfect as it is, this paper will have its uses. By exhibiting what has been done, it will shew what remains to do, and it will serve as a guide to direct any future labours, by pointing out in what quarter interesting facts may, or may not be expected to occur.

4. Considered as a geological description of these mountains, many blanks will be observed. For besides that, it was impossible in so short a time to go over every part of them, there is a difficulty peculiar to this quarter which very much interferes with geological investigation. This is the total absence of every kind of excavation calculated to afford information, whether mines, roads, or quarries. The former, few as they are, are inaccessible to any but those accustomed to them from their infancy. The total length of roads as yet laid open, does not much exceed 150 miles, and such is the light thrown on the subject along the different lines as to render it still more a matter of regret that we have not greater access in this way to the actual rocks, the nature of which is often only to be guessed at. Of quarries there are absolutely none, for the province, though possessing excellent limestone, slate, and other productions, capable of being turned to account, had been, up to the period of our conquest, so wretchedly misgoverned, as to have occasioned resources of this kind to lie utterly neglected. From the consequent difficulty of determining in many cases the nature or relations of the rocks, some particulars have necessarily been taken

for granted without actual examination, which in this case would have been impossible.

5. In the Geological Map I have laid down much that has not been actually examined, as might be concluded from what I have stated in my letter to Government, paragraph 7. To refuse to employ those generalisations which the experience of all geologists has shewn to be well-founded, is to forfeit the advantages derivable from the labours of our predecessors, and to impose on ourselves the task of reconstructing the whole science from our own materials. When the same rock has been found on the line of direction in every point in which it has been examined I have deemed myself justified in laying down that rock as continuous through those points. Even at the termination of the survey, many conclusions of this nature must be taken for granted; for it has been well observed, that "no human patience would suffice for the examination of every piece of rock that projects through the surface." And, even were that effected, still much must be taken for granted, especially in these mountains, the rocks being concealed, as they so often are, by deep collections of debris, and covered by luxuriant coats of vegetation. I was, however, in a very early stage of the survey, taught to except from this conclusion granite, as being a rock the occurrence or non-occurrence of which in any particular spot I found I could never predict with any certainty. Limestone also I found seldom could be depended on for any distance, forming always beds in other rocks, and never appearing under those relations which I conceive necessary to constitute a principal [*formation.*]

6. The elevations expressed in the sections,* have been determined by barometrical measurement, a method which unless under favorable circumstances, and with great facilities [*is liable to error, but*] the degree of accuracy attained is sufficient for the purpose, as it is a matter of no importance whatever whether the place of a rock be assigned fifty feet below, or above, its real level. They are as correct I believe as geological sections ever are, and certainly sufficiently correct to answer all the purposes for which they are required. The fixed points determined by the Trigonometrical Survey have been always

* I regret that the circumstances under which this report has been prepared, have prevented the preparation of these. They are, however, more than half finished, and shall be forwarded with as little delay as possible.

used when they fell in the line, and they have not unfrequently been found of value as terms of comparison by which to judge of the accuracy of the barometrical results.

[*The nomenclature adopted, is that of MacCulloch's*] Hebrides. It were no doubt very much to be desired, that a system of nomenclature founded altogether on mineralogical distinctions, (like Brogniart's for instance,) should be generally received by geologists. It would save much useless and cumbrous description. Till such a reform, however, be introduced, the safest plan is to follow the example given in the above work, of noticing and describing correctly every compound included under any general head or term, as constituting a distinct geological formation. By this means the danger of confusion is entirely obviated.

Silt, sand, gravel, or boulder stones which are evidently derived from the breaking up of pre-existing rocks, and are of the latest formation, are all comprehended by Dr. MacCulloch, under the term "alluvium of transport." Professor Buckland was, I believe, the first to establish in a satisfactory manner, that there are deposits which may be discriminated as originating in two distinct causes, either in the action of the present rivers of the globe, or of a mighty rush of waters or deluge, far surpassing the greatest effect of rivers as they exist at present even in their highest floods. To the former, the term alluvium is restricted. The [*latter he distinguishes by the term* diluvium, *and though this cause may not have operated on every occasion, yet it is always useful to*] bear it in mind. Its reality in some particular cases is too obvious, at least in this quarter, to escape the notice of the most indifferent, or even prejudiced observer. I have therefore adopted these terms, considering them conducive to precision, and as having the sanction of such high authority. The angular fragments and rubbish, which are generally found either in their original position or only so far removed as may be traced to the action of gravity, are termed by Dr. MacCulloch, "alluvium in situ," and "alluvium of descent." I have ventured to use the term debris.

9. In the mineralogical details, I have adopted the nomenclature lately proposed in the system of Professor Mohs of Freyberg. The synonyms in this science have, it must be confessed, become too numerous, and the knowledge of them forms a very considerable part of the little that is to be learned from what are called systems of Mineralogy. To

adopt, then, a new set of terms may seem like increasing the difficulty of making ourselves intelligible, and wilfully adding to the confusion. But amongst the old names, there are none generally received, all being originally imposed in an arbitrary [*manner.*] But in the new terminology there are legitimate grounds for selection, the names being connected with a system of arrangement, which, if it be not all that could be wished, is yet extremely convenient. They express in a greater or less degree, the relations which these minerals have to each other; in other words, their places in the system.

There appears also little doubt but that, eventually, this system will be universally adopted, and those names supersede the present barbarous collection, not more puzzling by their numbers, than objectionable for the total want of euphony, and [*I have*] given some account of the mineral productions considered in an economical point of view, and with reference to the question of the due development of the resources of these provinces. Their value is not to be correctly estimated in the present condition of the country. When an improved system of government shall have had time to produce its full fruits in the increase of the population, and the improvement of its habits, in exciting a taste for the arts and conveniences of civilized life, and in effecting ready modes of communication, and effectual means of transport, it will be seen how many and [*how vast are the resources which here present*] themselves, which [*under good*] management, might be made sufficiently productive to become worthy of attention to a Government disposed to improve its resources and to leave no source of revenue neglected.

11. Gold and silver have in every age been sought after with avidity as the most prolific sources of national wealth. Nothing, however, can be more certain, than that, in reality, they are the least productive of all the several different mineral resources. The comparatively small quantity in which these metals are found, and the greater expence in raising them, satisfactorily account for this apparent paradox. In South [*America this is well known to the*] speculators in mines. It is there a common saying, that a copper mine is a fortune, a silver one scarcely pays itself, but a gold mine is ruin."

12. It is not then as considering the existence of the precious metals as the most promising, or the most productive, that I would lay stress on the great probability which there is of the discovery of a mine of gold

within these provinces. The reasons on which this probability rests, will be found in the Supplementary Paper.* Whether the discovery may in any reasonable period reward the zeal of an enquirer, or may wait finally that advanced stage of improvement in [*which all the resources of a country are carefully and accurately explored is a problem, the*] solution of which it were vain to seek. But of the actual existence of the metal within these mountains, no one can doubt who will read the few details I have given.

13. In the copper, lead, and iron, however, in which the province abounds, may be found a more tangible, as well as more productive source of wealth. It is certain that the former metal exists in very considerable quantity, and for the iron, nothing is wanting but a proper system of management to render it superior to that of England. To her repositories of these metals, of tin, and of the mineral coal, is England mainly indebted, [*for her vast wealth and power; and it is strange that they should be neglected in India, as if*] the truly valuable minerals were the gold of Potosi, or the diamonds of Brazil and Golconda. Why they should not here equally prove mines of wealth, if properly managed, appears difficult to understand. With the ore in abundance, fuel, and other means of reduction at hand, labour cheap, a very short line of mountain carriage, and half of that a line of made road, what is there, but capital and skill required to produce any quantity of the metal, and considerably under the present market price?

14. But these though probably the most productive, are not the only mineral sources of wealth * * * * nearly its weight of silver, as even though it should not all prove to be of such first rate quality, yet the inferior kinds are also of such extensive use and application, as to render it a truly valuable deposit. Quarries also of marble, of slate, of potstone, of gypsum, supplies of sulphur, of sulphate of iron, and of alum are found. The trade in borax is well worthy of attention, and no doubt the whole supply of Europe might be drawn through these mountains. If to these be added other articles of trade and consumption, such as timber, hemp, bees' wax, wool, and live stock, as sheep, &c. it will readily be acknowledged in

* Captain Herbert alludes here to his paper on "the Mineral Productions of the Himmalaya Mountains," p. 236 Part I. Vol. XVIII. *Trans. As. Socy.*—Ed.

contemplating these [*provinces, that they are by no means so barren or so worthless as may at first sight appear.*] The indigenous population is not likely speedily to improve, or to enter into *these* views, at least without the support of European capital and the example of European enterprise. And certainly, if the experiment of European colonization is ever to be tried in India, we cannot select a better spot than these mountains, whether we consider the favorable nature of the climate, the great room for European improvements, the quantity of available land, or lastly, the nursery which such a colony might form of a hardy and warlike race to which we might in the hour of need owe the safety of the empire. [*But these views may be by many thought*] visionary, and [*I now*] turn to notice, before concluding these preliminary remarks, one other probable source of wealth, which though not, strictly speaking, belonging to these districts, is yet at no great distance from them; and to the discovery of which, should it be discovered, the geological investigations now going on must furnish the key. I allude to the strong reasons I have brought forward for believing in the existence of coal in some part of the Dooab; such a discovery would indeed be more valuable than that of a mine of the precious metals. In the great scarcity of fire wood, [*this mineral*] would be invaluable. When we consider too how completely the Dooab is adapted by nature to the ready formation of a complete system of internal communication, we shall be convinced that it would be sufficient to give an astonishing impetus to the march of improvement, and effect probably in a few years such a change as is difficult to form even an idea of at the present moment.

The following paper may be conveniently divided into five sections, the subject of each being as follows:—

1. Physical aspect and arrangement of the surface.
2. Geological details.
3. Recapitulation of the preceding, or general view of the geological structure.
4. Conclusion; with notices of the most remarkable features of the preceding general view as compared with systems, and with observation in other countries.
5. Mineral productions, comprising an account of the mines, method of working, and suggestions for their improvement.*

* See Note at p. vi.

Of these the second being the most voluminous, and consisting entirely of practical details, can only be interesting to a professed geologist. [*It is my intention hereafter to label and refer each rock specimen of the large collection*] I have made to the account of its occurrence as here given, by number, so that, when the paper is studied with the cabinet to refer to, I consider that it will give as correct an idea of the geology of the province as could be had by actually travelling over it. And there will be the further benefit that the experienced geologist will be able to correct any mistakes into which I may have fallen, either through inadvertence or want of knowledge.

The first section constitutes a detailed and systematic account of the Physical Geography of this district, being the first ever given. Such a view independent of [*its connection with the geological details, to the full comprehension of which it is absolutely necessary, is also much*] called for as a contribution to general Geography, the latest works published being singularly deficient in details on this subject, as well as erroneous in the few that are given. As an example, I would refer to Mr. Meyer's Geography, a very costly and bulky work, lately published, and to Brewster's and Rees' Cyclopœdias, (Art. Himalaya and Physical Geography.) In none of these works is a clear idea obtainable of the physical features of this interesting quarter of the globe. I could have wished to have had a little more [*time for the systematic arrangement of the facts and opinions in this*] division, and I intend to improve and extend it considerably hereafter.

The geological reflections with which the paper concludes are, I am sensible, those in which I stand most in need of candid criticism. The early period at which I have been obliged to draw them up, the want of books of reference, till within the last two months that I have been in Calcutta, and the necessity of attending to the arrangement, digestion, and revision of the other parts of the report during this time, thus distracting my attention; added to the anxiety I have felt to [*do justice to*] the subject will, I trust, plead some excuse for the deficiencies observable in it. Altogether, indeed, I would state as a sufficient apology for the errors which may be found doubtless in every part of the paper, the great hurry entailed upon me in the preparation of the fair copy owing to the difficulties and perplexities originating in circumstances which I have explained in my letter accompanying.

But these hindrances are now I trust at an end, and with the assistance so liberally granted me, I am not without hopes of improving and adding to this paper so [*as to render it not altogether discreditable to myself, and I trust such as may*] embolden me to look forward to the patronage of Government in the eventually contemplated act of publication.

SKETCH OF THE GEOLOGY OF THE HIMMALAYAS.

Section I.

1. Previously to entering on the detailed description which is to be the subject of this paper, it will be necessary to take a general but cursory view of the Geography of Central Asia. This great country, so interesting in every point of view, constitutes it is probable, whether we consider its physical aspect, or its geological structure, a system, or whole, without [*some general view of which to assist us, none of its*] parts can be fully [*comprehended.*] It is in their connection with this singular country that we shall see some of the most interesting relations of the tract in question. Nor does it appear possible to obtain a clear and connected idea of those relations, without extending our view to the great whole, of which our mountain provinces form but a part.

2. Unfortunately, however, so deep is the obscurity which covers the Physical Geography of Central Asia, that little is to be done beyond offering probable guesses on many of the most important points. The [*accounts of geographers and travellers, even those lately given to the*] public, are so meagre as to leave us little to glean. And even in that little they are frequently so contradictory, that it is not easy to obtain any thing like certainty, except as to a few leading features.[1] Even

1. It is quite astonishing how little we know even of countries comparatively easy of access, and often visited, I mean of their physical features. Of Persia we do not to this day know the elevations of its great plains and mountain ranges. Of Cabul we are equally ignorant. It would appear as if observations, amongst the easiest to be made, and requiring little skill or ability, have yet a mysterious terror for the otherwise most intelligent and able travellers. Our ignorance is the more provoking, as very near approximations to truth may be made in all the several results required by Physical Geography, with very slender means, and scarcely any science: how much may be done by a traveller possessed of only a pocket sextant, a good watch, a thermometer, and a pocket compass.

these will throw perhaps some light on the subject, and will at all events enable us to take a view of this tract, altogether different from what has hitherto been adopted.

3. If we [*consider the map of Asia, we shall be struck with the appearance of a*] large central space, which is strongly marked by the circumstance of being but little intersected by rivers, while yet on every side innumerable streams flow from it, and unite to form some of the largest rivers of the Old World. The Amur, the Hoangho, the Yangtse-Kiang, the Maykaung, the Maygive, the Irrawaddy, the Kiendun, the Burampooter, the Ganges, the Indus, the Oxus, the Jaxartes, the Obi, the Jenisei, and the Lena surround with their sources this tract, and with courses varying from 1,200 to 3,000 miles in length, radiate from it to the surrounding seas in every direction.

4. Inasmuch as the source of every river must be higher than any other part of its course, it is just to infer, that the zone in which these rivers originate is higher than the plains through which [*they flow*] to seek the Ocean. [*Their*] lengths of course may be considered to be, within certain limits, proportional to the elevation of the source; we may further infer, that the line which connects the water-heads of these great rivers, must be of very considerable elevation, compared with other parts of Asia external to that line.

5. We know from observation, that the tract in which are found the sources of the Ganges, the Indus, the Oxus, the Obi, the Jenisei, and the Lena, is diversified by lofty mountains, some of them the highest on the globe. The Himalaya, the Karakoorum, the Hindoo Koh, the Beloor Tag, the Bogdo, the Alak, and the Altai mountains are all found along this line. We are then entitled to infer, that this mountain zone is in like manner continued to the S. E. and to the E., consequently that it completely surrounds the central tract.

6. Of the particular features of the interior, little is known. It has been usual to call it a plateau, and to suppose it of very great elevation. The great sandy desert of Cobi, which is known to occupy part of it, affords some grounds for this appellation; but with regard to the conviction of its great elevation, this seems to have originated in incorrect ideas of natural boundaries, and a consequent misapprehension of what is, or is not the central plateau. [*It has been*] presumed that the [*whole line of*] elevation along the mountain barrier above indicated should be

considered as the bounding limit, and that every point within this line was entitled to the above appellation.

7. Captain Webb, amongst others, appears to have fallen into this mistake in assigning the bed of the Sutlej (14,000 feet) as the lowest level of the plateau,[2] whereas the bed of the Sutlej belongs to the Sinditic Basin, (so in MSS. qu: *Ind*itic?) and is consequently part of the barrier zone which surrounds the central tract. In like manner, the country visited by Captain Turner, and commonly known as Thibet, the description of which is generally adopted as that applicable to the interior, must be considered also as part of the mountain barrier, since it is watered by the streams or feeders of the Sanpo; which if it be not the Burampooter, must be either the Kiendun, or the Irrawaddy.

8. Considered [*as a question*] of Physical Geography, [*the true*] line of boundary is undoubtedly the chain of water-heads, and this is by no means synonimous with the line of greatest elevation.[4] It may be that the central tract is not of such great elevation as has too hastily been presumed. It may be that this presumption is correct; the mountain barrier which surrounds it serving, as in the [*case*] of the Ghats of Malwa,[5] to [*support*] a high table land of tolerably even surface. But however this be, it is not the less necessary to avoid confounding the boundary tract of mountain land with the central included area.

9. Of other particulars we are equally ignorant; what its rivers are, if any; and whither they flow; some we do know [*contribute to*] certain

2 The *Quarterly Review* in reporting this fact, has not noticed the error. But this work has never been celebrated for its disquisitions on physical or mathematical subjects. In this particular article, and the abusive one on the same subject which called for it, they are particularly open to censure. The two productions form an amusing contrast.

3 The latter is D'Anville's opinion, the former Rennel's. The great mistake into which this acute geographer fell regarding the course of the Sutlej and Ganges, naturally makes one distrustful of his authority on this point. The little light which the employment of our troops to the Eastward has thrown on the subject, tends to add strength to these doubts.

4 This remark is not unnecessary, for it is a mistake made by many, who conceive that because the source of a river must of necessity be higher than any part of its bed, *therefore* all the elevations in its immediate neighbourhood must be higher than those situated near a more advanced part of its course.

5. There is not however the analogy of geological structure to make this conclusion probable. Malwa is of the trap or overlying formation one which has derived its name from this peculiarity of structure, whereas all the evidence we have on the subject tends to support the opinion of this great circular barrier being composed by primary rocks.

lakes; and some [*we presume*] are lost in the sands of the Great Desert. But to obtain any thing like detail, on these and many other points, is in the present obscurity of the subject impossible. Of its geological structure, we have not an idea that is not purely hypothetical.[6] And yet, it may be averred, that the geology of Asia can never be rendered fully intelligible, or even the science itself be placed on a firm basis, till the whole of this tract be fully explored, and the rich mine of illustrations, which it doubtless contains, be fully laid open.

10. Considered in its various relations to Asia, I might even say to the Old World, it is undoubtedly the most interesting spot on the surface of the globe, and it is certain that the traveller who shall first succeed in developing these relations in all their bearings, will establish for himself no inconsiderable name. Unfortunately for science, this task is not likely to be soon effected. The jealousy of the Chinese government, to which the greater part of it belongs, opposing insurmountable obstacles to the progress of investigation and discovery.[7]

Section II.

11. It appears [*certain that*] this central area—whether we call it a plateau, a basin, or series of basins—is surrounded on all sides by a broad zone of mountain land in which originate the great rivers of Asia. The [*tract*] of which I am now to give a description, and which comprises all the British possessions within the mountains, forms but an inconsiderable portion either in length or breadth of this great Alpine belt. In interest of description, however, it does not yield to any part of it. For within its boundaries rise some of the most remarkable peaks of the Himmalaya summits, not more celebrated in the annals of superstition than in those of science, and from its area spring the sources which unite to form the Ganges. The sacred River! the fertiliser of pro-

6 That is of the interior.

7 The extraordinary perseverance and intrepidity which distinguished the late Mr. Moorcroft, bade fair to give us some knowledge of part of this country, certainly of a great portion of the surrounding mountain tract, had his life been spared. Few men have possessed in an equal degree the qualifications necessary to ensure a traveller's progress through those countries, and it is not likely that an enquiring spirit like his would have rested while any thing remained to be learned, or any quarter open to research presented itself. His premature death, while on the point of returning to his countrymen, is much to be deplored. It is hoped that the materials collected may yet be made available to the increase of our knowledge of those countries.

vinces! the waters of which bear health and plenty through a course of 1,200 miles!

12. The boundaries of this tract are to the S. E. and N. W.; the rivers Kalee and Sutlej; to the N. E. a line drawn from the Kalapanee fountain, (one of the sources of the Kalee,) to the confluence of the Tedong river with the Sutlej; and on the S. W. by a line drawn from the Kalee, in latitude 29°, longitude 80° 8′, to Ropur, on the Sutlej. These boundaries form a right-angled trapezium, the two parallel and longest sides being directed about N. 60 W., the rectangular side being to the Eastward, and the oblique side to the N. W., forming angles of 50° and 130° with the parallels. The only exceptions to the regularity of these boundaries are: 1. A narrow strip comprehending part of the vallies of the Sutlej and Speetee rivers, which runs up as high as latitude 32°, and which is within the British limits. 2. The valley of the Jahnuvi river, or right bank of the Bhageerettee, which though included by the above boundary, is considered to be part of Thibet.[8]

13. The length of the several bounding lines are as follows:—

1. That facing the S. W. ..... 272 miles.
2. ..... N. E. ..... 192 ditto.
3. ..... S. E. ..... 96 ditto.
4. ..... N. W. ..... 120 ditto.

and the superficial extent in round numbers may be taken at 23,000 square miles. If we include the slip of plain country along the S. W. boundary, and which is geologically connected with it, the extent will be about equal to that of England Proper.

14. The tract limited by the boundaries just particularised, may be described as altogether mountainous. A few inconsiderable and level spots, hardly to be called vallies, are found, but neither is their number or extent such as to render any qualification of this description necessary.

8 The only village, called Choongsa or Neelung, owes also a nominal subjection to the Rajahs of Gurhwal and Bissahir, whose countries are conterminous with this district. The villagers are of the Thibetan race. Their village consists of about sixty houses, which are but little raised above the ground and flat roofed, on account of the extreme violence of the winds which prevail in that quarter. It is situated on the right bank of the Jahnuvi, in latitude 31° 8′, longitude 79° 5′, and has an elevation of about 10,000 feet. The river is about 100 feet broad, and from four to six feet deep.

In ruggedness of feature, it does not yield probably to any country in the world, and such is the irregular and confused appearance, which the endless ramification of its mountain ranges presents, that it is with difficulty the unpractised observer can persuade himself that any thing like order or regularity can be deduced out of such a seeming chaos.[9]

15. No continuous chain of elevations can be distinguished on a first and cursory view; no great vallies, no table lands, nothing in fact to lend a clue to the development of the mountain masses. The aspect, from whatever height the country be viewed, is that of an assemblage of elevated peaks, irregularly and confusedly heaped together. Even the snowy chain, though defined to a certain degree by a phenomenon so singular on a first view to the inhabitant of the plain country, loses on a nearer approach all character of continuity and regularity, and appears under the same confused and irregular aspect which the lower elevations are observed to bear.

16. It is only by tracing the courses of the rivers and their tributary streams, that a clue can be found to lead the observer out of this labyrinth. By connecting their sources, and by following out the devious windings of the several feeders, an idea is obtained of the extent, the direction, and the connection of the several ranges. Such an analysis, (vide sketch of the great river basins,) will be found to modify considerably the notions which the first view of this mountain tract from the plains is calculated to give.

17. Instead of a succession of parallel and continuous ranges running S. E. to N. W., and rising one behind another in regular array and increasing elevation, till the series is closed in the farthest distance by the line of snow-clad peaks,[10] we see only one continuous range of any extent forming an irregularly curved line, which bends round the tract commencing on the N. E. angle, with a North-westerly direction,

9 This is also the arrangement, or rather apparent want of arrangement observed by Saussure in the Alps, who says, "When we contemplate the range of which Mount Blanc forms a part, from less considerable elevations, it appears as if these colossal mountains were situated in a line, and formed a chain, but this appearance vanishes entirely from the bird's-eye view here presented. They are distributed in great masses or groups of various strange forms," &c. &c.

10 The deception is so strong in viewing these mountains from the plains, that most people continue, even after having visited the interior, to speak of the 1st, 2d, 3d, and snowy ranges.

which it gradually alters to a South-easterly one on the S. W. angle, and latterly due South, just before it is lost in the plain country.

18. This range forms one of the boundaries of the basin of the Sutlej which bends round the convex side, while within its concavity, are contained the numerous sources of the Ganges, the several feeders of which are separated by a most intricate ramification. On this account, (as it will be necessary often to refer to it,) and as there is no native name for it, it may be termed the Indo-Gangetic chain.

19. We see then, that with the exception of a narrow strip belonging to the Sutlej, all this tract is occupied by the sources of the three principal branches of the Ganges; viz. the Jumna, the Ganges Proper, and the Kalee.[11] A line drawn through the points where they severally enter the plains, represents pretty exactly the common boundary of plain and mountain land. It is the S. W. boundary mentioned in Art. 12, and its length from Ropur, the *debouché* of the Sutlej, to Brihon Deo, that of the Kalee is 272 miles.

20. The great disproportion of drainage effected by the Sutlej, which is one of the boundaries, and by the other or Gangetic system, is very striking. Not less so is the difference of their courses as to direction, the one running nearly due West, the other South; and as to length, the former having a course from its origin in Lake Monsuror to its *debouché* at Ropur of 550 miles, whereas the longest branch of the latter has only a course of 292 miles. It is this want of analogy in the character of these two great river systems that forbid our speculating on the arrangement of surface which may obtain beyond them.

21. In the case of two rivers of such magnitude as the Indus and Ganges, which direct their waters to the opposite seas of India, we naturally expect to trace some indications, however obscure, of a separating elevated tract, something farther than the point where the Indo-Gangetic chain ceases. No such indications are however found, for the intermidiate tract is much at the same level as the interior of the river districts which it separates.[12] Physical Geography is full of these disappointments,

11 In terming the Kalee one of the sources of the Ganges, I mean of course the Ganges of Bengal; the Kalee is the principal branch of the Dewah or Gogra river, which falls into the former near Chuprah

12 This fact is very important, and points out the facility of establishing a system of irrigation all over the Dooab and Rohilkund. I ascertained that the bed of the Jumna at Raj Ghat, on the road between Chilkana and Boorea, is but five feet

a proof, if it were wanting, that we are still but imperfectly acquainted with the structure of the globe.

22. The length of the Indo-Gangetic chain is about 340 miles, as defined on one side by the Kalapanee fountain, one of the sources of the Kalee, where our first precise knowledge of it commences, and on the other by its termination in the plain country, which is sufficiently sudden to be definite. From its gradually decreasing elevation along this line, it is natural to infer, that it is but a ramification of that more extensive line of water-heads, (Art. 5,) which would exclude from the central plateau all the mountain tract watered by the Sanpo and the Indus, as well as by the Ganges. We are not then to suppose that in crossing the Indo-Gangetic chain, we have made a near, or even the nearest appulse to the great table land of Tartary;[13] we are equally near it in the basin of the Ganges. But if this central plateau really means any thing, it must be something distinct from its surrounding barrier of mountain land, or if not, all the river basins are equally entitled to the appellation.

23. Next in extent to the Indo-Gangetic chain are the two principal ramifications; viz. that which separates the subordinate basin of the Jumna from that of the Ganges Proper, and that of the latter river from that of the Kalee. From their origin in the parent ridge to where they are lost in the plain country, their length is about 160 miles. Like the principal chain, they cease suddenly, nor is there any trace either in the Dooab or in Rohilkund of a continuation of them, however obscure.[14]

below the level of the Saharunpore cantonment, (month of March.) At Badshahee Mahul, it is 200 feet. Here then is a water-head capable of supplying any number of canals, and for a continuance the Ganges offers similar facilities for Rohilkund. The elevation of its bed at Hurdwar is 1,000 feet above the sea, while that of Mooradabad is only 609 feet.

13 The bed of the Sutlej can by no figure be termed a table land, for it is a deep valley shut in by lofty mountains. But even if it were, it is not the table land of Tartary, which is the country watered by the Oxus and Jaxartes. It is a strange mistake which is made, and by many who have the reputation of being well informed, that of confounding the Calmuck or Mongolian race with the Tartars, and their country with Tartary, whereas no two races can be more distinctly marked than these are. It was the country of Thibet, and not Tartary, which Captain Webb saw, and which is inhabited by a tribe of Calmucks or Eleuths.

14 A levelling operation which I executed some years ago, connecting Seharunpore with the Jumna, and which furnished the result mentioned in the note, page xvii. established also a more unexpected conclusion; viz. that the ground in the immediate vicinity of the river for a short distance rises to the height of forty-five feet above its level in the cold season.

The great disproportion in the length of these branches compared with those thrown off to the Sutlej, is very striking, (Art. 20.)

24. From these, as well as from the main chain, proceed a multitude of other ridges, and from these again a third set, and so on till the area becomes covered with this intricate ramification, which but for the assistance derived from observing the courses of the rivers, would almost bid defiance to any analysis. The longest of these, is that which separates the principal branches of the Ganges Proper; the Bhageerettee and the Alecknunda, of the Jumna; the Jumna Proper, and Fouse, and of the Kalee; the Gunjeea, and the Ramgunga. These vary from fifty to 100 miles in length. It would be useless to enumerate the others, especially as they have no distinctive appellations. Nor would the enumeration add any clearness to our idea of the aspect of the country. Suffice it to say, that as they descend in the scale of subordination, they become shorter, and diminish in elevation.[15]

25. All the passes leading into the country of Oondes, are situated in the main chain, it being indeed the only one, as will be evident from the foregoing description, necessary to be traversed between the Dooab and valley of the Sutlej, unless for the convenience of a better road, or more regular supplies. These passes have all, with the exception of three, been visited, and their height above the sea determined, excepting the main pass, of which though supposed to be the highest, it is to be regretted Mr. Tate, the Surveyor, who visited it has left us no measurement. The higher points of the chain are not so well ascertained in all their details, owing partly to their not being visible, and partly to an idea which has prevailed of their great inferiority to the southern peaks, or those included within the Gangetic basin, and consequently ramifications from this chain.

26. It appears however to be sufficiently established, that from latitude 31° 23′, longitude 77° 50′, the elevation of this chain is considerable, being with the exception of a few passes, clothed in the livery of snow all the year round. Its tendency to fall off in that direction is evinced by the gradually decreasing height of the passes, and from the latter point to its termination, little snow is seen, excepting during the winter months. In latitude 30° 35′, longitude 17′, the 77° elevations of what

15 This is to be understood, however, only in a general sense, as in many instances the subordinate ridge rises to a greater elevation than that from which it ramifies.

may be called one of its passes is only 2,500 feet. A little beyond this it is lost in the plain country.

27. The following Table of heights contains every point measured in this chain, and the accompanying section embodies the particulars. I have included the names of a few passes, which though not measured, appeared worthy of notice, either as forming frequented points of communication with Oondes, or as presenting unusual difficulties to the few venturous mountaineers who have attempted them :—

Table of the Elevations of the Principal Peaks and Passes of the Indo-Gangetic Chain.

Peak or Pass.	Elevation.	Remarks.
	Feet above Sea.	
Pass to Tuklakot, ...	17,598	This Pass is on the N. E. corner of the Mountain Tract, and leads to Tuklakot, a Chinese or Thibetan factory.
Koontas Peak, No. 2, ...	20,992	
Koontas Peak, No. 1, ...	22,441	
Labong Pass, ...	18,870	
Danna Pass (at least,)	18,000	Not measured
Jowahir Pass (at least,)	17,000	Ditto, ...
Neetee Pass, ...	16,814	.... These are two of the most frequented, the first is easy, the other difficult.
Mane Pass (said to be,)	18,000	Visited, but not measured.
Neelung Pass (probably,).....	16,000	Is said to be very easy of access.
The Cone (Snowy Peak,).....	21,178	These Peaks are visible from the Plains, they give rise on the Southern side to the Tonse.
No. 39, vide As. Res., 14 vol.	19,481	
L. Ditto, ...	19,512	
The Needle, ...	19,064	
Goonass Pass, ...	15,459	A good deal of snow in Sept.
Borando Pass, ...	15,000	Much snow in June.
j (Snowy Peak, vide as above,)	17,425	
i Ditto, ...	17,331	
h Ditto, ...	17,337	
g Ditto, ...	17,035	
Shatool Pass (at least,)	15,600	A very difficult Pass.
d	17,174	
C	16,982	
a	17,044	
Pass below Bagee Fort, ...	9,039	The range has here a S. W. direction.
Pass below Bagee Fort, ...	9,039	
Whartoo Peak, ...	10,673	
Nagkunda Pass, ...	9,000	
Theog Fort, ...	7,926	

Peak or Pass.	Elevation.	Remarks.
	Feet above Sea.	
Mahasoo Temple, ...	9,265	The Camp was 8,965 feet, temple 300 more.
Juke Peak, ...	8,120	
Tarba, ...	5,000	
Kimdera Pass, ...	4,989	
Kol Peak, ...	7,612	
Ujmergurh, ...	4,000	
Bhoora Peak, ...	6,439	
Suran Village, ...	5,500	
Bonytee Debee,...	5,120	
Jytuk Fort, ...	4,854	
Gutasun Debee,...	2,500	Not measured.
Sandstone Hills, ...	3,000	Ditto.
Foot of Hills, ...	1,500	Ditto.

28. A geologist of some eminence, and remarkable for the soundness of his views says, that "writers have erroneously confounded the line of greatest elevation with a chain of water-heads." If we take a survey of the present tract, we shall every where see this opinion confirmed. The range above described, is that which separates the two river systems of the Ganges and the Indus, the principal drains on the side of India from the central plateau. But it is by no means the highest ground, for it is within these basins, and not on their common boundary, that are found disposed those elevated peaks, the real height of which has so long formed a subject of discussion,[16] and from which, as considered the highest summits of the globe, this tract derives one of its principal sources of interest.

29. The term Himmala, generally applied to these peaks, means snowy, so that it is rather descriptive of a broad zone or belt, than of a series of peaks as distinguished from the lower ridges in their immediate vicinity. They have been called a chain, yet no term is less descriptive of the manner in which they are arranged; neither are they a

16 It is a curious fact in the history of science the extreme slowness and even unwillingness with which this result has been admitted. Theoretical considerations founded on an experiment in an air pump were held to be sufficient grounds for doubting of our Indian observers. "Jurare in verbo magistri" was the order of the day, and the authority of a name was considered sufficient to justify doubts of results which should have been judged of on their own merits alone. The infallibility of their own dogmas was never even questioned.

series of groups,[17] but rather of transverse ridges (at least within the basin of the Ganges,) which ramify from the Indo-Gangetic chain, over which they yet tower several thousand feet.

30. A line or plane connecting their summits will represent that of greatest elevation. It is evident from Art. 17, that it must cross the Indo-Gangetic chain. It is nearly certain, that in like manner the highest summits of the next portion of the great circular barrier are to be found within the basin of the Indus, and the line continued still farther would doubtless cross the separating chain of the Oxus.[18] Whether this arrangement holds all round, or how far; what is the elevation of this line in every part of its course; of these points, and of many others equally interesting, we are entirely ignorant.[19]

31. But we do know, that from the Hindoo Koh, or Snowy Mountains of Cabul, to the peaks visible from Patna, this line or plane never sinks for any distance below 21,000 feet. Lieutenant Macartney measured one of the former, and found the height 20,493 feet;[20] and in 1815, when with my corps on the Goruckpore and Betwah frontiers, I determined

17 On design communement toutes les elevations de terrain, pour peu qu'ils se prolongent, sous le nom general de chaines. Mais il est certain que les montagnes forment plus souvent des groupes que des chaines. Mais les chaines les plus apparentes ne sont souvent que de Lignes de groupes "Malte Brunn Precis de la Geographie," tom. 2, p. 160.

18 It has been thought otherwise: the Himmalaya have been supposed to find their continuation through Persia, and the chains of Taurus and Caucasus as far as the Caspian Sea. The point may, however, easily be settled, for it appears from Captain Christie's Journal, that there is no snow on the mountains in the neighbourhood of Herat, and it is known from the Ayeen Akberry, that the journey from Bokhara is unattended with difficulty. It is therefore evident, that the Himmalaya, as such, have no continuation in this quarter. But it may be said, and with truth, that the phenomenon of snow is no test of the identity of a chain or ridge of mountains. The Himmalaya, however, is no chain, as I have already shewn, and when we speak of these peaks as constituting a series, it is either as snow-clad summits, or as the highest in their immediate neighbourhood. Considered in either of these lights, their continuation must be sought in the Beloor Tag, and that these are situated within the basin of the Oxus, admits of little doubt. Lieutenant Macartney appears to have been puzzled with regard to this point, but this was owing to the mistake he fell into regarding the course of the Indus. He at once decides against the common opinion. Vide also Rees' Cyclopædia. Art. Altai Belur.

19 The papers of Mr. Moorcroft and Mr. Trebeck, should they ever be recovered, will doubtless supply many interesting particulars on this subject, and it would be extremely curious to compare their results with what is here hypothetically stated.

20 So in the account of Cabul, but from the data given, allowing one-tenth for refraction, I find 19,470; doubtless the place of observation is elevated 1,000 feet or more above the sea.

one of the latter to have an elevation of 27,000 feet.[21] Those who have travelled through Oude, within a sufficient distance of the mountain tract, know that the series continues in all that line without any such inferiority, at least as the eye can detect. This is a presumption, if it be no more.[22]

32. The fact, that in a line of 500 miles two summits are found exceeding five miles in perpendicular height, not isolated, but connected to appearance by a regular series of peaks of very little inferior elevation, is alone calculated to give us a lively idea of the enormous magnitude of this mountain zone. It is almost certain, that if we confine ourselves to 21,000 feet, we may find a connected line of such peaks extending through a distance of 1,000 miles. When I say connected, I mean without any apparent breaks, because as already noticed of those within the basin of the Ganges, it is probable that they are not connected in reality, except through the line of water-heads from which they ramify.

33. But, it may be asked, how shall we be certain that this is really the line of greatest elevation, and that is on this side the highest peaks are within the river districts, and not on their boundary; may they not be so likewise on the other side, and consequently there be found in the basin of the Indus, as suggested by M. Humboldt, still loftier summits than those which distinguish that of the Ganges ?

34. To this it may be answered, first, that as we have already seen this line of greatest elevation is undoubtedly prolonged into the basin of

21 This is the peak mentioned by Mr. Colebrooke, (As. Res.) under the name of Dhawala-giri, or the White Mountain. Captain Webb, whose measurement he reports, found nearly the same result. Captain Blake also, when employed as Surveyor on the Goruckpore frontier, found the same height nearly. I consider my measurement as less exceptionable than either of these, for the following reasons:—

(1.) The position of the peak depends on a traingulation established from a base of 1,142 feet measured with a chain, and not from the protraction of the route, the angles being taken by an excellent sextant of Berges. (2.) The angle of elevation was taken repeatedly, and at different seasons, by reflection from mercury with the same sextant. (3.) A much nearer approach to the peak was made one of the stations, being distant only seventy miles, whereas the nearest of theirs was 120 miles.

22. It would be very desirable to have the positions and elevations of the principal summits along our frontier fixed with tolerable correctness Such a task would not be either difficult or tedious, provided the attention were confined to those points alone. It would form the very best foundation for a correct map of India, for these peaks once fixed, every place from whence they are visible, may be settled with equal precision, and thus afford means of correcting the Easting or Westing of our protractions, which is the great desideratum. This subject has been noticed by Major Hodgson in the paper in 14th vol. A. S. Res.

the Indus, and most probably into that of the Oxus also, that in some part of this line there may be peaks higher than those in the Gangetic basin is possible, nor can we assign any reason, why it should be improbable. But that there is a higher chain, or series of peaks, beyond the Sutlej, parallel to that which we are considering, is an opinion which is supported by no probabilities whatever.

35. Undoubtedly the subject is even yet involved in some obscurity, which cannot be fully cleared up till all the particulars in that quarter become known. The only direct evidence which we possess on the subject is unfavorable to this conclusion. Mr. Moorcroft, who crossed, and Captain Webb, who visited the Neetee Pass, are both silent as to the existence of such loftier peaks to the N. or N. E. In my journey to lay down the course of the Sutlej I found that after passing this line, all the loftier peaks appeared to the Southward, while those to the North were of a totally different character, rounded summits, almost free from snow, and evidently of less height. In like manner in ascending the height above Shipkee, (16,000 feet), the peaks to the N. E., East, and S. E., were of this character, while to the S. and S. W. appeared those of the true Himmalaya aspect.[24] Nor does Captain Webb, in his visit to the head of the Kalapanee river, notice any high peaks as being visible to the N. or N. E., though he was then not twenty miles from the lake Mansuror.

36. We are justified then, by all that we know of this elevated tract, in considering it as unconnected altogether with the disposition of the water-heads. Nor can any principle of arrangement be traced, which will allow of our proceeding one step beyond that point, at which our positive knowledge of the subject terminates. We may, if we choose, guess, that beyond this, another line still higher may be found, and we may even add a third, still more lofty, but we must be contented to have these conclusions considered as mere guesses too, unsupported by analogy, and having no claim whatever to be received even as probable.

23 Further reasons will appear for doubting the existence of a series of loftier summits to the North, when we come to the geological details. Strange that Europe should have been so slow to acknowledge the actual height of the Himmalaya; still stranger, that being unable any longer to deny the accuracy of the measurement, a higher range must be supposed to the North of it, so that it may still be averred, they are not the highest.

24 Vide *Asiatic Society's Researches*, Vol. 15.

37. It should be noticed, however, that the term line is incorrectly used, or at least with great latitude, and even substituting that of plane it is still necessary to bear in mind, that its direction, whether as referred to a great circle, or the loxodromic curve, is by no means uniform or even regular in its deviations; unless indeed we regard it as of considerable breadth, and in that case its surface would be very irregularly studded with peaks. In this way we may certainly affirm, that it is parallel to the common boundary of mountain and plain land. In fact it is impossible to contemplate such masses disposed along such a distance without feeling convinced, that there is some connection between the greatness of their elevation, and the original formation of the mountain systems in which they are found. The parallelism becomes more obvious when we consider a more extended tract.

38. The following is a Table of all the results hitherto measured, distinguishing also the river basins within which they are situated:—

		Captain Webb.		Major Hodgson.		
No.	Designation or Names.	No.	Elevation.	Letter.	Elevation.	River Basin.
		27	20,923			...
		26	21,045			...
		25	22,277			...
		24	22,238			...
5		23	22,727			...
		22	19,497			...
		21	19,099			...
		20	20,407			...
		19	22,635			...
10		18	21,439			...
		17	19,153			...
		16	17,994			...
		15	22,419			...
		14	25,669	A No. 2,	25,749	...
15		13	22,313			...
		12	23,263	A No. 1,	23,531	...
		11	20,686			...
		9	21,311			...
		,,	...	A No. 3,	23,317	...
		8	23,164	B.	23,441	...
		7	22,578			...
		6	22,498			...
		5	19,106			...
		4	21,611	U.	21,612	...
		3	22,840	D.	23,062	...
		"	...	Q.	19,928	...

No.	Designation or Names.	Captain Webb. No.	Captain Webb. Elevation.	Major Hodgson. Letter.	Major Hodgson. Elevation.	River Basin.
						...
		3	19,938	Q. C.	19,530	...
		,,	...	C.	21,940	...
		2	22,058			...
		1	22,345	M.	22,792	...
	St. Patrick,.....	,,	...		22,798	...
	St. George,.....	,,	...		22,634	...
		,,	...	F. C.	21,772	...
	The Pyramid,.....	,,	...		21,379	...
35		,,	...	F.	21,964	...
	Sree Kanta, ...	,,	...	G.	20,296	...
	Rudra Humdah, ...	,,	...		22,390	...
	Serga Raur, ...	,,	...		22,906	...
	Bunder Pooch, ...	,,	...	E.	20,916	...
40	Another summit, ...	,,	...	E.	20,122	...
	Shippure, ...	,,	...		18,681	...
		,,	...	C.	21,155	...
		,,	...	H.	20,668	...
		,,	...		20,501	...
45	Peak visible from Jhala, ...	,,	...		18,795	... ...
	Ditto Twara, ...	,,	...		19,352	...
	The Cone, ...	,,	...		21,178	...
	Raldung,.....	,,	...		21,411	...
	Rishee Gungtermy,	,,	...		21,389	...
50	Poorkyol, ...	,,	...		22,700	...

39. In judging of the comparative direction of these summits and those of the Andes, it is not sufficient to be told that the highest of the former overtops Chimborazo, the principal summit of the latter, by nearly one mile of perpendicular altitude; for this single fact, great as is the difference which it implies, falls short of giving a competent idea of the subject. Let us take the highest summits of the Cordilleras measured by Humboldt, and those of the Andes of Peru by Condamine, and others. Although not the same chain, they are situated on the line of greatest elevation, and in both these particulars, they correspond with the Himmalaya. According to Myers, they are as follows :—

Chimborazo, ... 21,441
Desea Cassada, ... 19,570
Cayambe Area, ... 19,336
Cotopaxi, ... 18,891 or 19,155 according to others.
Antisana, ... 19,149

Popocatepetl, ...	17,716 or 17,734
Chillatepetl, ...	17,371
Illinissa, ...	17,238

From this list it would appear, that there is but one summit elevated more than 20,000 feet, and only five which exceed 18,000.

40. Of the fifty-one measured peaks of which we have given a table, there are twenty-eight as high, or higher than Chimborazo, and there are forty-four as high, or higher than Desea Cassada, the second summit of America. Popocatepetl, the sixth in order, is overtopped by not less than 100 summits within the limited tract we are considering; many of the passes even (which are the lowest points) in the Indo-Gangetic range, (which as I have before stated is not the highest ground,) exceed in elevation the sixth summit of America. These facts may perhaps give a more correct idea of the great difference which exists between these two tracts, the loftiest on the globe, and the most remarkable in every point of view. If the rivers of America (and even this is doubtful) exceed in volume and length those of the Old World, at least the mountains must yield.*

41. The great elevation of these peaks is scarcely more striking than is the depth of the vallies or hollows which separate them, and which are always the beds of the rivers. Thus the Poorkyool Peak towers to a height of 22,700 feet, while its base is washed at a horizontal distance of five miles by the waters of the Sutlej; the bed of which river has here only an elevation of 9,500 feet. The difference is 13,200 feet in five miles. In like manner the difference of elevation from the summit of the Kuldung Peak to the Sutlej, in a distance of five and half miles, is 14,711 feet. Of the Soommeeroo Peak to the Mundaknee, distant four miles, 11,000; of a peak (No. 17, Captain Webb's list) to the Gurjeia, distant two miles, 12,370; of the Jowahir Peak to the Goree, distant eleven miles, 15,749. These vallies are far beyond any thing that is to be seen in the Andes.[25]

25 Although the Andes have no river vallies comparable in depth with these, yet there are some chasms, as they should rather be called, which taking together their

* Our author was, it will be remembered, writing before Mr. Pentland's measurements of Sorato 25,400, Illimani 24,350, and Descabezado 21,100 feet.—H. P.

42. The above list, if it were thought necessary, might be much increased. It is very true that they are nearly consequences of the manner in which these peaks are disposed, but it is this very disposition which is so singular, and worthy of remark. It is the extraordinary elevation above the ground on which they immediately stand that is so striking to a traveller within these mountains, because it is at once taken in by the eye, and requires no consideration to aid the effect. It is different with summits placed on an elevated table land, where we are continually obliged to remember the height of the latter, and even with this assistance, they fail to astonish and confound the imagination in the degree that a nearer view of the Himmalaya is found to do.[26]

43. I must remark here, that the instances given above, belong to a fact which is general throughout these mountains, and which as it is very striking, and seems capable of throwing some light on the mode of their origin, ought not to be passed over. It is this: wherever the separating ridge of two river vallies approaches the banks of one of them, there is its highest point; and where it holds a middle course for any distance, it is there found to be lowest; equally throughout the higher and the lower mountains will this remark be found to hold good, nor am I aware of a single exception to it.

44. But it is chiefly as snow-clad summits on the border of the Torrid Zone that these mountains have attracted attention. It is probable that but for this phenomenon, their elevation would have remained to this day a desideratum. To the inhabitant of the plains, who being under a summer temperature of nearly 100°, is exhausted with heat, it is certainly a phenomenon full of wonder. To those too who consider the heat to be in the sun's rays, (the bulk of common observers,) the wonder must be greatly increased, as the summit of the mountain is nearer by five miles to the sun than the plains at its foot; even the scientific observer cannot entirely divest himself of that feeling of admiration, which the sight of any thing so unusual to his common ex-

depth and extreme narrowness, are very striking. M. Humboldt mentions several of these, one of which though it be not 3,000 feet across, is yet upwards of 4,000 feet deep. Captain Hall too, notices the depth and steepness of the ravines or *quebrados of Chili.*

26 But as these mountains are elevated on the high plain of Quito, which is elevated farther above the sea than the top of the Pyrenees, and constitutes more than one-third of the computed height, they are inferior in actual elevation to Mont Blanc. See Rees' Cyclopædia, Art. Andes.

perience, however agreeable to the deductions of science, must necessarily excite.

45. It is this phenomenon which has always occasioned them to be objects of attention, and it is singular enough that it is also on erroneous considerations connected with this phenomenon that the doubts of their superior elevation have been founded. I shall include under the remarks on climate, what I have to offer on the theory of the subject and the arrangement of the Isothermal bands. I shall here confine myself to a statement of a few of the most interesting particulars connected with the occurrence of this phenomenon.

46. It will be readily understood, that according to the season of the year, the zone which is marked by snow will be of more or less extent. If we take our estimate in that month in which the quantity is a minimum, and after which there falls more than melts, we may satisfy ourselves that a belt of ten to fourteen miles in breadth is distinguished by this phenomenon. It is not meant that snow lies in every point of this tract, but merely that within it will be found summits bearing snow all the year round. The minimum elevation of this snow-bearing tract is nearly in round numbers 15,000 feet, which may therefore be taken as the elevation in this latitude of the curve of perpetual congelation. There are, however, many spots of greater elevation perfectly bare of snow, this fact is, however, connected with a different arrangement of the seasons, and will be noticed in the section on climate. At all elevations exceeding the above, where snow lies, it is generally quite firm, except immediately after a fresh fall.

47. Many parts of this zone have such a disposition of the surface that it is quite impossible that any part of the snow which falls should ever be lost, except by melting, or by evaporation. The loss from the former cause must be very little at elevations much exceeding 15,000 feet. At 18,000 it must nearly cease altogether. The loss from evaporation will doubtless be considerable under so rare an atmosphere, still however we may safely conclude, that a surplus is left every year to accumulate. In favorable situations, we may imagine then the depth of these snows to be very great. In fact, we may suppose a case, without hazarding any improbability, where they have been yearly increasing since the origin of these mountains. Such supposition is calculated to give us a stupendous idea of the magnitude of these deposits.

48. We have seen that the line of greatest elevation intersects instead of bounding the river districts (Art 30). On each side of this line to the north as well as to the south the peaks diminish in elevation, yet not equally. To the southward the decrease is more rapid, and is accompanied by an anomaly which is sufficiently striking. The diminution of elevation, which is pretty regular till near the boundary of the plains and mountain land, is there suddenly interrupted. The peaks shoot up considerably above the mean elevation of those immediately north of them, and as suddenly sink into the plains; so, that if we divide the country, south of the line of greatest elevation, into five parallel zones, the fifth will be as high as the third, while the fourth will be found considerably lower than either.

49. Some of the most remarkable instances of this fact are the following: The Ghagur, which rises above Bhumowree, has one of the lowest of its passes, in a road distance of fifteen miles, elevated 7,121 feet above the sea. Another instance may be seen in the high range south of Sreenugger. A third in the Soorkunda range, as connecting that peak with Bhudraj. The latter overlooks the Doon, the former is but fifteen miles from Dhera, situated in the centre nearly of the valley, yet their altitudes are respectively 7,510 and 9,271 above the sea. The Jamoo Peak is another example. The Bhoora Peak a still more remarkable one. The latter elevated 6,439 feet above the sea, appears actually to overhang the lower hills which form the transition from its foot to the plain country. Many more instances might be adduced, were it necessary to multiply the examples. If a surface be supposed, such as to represent everywhere the mean elevation, that surface will not be inclined regularly plane, but will have a considerable curvature.

50. Another curious feature in the physical structure of this mountain tract is the situation of the high peak called the Choor. Its summit is elevated 12,149 feet above the sea, and if it be made the centre of a circle of sixty miles diameter, the circumference will on one side just fall on the common boundary of plain and mountain land, while within this circle, no point will be found within 15,00 feet of this height, and even those mountains which approach this limit, are, strictly speaking, part of the chain of which the Choor is the highest peak. From whatever quarter it be approached, it will be seen from very great distances standing up above the surrounding ridges like a huge beacon,

at once remarkable for its superior elevation, as for its peculiarity of form. The investigation of its geological structure must, for these reasons, be found very interesting.

51. Of the several rivers and streams by which the drainage of the Gangetic basin is effected, some have their origin from the Indo-Gangetic chain, that is, from the farthest side of the snowy zone, others spring from various points within that zone, or from its southern face, and a third class from the lower mountains where snow only rests a few months in the year. To the first class belong the principal sources of the Kalee and Ganges Proper, the Kalee, the Dhoalee, and the Sooree, branches of the former. The Dhoalee, the Bishun Gunga, and the Jahnuvi of the latter. To the second class belong the subordinate branches of these two rivers, and the principal ones of the Jumna, that is to say, the Ram-Gunga and Surjoo (Kalee); the Pindar, Mundaknee, Kalee, Bhillung and Bhageerethee, (Ganges); and the Beraee Gunga, Jumna, Soopin, Roopur, Pubbur, and Andryttee (Jumna). To the third class, which is the most numerous, belong all the other branches of these rivers, but six of them only require mention, as being at all remarkable. Of these, three pour their waters into the principal stream within the mountains. These are the Luddeea which joins the Kalee, the Nyar which belongs to the Ganges, and the Girree a branch of the Jumna. The other three have a considerable course within the plains. The Cossillah and Ramgunga join a little below Mooradabad, and with the united stream, eventually contribute to swell the waters of the Ganges. The Murkunda, the third of these, loses itself, it is said, in the sands of the Desert.

52. Amidst so many branches, it may seem difficult to fix on that which is entitled to the pre-eminence, and to be considered as the principal source of the river. If, however, we recollect that the most distant source must be the most elevated, and must have contributed the largest supplies, we shall have a principle of selection, easily applied, and which leads to some curious results. In particular, it will appear, that the Soopin is the parent stream of the Jumna, and its source must therefore be the principal one. Of the Ganges, neither the Bhageerettee or the Dhoallee, so long considered rival sources, is entitled to that distinction. In reality, the Jahnuvi is the most distantly derived of all its branches, and must therefore be admitted to be the real source of this great river. Singularly enough too, of all the mountain rivers, this is the only one

that has not been traced up to its origin, owing to its being within the limits of Chinese authority; the conclusion then is inevitable, that however we may pique ourselves on having visited and fixed the sources of the Ganges, the position of its most elevated and distant source is still a desideratum. Nor has the first beginning of this mighty river been yet beheld by European eye.

53. The following Table gives the particulars from which the foregoing conclusions have been drawn. It exhibits the distance, in miles measured along the river's course, of each source, taking as the point of departure, the place where the river enters the plains.

Name of Branch.	*Dist. of Source.*	*River Basin.*
Kalee, ...	180	
Dhoalee, ...	180	
Gungeea, ...	165	Kalee.
Ramgunga, ...	127	
Surjoo, ...	143	
Dhaolee, ...	225	Ganges.
Bishunnunga, ...	202	
Jahnuvi, ...	233	
Pindur, ...	203	
Mundaknee, ...	150	Ganges.
Kalee, ...	143	
Bhaeergettee, ...	203	
Bhillung, ...	150	
Jumna, ...	123	
Bheeraee Gunga, ...	124	
Tonse (Soopin), ...	154	Jumna.
Pubbur, ...	150	
Roopur, ...	143	
Andryttee, ...	145	
Sutlej, ...	555	Sutlej.
Cossillah, ...	100	Kalee.
Ramgunga, ...	105	
The Ludhee to its confluence, ..	52	
Nyar, ...	82	
Girree, ...	112	

54. The sources of these rivers which spring in, or from, the Snowy Zone, are elevated from 10 to 17,000 feet, the first being that of the Jumna, the latter of the Sutluj, the two extremes. There is evidently some connection between the length of a river course and the elevation of its source. I find from a comparison of those which flow in the same direction, and which may be consequently supposed to have the same declivity, that the height of the source above any given point is as the square root of the distance from that point. Thus the Jumna, Kalee, and Bhagerettee are respectively elevated above the points where they enter the plains, 9,573 feet, 10,593 feet, and 12,776 feet, which results are as the numbers 10, 11, 6, 12, 9. Their distances from those points are 123, 143, and 203 miles, the square roots of which are as the numbers 10, 11, 1, 13, 3, differing by less than unity from the preceding.[27] The Sutlej will not bear a comparison with these, because its course *is* in a different direction, and has not consequently the same declivity. In the direction of its course, its great length, and the little aid it derives from accessory streams, it forms a strong contrast to all the other mountain rivers.

55. A feature common to all the water-heads that belong to the Snowy Zone, is their situation always in a comparatively open and level spot, with an accumulation of snow resting against the base of some lofty peak, from which the embryo stream derives its first supplies. According to the season of the year, the snow-bed will be of greater or less magnitude and depth. During many months, the place will be deep in snow, and unapproachable. After the snow begins to melt, a constant moisture is kept up for many months, while in the fine season again, vegetation goes on luxuriantly. The consequence is, the formation of a thick coating of peat, which is invariably found at all elevations, having a temperature such as to ensure during several months the slow and gradual melting of the accumulations of snow that occur during the winter. From 11,500 to 13,000 feet, according to locality, may be considered as the height at which peat will be found. It is always however

27. This law is not applicable to different parts of the same river's course, and yet it gives very near approximations in the case applied. Thus if from the distance in miles of any source from the *debouche* the square root be subtracted, and multiplied by 882, the product is the height in feet above the *debouche*. This would give 12,221 feet as the height of the source of the Tonse. The result by the temperature of boiling water was 12,784

in greatest quantity, and of a better quality in such spots as above described; that is, in hollows; because the supply of water is more constant, and equally gradual.

56. The discharge of the four great rivers at their entrance into the plains, has not been directly measured, except in the case of the Jumna. It appears however reasonable to infer, that the discharge will be proportionate to the extent of country drained; in other words, to the total length of course made up by adding the several branches of the river together. This rule I found to hold in the case of the Tonse and the Jumna, the discharges of which I measured in 1819. Thus, their total lengths of course were as the numbers 1, 2, 6. Their discharges as the numbers 1, 2, 8. In adopting then this expression for the valuation of the discharge, and taking the Jumna at 4,000 cubic feet in a second, (which is within a few feet of the result I obtained in March 1819,) we shall have the following results:—

	C. F. in one second.
Discharge of the Kalee at Bishin Deo, ...	4,800
Jumna at Badshahee Mahal, ...	4,000
Ganges at Hurdwar, ...	7,000
Sutlej at Ropur, ...	8,100

We see here that, notwithstanding the far greater length of course which distinguishes the Sutlej, (more than double,) it does not greatly exceed the Ganges in discharge. This is owing to the comparative narrowness of its basin, and its want of great branches.

57. Although there are no great vallies in the interior, (Art. 15,) yet along the common boundary of mountain and plain land, on a line parallel to that of greatest elevation, there are seen a series of small vallies, which are however unconnected with each other, and sometimes separated by a long interval. These vallies are always marked by the *debouche* of some great river, and there is doubtless some connection, in the origin, between them and the river systems. Although there is not a valley to every river, yet they are found along the whole tract at intervals, as far as Patna on one side, and beyond Cashmeer on the other. The occurrence of these vallies through such a distance, and so symmetrically situated, favors the idea which would attribute a community of origin, or at least connection in structure, to the whole of this tract of Alpine land.

58. Those belonging to the tract to which the present description is confined, are the Pinjore Doon or valley, the *debouche* of the Guggur; the Kyarda Doon, the *debouche* of the Jumna and Ganges; and the Pattee Doon, the *debouche* of the Ramgunga. They are all bounded, or separated from the plains by a low chain of hills, which is also a line of water-heads, and contains the sources of those streams which, engulphed in the tract immediately at their feet, afterwards spring up in the Teraee, occasioning the humidity of soil which is so characteristic of that tract.

59. The Dehra Doon, which is the principal of these vallies in extent, and probably the only one demanding a detailed description, is from the Jumna to the Ganges about forty-five miles in length. Its breadth is variable, being in some places scarcely ten, in others fifteen miles.[28] The surface is undulated, and has, in particular directions, a strong declivity.[29] Many banks or steps occur, varying in height from one to thirty feet. These generally follow the course of the streams, one on each side; appearing to have the same relation to them which the Kadur, or marshy lands of the plains, have to the rivers there. Their distance, or the breadth of the channel they mark, is very considerable even in the case of the smallest stream, and they exhibit the same variations in arrangement which the river banks in the plains do.[30] There is little question but that they have once been the beds of running water, however incapable the present streams may appear of filling them even in their highest floods.

60. The drainage of this valley is effected entirely by the two rivers, Asun and Sooswa, which rising within a few hundred yards of each other near the middle of the valley, run in opposite directions, the former to meet the Jumna, the latter to the Ganges. The fall of these rivers is considerable; the elevation of the source of the Asun being 2,148 feet above the sea, and its confluence with the Jumna 1,469 feet, being a fall of 652 feet in little more than twenty miles. The fall of the Sooswa in a course

28 The admirable new road made by the Honorable Mr. Shore, leading from the Keeree Pass through Dehia to Rajpoor, at the immediate foot of the northern hills, measures, I think, fifteen miles.

29 The base which I measured in the Doon in 1819, had a difference of level of 300 feet between its two extremities. Its length was about four miles.

30 That is to say, a steep bank is always opposed to a low shelving one. When both are alike, neither are observed to be remarkably steep or shelving.

of about the same distance is 948 feet, its confluence with the Ganges having but an elevation of 1,200 feet above the sea. The course of these rivers is parallel to the direction of the valley, and very near the South-western boundary, so that their supplies are almost entirely drawn from the Northern barrier of mountains. The numerous feeders which spring from these, all flow across the valley, shewing, that there is a considerable declivity also in that direction. In fact it is found, that from Rajpoor at the foot of the hills, the fall is regular to within three miles of the Kheree Pass, and amounts to 1,300 feet. Thence to the Kheree Pass is a rise of 618 feet. This line is that of the new road; it passes through Dhera cantonment, and very nearly, if not exactly, separates the two basins.

61. The range of hills which bounds the Doon to the Southward, is of peculiar aspect, and presents some very interesting appearances. The total depth of this belt in the widest part is about ten miles. The range is not intersected by vallies with sloping sides, as the great mountain tract is, but by the beds of torrents which are generally bounded on each side by perpendicular precipices, sometimes 500 feet in height. The ridges are extremely narrow, so as to bid defiance to any examination of them, except such as can be effected in the beds of these torrents. The line of water-heads which separates the streams which seek the Doon from those flowing plainward, does not hold a regular course, as compared with the general tendency of the mountain belt, being sometimes at the border of it, as at the Lal Durwaza Pass, sometimes nearly in the middle, as at the Timlee Pass. The former has been stated to have an elevation of 2,935 feet, the latter is only 2,339. The peaks do not rise more than 600 feet above these levels, so that 3,000 to 3,500 may be taken as their general height.

62. The appearance of this valley is highly picturesque, particularly in the neighbourhood of Dehra. The intermixture of cultivation, in which the fields are defined by hedges, with patches of green, over which are scattered fine groves of trees, the undulation of the surface, and its intersection by numerous streams, are features that might almost remind one of the scenery of England. The proximity of lofty mountains occasionally clothed with forests, in which the pine, oak, and walnut are conspicuous, gives a variety to the landscape, which viewed at a favorable season, is picturesque and beautiful in a high degree. The soil is gravelly,

yet to judge from the cultivation, far from poor; and though at present thinly peopled, and but partially cultivated, was once otherwise. The land revenue had dwindled down to 10,000 rupees, when it came into our possession. It is said to have yielded 80,000 in the time of the Rajahs of Gurhwal. Under the fostering care of the British Government, it will not be long in recovering its former prosperity. The principal difficulty appears to be the want of water for irrigation, yet this is an objection easily remedied, for with so varied a surface, and so many streams, water might at a trifling expense be conducted in almost any direction. Capitalists are wanting to undertake this and other improvements.

63. The Pinjore Valley is the next in point of extent. It has in parts a breadth of perhaps six miles, and its length may be estimated at about thirty. It is tolerably even in its surface, and the hills which bound it to the Southward, are of much less depth and of less elevation than those of the Dehra Valley, at its South-east angle, in the *debouche* of the Gaggur, a river which is lost in the sands of the Desert. From Tuxal the streams run in one direction towards the Guggur, in the other towards the Plassia river, a feeder of the Sutlej. Pinjore, the principal village or town, with a fort, of masonry, is elevated 1,819 feet above the Seebar, which is at the foot of the mountain, and near the separating ground of the two river basins is 2,402 feet above the sea. Munsie Debee, a temple in the plains, just without the Doon, is 1,263 feet. From these results an idea may be formed of its declivities. It is not so well cultivated as the Dehra Doon, though it appears to possess equal capabilities.

64. The Kyarda Doon is of less extent than the last, having in its widest part but a breadth of six miles, and in length being but twenty-five miles. This estimate of its length supposes it to terminate at the Pass of Ghatusun Debee, where it narrows so much as to be scarcely entitled to the name of a valley. From Ghatusun, the elevation of which is 2,500 feet, the streams flow eastward to the Jumna. To the westward flows the Markunda, which enters the plains under Nahun Siki, on the Ghuggur. It loses itself in the sands of the Desert, so that we cannot refer it either to the Sutlej or the Jumna basin. I have however considered it to belong to the former, and Ghatusun I suppose the lowest point of the Indo-Gangetic chain. Of the Pattle Doon, I cannot give any account, as I have never visited it.

65. About thirty miles north of Almorah, or a little west of north, there is a small tract of rather greater extent than those to be hereafter noticed, and more uniformly level in surface. It is watered by the Gaomuttee and its several feeders, a river which joins the Surjoo, one of the branches of the Kallee at Bagesur. These feeders are very numerous, and the glens in which they rise being broad, with a level terrain, form by their inosculations with the principal one, the appearance of a considerable tract of open and almost level country. From Koolan to Retora is a distance of ten miles, in all which line the surface appears to have little undulation. The forest is not too thick, and yet from some unexplained cause, the tract is unhealthy in a high degree, so much so, as to be in a great measure neglected, and allowed to run waste. The elevation of Byznoth, a temple of some sanctity on the Gaomuttee, and which may be taken as the lowest point of the valley, is 3,800 feet; the villages are situated chiefly on the lateral ridges which divide the several subordinate glens.

66. In the beds of the different rivers there are, as might be expected, various spots of a limited extent, and of sufficient evenness of surface to be always objects of interest to the cultivator, though from their smallness, scarcely entitled to the denomination of vallies. These spots generally occur in an advanced part of the river's course, and being therefore the lowest places in the mountains, are necessarily the hottest. In general they are fertile, yet are all considered more or less unhealthy, particularly at the breaking up of the rains; and when narrower than usual, so notoriously subject to the *awal*, or jungle fever, as to be entirely neglected; instances occur in the bed of the Surjoo and Kalee. But where the width is rather greater, or the surrounding mountains not too lofty, they form the most populous, the most productive, and the most beautiful spots within the mountains. The width is seldom more than half a mile, but the length is sometimes considerable.

67. The most remarkable instances of this kind may be seen in the bed of the Sutlej at Soonee and at Dutnuggur; of the Bhagerettee at Teeree; of the Aluknunda at Sreenuggur; at Pannae of the Western Ramgunga along nearly the whole of its course; of the Cossillah for a distance of ten miles; of the Benee Gunga for about the same distance; of the Buspa at Sungla; the Sirjoo at Kubrol, of the Geree Gunga in a great part of its course; and in the Comoulda, one of the principal

feeders of the Jumna: several smaller streams are equally, if not more, remarkable; and in general, similar level, and comparatively open, spots are found at the heads of all the rivers.

68. To this class also belongs the series of petty vallies to be seen in the neighbourhood of Petorah, though not constituting the bed of a river. The largest of them does not exceed perhaps two square miles, but they are in such number, as to render that district one of the most productive, for its extent, in the mountains. They are generally connected by some narrow gorge, so that, in one quarter, a distance of five miles may be travelled in which the surface is almost perfectly even. The appearance of the country, owing to such a number of these local spots, and the consequent insulated situation of many of the peaks, is peculiar to that quarter, and very striking. In the neighbourhood of Dhooara Hath, about twenty miles from Haurel Bagh, a pretty extensive piece of tolerably level ground is to be seen, and similar pieces in the neighbourhood of the small lakes, which are to be seen about ten miles above Bhumowree, on the road to Almorah. With the exceptions here stated, (and their collective sum bears but trifling proportion to the total surface,) all is rugged and difficult, a succession of steep and lofty ridges and deep glens.

69. The lakes mentioned in the preceding article, constitute a feature in the physical description of this tract which should not be forgotten. They are, however, on a very small scale, compared with the grand system of mountains to which they belong. One of them, Bheem Tal, situated about ten miles above Bhumowree, on the Almorah road, is only 3,000 feet in length, by 2,400 in breadth; the depth, however, is said to be very great. It is situated at the lowest point of the valley, about three miles in length, and at some distance from it appears a considerable pool, which is at present connected with it by a running stream, the intermediate ground being marshy, and covered with flags. These circumstances leave no doubt in the mind of the spectator, that the whole of this valley once formed a lake, and it might easily be restored to the dominion of the water, by damming up the outlet, which the present lake has found for itself. The elevation of this spot above the sea is 4,200 feet.

70. About five miles east of Bheem Tal, is another called Nynee Tal, having nearly the same extent. A little beyond this is a third, called Nakoon-ka Tal, and besides this, some others of much less extent.

Within ten miles of Jytuk, near Nahun, is another called Ren Kee Tal. It is in breath about 400 feet, and in length, as measured by the perambulator, one mile and a half. In common with all the others it is said to be of great depth, and to abound with excellent fish. A pool at the head of the Tonse, called Resul Kee Tal, and thought by the mountaineers to be unfathomable, may also be mentioned. As likewise a similar pool at the head of the Dinee river, one of the feeders of the Bhageerettee. The waters of all these are perfectly sweet and tasteless.

71. Along the foot of the mountains extends a tract called Bhabur, which has been always I believe reckoned an integral part of the mountains, politically speaking; it is of considerable elevation, and is farther distinguished by an almost total deficiency of springs or running streams, excepting such as, issuing from the mountains with a large body of water and considerable force, make their way through it without having their waters engulphed.

72. It is bounded to the southward by a line of springs or waterheads, which is also the northern boundary of the tract called the Terrai, one equally distinguished with the former from the southern plain country, but occasionally annexed to it and occasionally to the hills. This tract is remarkable for its moisture, as the other is for its dryness. Water in the driest season, (March 1826,) is never more than thirteen feet from the surface, generally much less. It is intersected by numerous streams, which with the inclination of the surface, affords such facilities for irrigation, as to render the tract, when fully cultivated, highly productive.

73. The Terrai is defined in its southern boundary by a rise or step, which runs parallel to the common boundary of mountain and plain land. This rise is a very singular feature in the aspect of the country, and forcibly impresses the spectator with the idea of some great catastrophe in which water has been the chief agent. The height is variable, and occasionally is as much as thirty feet, sometimes it is sudden or steep; and it is then intersected by ravines, the effect of floods in the rains; sometimes it is gradual, and it is then liable to be mistaken for an undulation of the surface; sometimes it consists of two banks or steps, and occasionally even of three; a similar step or break in the surface is found to accompany the course of each of the rivers after quitting the mountains. In this case, it forms the boundary of what is called the *khadir*, which as may

be understood from what precedes, is a low tract of variable width within which the river has its bed. These appearances correspond exactly to the banks described as accompanying the rivers in the Doon.

74. The Terrai may then be considered as a very shallow valley parallel to the direction of mountain land, and the *khadirs* or low lands of the rivers, as so many transverse vallies communicating with it. This itself is a presumption that the rivers have not formed their *khadirs*, but this is further established by the fact that the *khadir* is widest in the vicinity of the mountains, and diminishes as the river flows southward, till at no great distance it disappears altogether. At Bhogpoor on the Ganges, the *khadir* is of great width, yet in the highest floods in the rains, the river never rises to its level. At Durra Nuggur, the *khadir* is from five to seven miles in width; such a valley could never have been scooped out by the stream which now flows there.

75. The Terrai being thus distinguished by a fall or step, is usually considered very low in comparison with the low country south of it. Such however is not the case, although so strong is the deception in looking at the face of the country, that few people can be persuaded of the truth of the matter. Yet a little reflection would be sufficient, without any thing like measurement, to shew that it is a deception. The streams which take their rise at the foot of the Bhabur all flow southward, with banks of nearly equal height, and currents of considerable force. And from the Bhabur, which is so high as to be visible to the eye, there is no sudden descent to the Terrai, the line of demarcation being traceable only from the presence or absence of the springs, or from geological considerations connected with the nature of the deposits.

76. The preceding will, I hope, give some idea of the physical features of the country I have undertaken to examine, without which the geological description must be in a great measure unintelligible. The two classes of facts are so connected, that it is impossible to separate them; each throws light on the other; and if we wish to trace those general relations which furnish the highest and most interesting discussions in this new science, we must begin by taking a clear, as well as comprehensive, view of the physical aspect and arrangement of the surface.

77. It is my intention to give in the first place the simple geological details as observed, in order that a clear idea may be had of what is ac-

tually known, as distinguished from what may be considered matter of opinion or inference, subjoining an attempt to combine these details into something like a systematic view of the general structure of the tract, adding such inferences and illustrations as have occurred to me in reconsidering the subject. In the geological details, I shall follow out the extent of each rock as yet observed separately, and in the order in which they actually occur, beginning with the highest zone, and descending gradually to the plains.

Section II.

GEOLOGICAL DETAILS.

78. In the zone of the Himmalaya, the only rock which I have yet observed, I mean as covering any extent, that is, as constituting a formation, is gneiss; other rocks are found it is true, but only in the form of veins or beds. Gneiss has been traced from Deao, opposite Muzzoolea near Seran in the western corner of the Survey, by Brooang in the valley of the Buspa, and thence ascending to the Snowy Pass of the same name, leading into the valley of the Pabur. In this line the varying level, (5,500 to 15,000 feet,) leaves no doubt of the great thickness, as well as lateral extent of this formation. It is not, however, every where equally obvious, the coating of debris being often of great thickness and covered with luxuriant vegetation. Frequently the only trace of its occurrence consists in large angular blocks lying on the surface or imbedded in the coat of debris. This may perhaps be considered inconclusive evidence of the existence of this rock as a formation, but the case admits of no other, and the same difficulty meets us at every step in these mountains, and as no fragments or any other traces occur, or any other rock in this tract, with the exceptions I shall presently mention, we shall find a difficulty in saying what rock is found below the surface, if we find it necessary to deny the existence of gneiss.

79. This rock is of the most ordinary character in the greatest number of instances, consisting of quartz, felspar, and mica, and nearly in the usual proportions. It seldom contains any foreign imbedded mineral. The felspar is almost always white, seldom grey, and only

in one instance of limited occurrence have I observed it of reddish hue. The quartz is most commonly white and semi-transparent, occasionally grey; the mica is of all shades, varying from silver white to a deep brownish black; some specimens contain both extremes of colour.

80. There are three distinct types of structure in this gneiss, two of which are well separated, both in appearance and position. The laminar which is often contorted, the granular,[31] in which the laminar structure is often obscure; and what may be termed the glandular. The first two appear to pass into each other, and to be irregularly mixed together, but the third preserves a great uniformity of appearance over a considerable tract. It has really the laminar structure as strongly marked as the first, but it is well distinguished from it by the imbedded lenticular, or round nodules of felspar which it contains, and which give it a most peculiar appearance. The laminæ are bent round these nodules, which have a foliated structure, and are sometimes disposed in two layers; the line of junction, which coincides with the axis of the nodule being so faint as only to be perceptible by the varying reflection of light from the two parts. There is very little doubt but this line of junction coincides with one of the faces of composition of the mineral, but I have not yet established this point to my satisfaction.

81. The dip of this rock appears involved in some obscurity; along this line, at least it presents some anomalies, the explanation of which I have yet to learn. This may be, nay doubtless is, partly owing to the frequent concealment of the rock beneath the coating of debris, leaving us in these cases to form our judgment from the configuration of the mountains, with reference to the sides of slope and precipice. Even this test sometimes fails, either from the great accumulation of debris completely modifying the superficial forms of the rock, or perhaps from the absence of definitely marked stratification. For even occasionally when the rock itself is visible, there occurs doubt as to this point, the fissures being so numerous and variable in direction, as to render it impossible to pronounce which are, and which are not the lines of stratification.

82. From Deao to Kungos, the dip appears to vary between N. and E.,

31 By this term it is not meant to designate the granitic structure, but an aggregation of small grains, in which the difference of the felspar and quartz is often difficult to be ascertained.

being often N. E., and this on both sides of the Sutlej, the angle of inclination being about 30°. One measurement gave N. 70° E. But near Nichar, again it appears to be to the West of North, the inclination still much the same, or even less than 30°. A very remarkable rocky precipice occurs opposite this village, traversed by numerous rents and fissures, but nothing can be traced like marks of regular stratification; nor can even a line from the neighbouring strata be fancied to connect with any of them; yet from the appearance of the rock, I have not a doubt but that it is gneiss. Near Keelba, there is a considerable access to the rock, which is a perfect laminar gneiss, yet nothing like the regularity of stratification is observable in it either, the lines running confusedly in every direction.

83. At Woongtoo bridge, the stratification is also very obscure, and the natural divisions of the rock very various in direction, but as the laminar structure, which is, or ought to be, discriminative of gneiss is here often obscure, if not altogether wanting; the rock by many will perhaps be considered a granite. A few miles beyond this bridge, with an interval of distinctly stratified rock, a similar amorphous mass is seen on the right bank of the Sutlej, surmounted by regular strata of gneiss dipping S. W., but presenting that arrangement which has obtained the name of wedge-shaped strata; the upper layers approaching more and more to the perpendicular position. On this side (the left bank) is a similar mass of gneiss, but with an opposite dip, (that is to N. E.), and with the same arrangement, the inclination of the lower strata being inconsiderable, while the superficial are nearly vertical. This appearance struck me very much, coming on me, as it did, after a long and patient examination of the Woongtoo rock.

84. Beyond the irregularly seamed rock noticed as occurring near Keelba, we find a perfectly stratified arrangement continuing from a considerable distance, the dip pretty regularly N. E. and the inclination between 20° and 30°. This is the glandular type noticed article 8. On turning up the Buspa, below the village of Brooang, extensive types of stratification are seen, but with a S. E. dip, and an inclination of about 25°. This dip continues in the ascent to the Pass as long as any thing like stratification can be perceived. But in the last 4,000 feet of ascent, the rocks again put on the shattered and fissured appearance before described, and on the Pass itself, nothing like stratification can be traced, owing to the

intricacy of these seams, and the various directions in which they lie. But of the identity of the rock there can be no doubt, as I examined it along the whole of this line, and collected numerous specimens. It is a gneiss of the most perfect type. The Pass is strewed, as might be expected from the appearance of this rock, with huge angular blocks. I may add, that on the South side, a N. E. dip is again met with, but accompanied by a considerable change in grain, and a thinner laminar structure. This observation was made at an elevation of about 12,000 feet above this; all around, the ridges appeared with the same fissured and shattered aspect, while the river (Pabur) bed is strewed with fragments of every size, leaving no doubt that the rock is gneiss.

85. The only imbedded minerals I have observed in this tract are, 1. mica in tabular crystals, but not well defined, nor otherwise of any particular value, (near Seran); 2. schorl occasionally sparingly disseminated in small prismatic crystals (near Seran); 3. garnets of a lighter colour than usual, small and sparingly interspersed, their figure obscure if not imperfect; 4. quartz of bluish green color in six-sided prisms, occasionally attaining to the size of an inch in diameter, and two or three in length. They are found imbedded in a granite vein near the village of Keelba, but are with difficulty separable from the matrix. The quartz which forms the regular ingredient of this granite is of a light grey colour; 5. it is said that copper and gold were formerly obtained at a spot between Yanee and Keelba on the right bank of the river, but that the workings have been long abandoned.

86. Hornblende rock occurs in beds in the neighbourhoods to Sera, Tanada, and Kemgos. It rarely consists of the pure mineral, most commonly of a mixture of that and felspar. It is sometimes of a schistose structure, sometimes of that which I call the cleaveable. The two types appear to pass into each other by imperceptible gradations; in one case only, near Seran, could I perceive any thing like a transition or passage of the gneiss into this rock, the change in the other instances being sudden, and the contrast marked. These beds are generally of very limited extent, seldom more than a few yards, particularly between Deas and Suran, in which line they are also numerous. Near Tanda, the bed is larger and occupies the whole of the mountain side, forming the ascent to the village. A bed of micaceous schist occurs near Seran, and one of compact quartz rock, forming a precipice of great mag-

nitude. At the confluence of the Buspa, the road lies along the foot of this mass, and is strewed with fragments from it.

87. Granite veins are evidently numerous in the neighbourhood of Wongtoo bridge, for among the fragments that are met with for several miles on each side, we observe a proportion of them to be granite. These fragments often present undeniable evidence of their veinous origin in retaining part of the gneiss which formed the wall of the vein, and it was this circumstance, combined with the low proportion they bear to the fragments of the gneiss, that first suggested the idea of their being derived from that source. But there can be no doubt on this subject, as in the immediate neighbourhood of the bridge, just before descending to the river bed, these veins may be seen in great number intersecting the gneiss, most commonly in a direction from N. E. to S. W., and again in the anomalous rock at the bridge.

88. The granite of these veins is always of a large grain, and is remarkable for the very large proportion of felspar it contains, the mica being comparatively deficient. The felspar is white and foliated, the quartz of a light grey, the mica generally brown. No difference of composition is observable between the middle and the sides of the veins, nor any change in the gneiss in its neighbourhood. The breadth is very various, and equally so the extent. The former is from a few inches to several hundred feet. They occasionally divide, but they cannot be said to ramify, at least not in a remarkable manner.

89. The rock which occurs at the bridge, and which contains the largest of these veins, is something of an anomalous nature, and might be adduced as an instance of that transition between gneiss and granite, which has been so often observed. Some specimens would certainly be considered to belong to the former title, while others might be chosen, which would as certainly be referred to the latter. It has, however, in mineralogical aspect, a strong resemblance to the more well-defined gneiss in its neighbourhood, while it has none whatever to the granite veins. I may add, that its occasional want of a distinctly laminar structure, and the indistinctness of its stratification, are the only obstacle to its being considered identical with the surrounding accurately defined gneiss.[32]

32 It has been usual to call anomalous rocks of this description granitic gneiss, but the mere giving it a name affords no new information, nor in any way settles the doubt as to which type of rocks it should be geologically referred.

However this may be, I ought to notice that it is of limited extent in this direction, certainly not exceeding a square of 500 yards.

90. The band of gneiss thus traced out from a recent visit, may have its limits increased by a reference to notes made in a former journey. The particulars will not be so minute, and specially the dip and inclination are wanting, as an examination of the rocks was then a secondary object, and the subject not so familiar. But they will be sufficient to establish the great extent of the gneiss formation, and I ought to add, that of the few particulars I am to mention, there can be no doubt; as I made an ample collection of specimens which I afterwards examined at my leisure, with the opportunity of consulting those who were well acquainted with the subject.

91. On the Gonass Pass, five and half miles east of the Brooang Pass, (Art. 84,) and elevated 15,516 feet above the sea, the rock is a small grained, dark coloured gneiss, with the lamina rather indistinct, and often breaking with a conchoidal fracture. The dark colour is owing to the mica, which is black. The ingredients are most intimately mixed, and scarcely to be discriminated by the unassisted eye. In the descent thence to the bed of the Buspa, (about 9,000 feet,) the rock is seldom visible, but at Singlo (9,178), and thence in the ascent to the Harung Pass (14,500), the rock is gneiss. At Mibar (9,698), the same rock prevails, and indeed as far as Pooaree on the Sutlej, between Pooaree and Poorboonnee, a crumbly white granite is met with, the type of which, as far as my memory can guide me, is to be found in other parts of these mountains, and will be described further on (Art. 264). From a recent examination between Poorboonnee and Reeba, masses or beds occur, but of limited extent, of a rock, consisting almost wholly of felspar, generally in a state of decomposition. It is probably a granite. From Reba to Rispa is again well-defined gneiss, which on the ascent above Moorung, is exchanged for clay slate. The clay slate continues by Nissung to very near Dabbling. Just above Dabbling, a mass of granite occurs, the true relation of which I cannot attempt to give at this distance of time. From Dabbling to Shipkee gneiss prevails, the laminæ and even strata frequently very much contorted, particularly at a precipice in the river bed between Doobling and Namja. Between Namja and Shipkee, it is imperfectly laminar, has a small grain, and is of a bluish grey colour. Beyond Shipkee, that is east of it, as far as it

could be judged of by contour, the mountains would appear to be clay slate.

92. To the north of Shipkee, between the Sutlej and the Speetee rivers, is gneiss, with some patches of granite, but whether veins or beds, must be left for determination on a future visit. This gneiss continues again by Nako to Shalkur, beyond which it is succeeded in the neighbourhood of Soomra and Laree by clay slate. We have thus traced gneiss very nearly to the confines of our possessions. In returning down the right bank of the river, we find it equally prevalent, the whole way from Shalkur to Woongtoo, with the following inconsiderable exceptions; limestone occurs in the bed of the Yoollung, which joins the Sutlej near Leoo, and again on the Hungrung Pass, (14,000 feet.) Whether these masses are connected, or form two distinct beds, must be left for future decision. Granite is found in the neighboured of Rarung, Meero, and Rogee: with these exceptions, and perhaps an occasional bed of mica slate and quartz rock, the whole of this line is gneiss.

93. The preceding account of the rocks of this tract, derived from recollection, agrees in the main with one published in the first volume of the Geological Transactions, new series, drawn up by Mr. Colebroke, from specimens forwarded by Captain Gerard, who also traversed that route. The chief difference is in my assignment of gneiss as the rock formation, giving to all the others, with the exception perhaps of the clay slate near Moorung, the subordinate character of beds or veins.[33] I may here add two other observations from that paper, which are not to be found in my notes, but are of importance. The dip is noticed at Poosaree as being E., and the angle of inclination 25° to 30°. The other is a notice of the rock found on the Shatool Pass, about five miles west of the Borunda Pass, and elevated 15,000 feet, which is stated to be gneiss.

94. We may now move eastward, and we shall find at the source of the Tonse (12,800 feet) gneiss again, of a dark grey colour, fine grain, and conchoidal fracture. This gneiss contains so large a proportion of

33 It will be readily understood, that a series of specimens collected by a person not conversant with geological enquiry, whose attention too was strongly occupied by another subject, may well fail to exhibit the relative extent of each rock; such a collection can give us no assistance in discriminating insulated beds from alternating formations, or either of these from veins.

quartz, and is so hard, as to afford sparks; at Jumnootree, also the prevailing masses are gneiss; quartz rock also occurs, but in subordinate quantity. From Jumnootree,[34] a route passes in the bed of the Bhagheerettee at Sookee, reaching in two intances an elevation of about 15,000 feet (Bamsoora and Chaigu Pass.) The whole of this line is gneiss. From Sookee again, in the upper part of the course of the Bhageerettee, we met with scarcely any other rock; granite I have only seen in fragments. The snowy peaks at the head of this river are distinctly stratified, and have all the appearance of the neighbouring accessible gneiss. In the Jahnuvi, gneiss continues to Neeling, where it is succeeded eastward by clay slate. The valley of the Chor (thief) river, which is a feeder of the Jahnuvi, and springs from that point in which the Buspa also originates, but with an opposite course, appears to be also formed of this rock.

95. We have now reached the Kalee, (branch of the Aluknunda), and here the recent examination of this tract equally established the prevalence of gneiss, from Ookee Muth Joola (rope bridge) to Kedurnauth, the source of the river. In this gneiss the mica is often black, and the quartz glassy, and in one solitary instance if I am not mistaken, it admits of hornblende as an ingredient in addition to the other three more usual ones. The most marked varieties in structure or mineralogical aspect are the following: Near Nalaputtun, the laminæ are undulated, the quantity of felspar diminishes, and I think it passes into a micaceous schist at length by the almost total loss of this mineral; beyond Mykunda, numerous fragments occur of the glandular type before described, and which is afterwards seen in Litee, in an immense precipice forming a beautiful natural section at the foot of the descent to Jilmilputtan. Some of the nodules have even a rounded appearance, similar to that of rolled pebbles; hornblende occurs in addition to the usual ingredients in specimens obtained between Mykunda and Ukrot Kothee. This rock is also remarkable for containing a peculiar mineral, which I shall presently have occasion to describe more particularly. Near Ukrot Kothie, it has all the aspect of quartz rock, exhibiting, what may be called, a transition into that congenerous formation. It gradually loses its mica, and appears at last to be a mere mixture of quartz and felspar, the fracture conchoidal and laminar, structure very obscure. Beyond Gowree

34 Mr. Fraser, who traversed this route, gives the same account of the rocks, and particularly dwells on the stratified aspect of the lofty peaks.

Koond, occurs a type in which the nodules of felspar assume a lenticular shape. The ground being a dark grey, and this mineral of a snowy whiteness, makes it occasionally a very beautiful rock. Beyond Bhyro Ghate, the rock is scarcely accessible in situ, but the angular fragments, which are very numerous, are sufficiently indicative of its nature, and prove that the surrounding peaks and ridges are chiefly, if not wholly, gneiss. And the correspondence of appearance between the nearer ridges, which have evidently furnished these fragments, and the great Soommero or Kedurnauth peak attest the fact that here also, as at the head of the Ganges, this rock attains an elevation of nearly 23,000 feet.

96. The dip of this rock is more regular within this tract than in the neighbourhood of the Sutlej. In the bed of the river below Ookeernauth, near the Joola, it was observed to be from 8° to 20° N. E., while the inclination was 30°. Between Mykunda and Bhet, the dip was found to be twenty-five to forty-five N. W., and a little beyond this, due North. Beyond Mykunda again, it was observed 50° N. E. Beyond Borosa, it is also E. of N.; but the strata have a secondary set of divisions which are at right angles to the former, and consequently dip in the opposite direction. The first set have but little inclination. The latter are nearly perpendicular. This is an appearance often met with, and it is sometimes difficult to say, which are and which are not the stratiform divisions. Those have been generally adopted which correspond to the general run of the neighbouring strata. At the fine section near Jilmilputtun, the strata which are from four to ten feet in thickness, dip 10° N. E., at an inclination of 30°. After crossing the river, the dip is 30° N. E., the inclination the same.

97. The only beds observed are one of micaceous schist near Nalaputtun,—if this be not indeed a gneiss with less felspar than usual, and an instance of that oscillation which is observed between rocks so nearly allied in origin and structure as these two? It is remarkable for containing the largest garnets (common) I have seen in these mountains. Their figure is however irregular. The specific gravity I determined to be about 3.8. This is rather higher than the determination hitherto made, but I think it must be evident to any one, who will examine the uninterrupted series of gravities between common and precious garnets, and will also consider the variations in the analysis, that the former is

merely a more or less impure specimen of the latter. The degree of impurity may be estimated from the specific gravity.

98. Between Bhet and Mykunda, also, occurs a bed of micaceous schist under much the same circumstances as at Nalaputtun, that is to say, containing felspar in small quantity; the contact with the well-defined gneiss not being visible, so as to allow it to be ascertained whether it be a bed or a mere modification of the more general rock. Beds of hornblende rock are very common, but always of limited extent; as before observed, they seldom consist of the pure mineral, almost always of a mixture of that and felspar. Occasionally this rock, by the decomposition of the hornblende and oxidation of the iron it contains, acquires a rusty colour, and an earthy composition. In this case it is soft, and partially disintegrated. And a mass of a similarly disintegrated rock, but of a yellowish grey colour, is found in its vicinity. It is probably a decomposing gneiss. A rock something similar occurs again in the ascent to Gunness Ghata from Jilmilputtun. The composition is arenaceous, consisting of quartzose particles in a white earthy basis. This is also probably a gneiss, though from the absence of every thing like the stratified structure, I am more inclined to consider it a granite. But the name is of little moment; whether gneiss or granite, it is of limited extent, and being such as I have described, is surrounded on every side by gneiss. It does not contain mica.

99. No granite veins, unless the preceding can be considered one, were any where to be observed. But fragments of great variety, size and beauty may be seen in the small valley at the head of the river near which the temple of Kedurnauth stands; all these consist in great proportion of felspar, containing very little quartz, and much less mica; some want the mica altogether, some the quartz. The felspar is always white or grey, in the former case perfectly opaque, in the latter translucent. The quartz is generally grey, the mica sometimes a deep black. Those compounds which consist of the translucent variety of felspar and black mica without any quartz, are extremely beautiful, and could this rock be obtained in any quantity, it would pay for its transport. But the small quantity in which each type occurs, is equally remarkable with the great variety of them, and their total dissimilarity to the granites found in more southern localities. They are all angular, appear to be of recent fracture, and with those

met with near Wongtoo, (Art. 87,) doubtless portions of veins, as in many the same circumstance may be observed which was observed there, the adherence of part of the containing rock to one of the sides of the vein. This is always gneiss.

100. In the bed of the Mundaknee, or Kalee as it is more usually called, below Ookeernauth, many very large rounded blocks are scattered about, of a granite very much resembling the anomalous rock at Wongtoo bridge; it contains angular nodules of a crystalline felspar imbedded in a granite paste. This felspar is here of the glassy variety, and it is the only example of the mineral I have ever found. These blocks have a smooth surface, unlike the rough and granular appearance left by the phenomenon of desquamation to which granite is subject, and to which so many granite boulders owe their origin. If these boulders have been also formed by this cause, it is equally certain that they have undergone also the attrition, which alone could have smoothed their surfaces to the degree observed.

101. The only imbedded mineral of any interest in this quarter, is one occurring in small amorphous grains. It is of a bluish grey colour, translucent, a vitreous lustre, and uneven fracture. It is very easily frangible, hardness 5.5: 6.0. The composition is impalpable. The quantity I was able to procure was so small, that I do not lay much stress on the determination of its specific gravity which appeared to be 2.3. It is certainly not under 2.2, nor more than 2.4. Before the blowpipe it is infusible, but decrepitates. It is not affected by acids. This character does not agree with any mineral yet described, yet I should wish to obtain it in greater quantity, and subject it to a more leisurely examination before I pronounce it new, in all but geological situation and infusibility. Before the blowpipe, it comes very near the species, empyrodox quartz.*

102. Some of the fragments of gneiss found at Kedurnauth, contain kyanite in flat prisms, from half an inch to an inch in length, and about one-twentieth to one-third of an inch in breadth. Cinnamon stone in grains is also to be found in them. The granite fragments abound in schorl, under its common figure of three-sided prisms,* the lateral angles replaced, terminated by obtuse trihedral summits. The largest I observed, was about an inch in length and half an inch in diameter, but the small crystals are always best defined. Hyacinth is more rare, and the

* MSS.

crystals, which are quadrangular prisms, terminated by quadrilateral pyramids set on the angles are very small, not more than one-twentieth of an inch in their largest dimensions. Carbonate of lime, (calcareous spar,) was observed only in one specimen.

103. In tracing this formation of gneiss eastward, we find it accompany us from the bridge under Ookeernauth, by Krokee and Oosaree, in the ascent to the Toongnath Pass, (10,000 feet.) Near Krokee, it contains the bluish grey grains described, Art. 101. At Oosaree it is chloritic, the mica having given way to this mineral. The quartz is rather in greater abundance than usual, which renders it rather a hard stone, and as the laminæ are very much undulated in the south wall, and the rock splits readily into masses of the required thickness, it is found valuable as a mill-stone, and is much sought after on the Pass. Well-characterised gneiss, of a small grain, and marked schistose structure, occurs. The dip was observed to be N. 20° E. It was particularly obvious in the arrangement of the mountain slopes and precipices. Fig.* will give some idea of this appearance.

104. Beds of hornblende schist, as usual, are met with, sometimes in a state of decomposition, (between Krokee and Oosaree), sometimes persistent (on the Pass), but in a very small quantity. It is here succeeded laterally by clorite schist, which also occupies a very small space, some very large masses of quartz rock are observed, which have evidently been derived from the lofty crest that crowns this Pass to the north. A small strip of granite of a middling grain and ordinary aspect, occupies the eastern edge of the Pass, and is I think, part of a vein. In the descent in the Pass no rock is seen in situ, but the fragments are all gneiss, and one type in particular is singularly beautiful, having thin prisms of kyanite dispersed through it in great abundance, thus giving it something of a porphyritic aspect.

105. The next locality within the elevated zone where gneiss has been traced, is at Dampa on the Gooree river. It was there observed under two types, interstratified with one another. The one a light grey, having much the appearance of quartz rock, the other darker coloured and larger grained, resembling the rock near Zanee on the Sutlej and

* The figures referred to here and other parts of this report are wanting, for the same reason that has interfered with the preparation of the sections. They will be forwarded hereafter.—MSS.

Jilmilputtun on the Mundáknee. The two types are interstratified. The dip is very regularly N., a little E., and the strata are occasionally curved amongst the fragments, besides gneiss which constitutes the major part. Quartz rock was observed, and a few spots of hornblende rock, but none of granite.

106. From this point in the ascent to the village of Sacen, gneiss is the only rock observable. Thence descending to the Nullah, and ascending to the Pass called Chabinna-ka-Doora, elevated 9,000 feet, the same rock continues, and in the whole line of so ordinary a type, and presenting so little new or anomalous, as to afford no room for description or remark. It yet accompanies us onward round the head of the Soorung glen to the Pass of Rooroo Dhooroo, elevated 10,000 feet; the line of route then descends to a Nullah, (elevation 6,000 feet). Gneiss the whole way. It ascends and descends, passing round the head of a valley, and finally crossing Sere Soongur Khan, a Pass elevated 10,000 feet, descends by Naneik into the bed of the Ramgunga, having yielded no rock but gneiss in all that line, not even a solitary bed. I ought however to notice that in a very great proportion of this distance the coat of debris is of an enormous thickness, and covered by a most luxuriant vegetation. In the bed of the Ramgunga, the dip was observed N. 5° W., the inclination being 15°. There were however two other sets of divisions, but not equally strongly marked.

107. The preceding comprehend the most northern observations of the extent of this rock. I shall now follow out its southern boundary, which as it presents some anomalies and irregularities, I have chosen to separate from the previous detail in order to avoid confusion, and to present in a clearer light the fact of the great lateral extent of this formation. I have not the least doubt, that a greater field of observation will establish the general prevalence of gneiss over the whole of what I have called the zone of the Himmalaya. It is true that this is mere opinion, but it is the opinion of one who has considered the outlines of the mountains with reference to their geological structure, and who may be said to have viewed the whole of it at greater or less distances.

108. I shall, as before, begin with the western parts, taking up my account at Deas on the Sutlej where, as I mentioned, gneiss occurs of a well characterised type. In the bed of the Nullah, between Deaoo and

Muzzooleea, may be seen a bed of chloritic schist. Dipping conformably with the gneiss it oscillates on one side towards talcose schist, on the other towards chloritic gneiss. The latter change is seen when it comes into contrast with the gneiss. This intermediate rock, as it may be called, is much intersected by veins of scaly chlorite in which quartz is also interspersed. The veins are very tortuous, and the quartz always follows the course of the chlorite. In the ascent to the Kutedorna Pass, just below the village of Darna, gneiss was observed, but of limited extent, and no other rock was visible.

109. Between this Pass and Putenoo I find no notice of the rock, owing I suppose to thick debris below Putenoo. In the route leading down that glen, one of the feeders of the Nowgree (to Roon on the latter river) chloritic and talcose schists are the only rocks observed, these rocks frequently contain quartz. The dip is generally north. The contact of the gneiss with the new rocks could not be discovered. In the bed of the Nowgree occurs an anomalous variety of talcose schist, or perhaps rather quartz rock. It is a mixture of silvery talc and quartz, but is not schistose, having more the amorphous aspect of granite. It contains, disseminated in grains, a mineral with the lustre of quartz, semi-transparent, varying in colour from a bluish white to an indigo blue. It does not appear to have any cleavage. The quantity was too small to determine the specific gravity. It is infusible *per se*. With soda it forms a clear glass. This rock has been meet with in very distant localities, and will be often referred to. At this place it is intersected by patches or veins of chlorite.

110. In the ascent from the Nowgree, fragments of a subschistose rock, of a greenish colour, may be seen, containing probably hornblende, besides chlorite; still higher on the pass above Birsoot, straight laminar chlorite schist prevails. In descending to the stream below Ketoo, the same rock continues, but having a fibrous structure; it contains nodules of quartz, and the chlorite is always observed to be bent round them. The dip was found here to be S. E. In the bed of the stream blocks of gneiss are seen, but no occurrence of it in situ. Chlorite schist continues to the foot of the ascent leading to the village of Koolior, when it is exchanged for a grey fibrous argillaceous schist, irregularly cleavable with a scaly granular fracture. The dip here was also found to be S. E. Probably this latter is in reality but a variety of chloritic schist. As long how-

ever as the green colour is made the discriminative character of chlorite, descriptive geology must notice it as a change.

111. This latter rock continues in the ascent beyond Teda, assuming latterly a magnesian character, and containing veins of quartz. The transition between magnesian clay slate, and talc slate with which chlorite slate is associated, is so common, as to render the above conjecture probable; masses of a rock which might be called quartz rock are then met with. It is of a fine granular composition and slaty structure; a little higher an enormous precipice occurs formed of the projecting ends of the strata, and facing the north. This rock is a gneiss of a grey colour, fine granular composition, and perfect schistose structure, and the dip, it would appear from the above, must be South on the Sulan Pass; again the rock is gneiss, but no observation of the dip could be made.

112. In the descent from this Pass to the village of Koornoo, so thick is the coat of debris, that not a single example of the rock is to be detected excepting fragments. These are gneiss; but from Koornoo the rock is finely exposed, particularly in the bed of the stream which leads from the bridge below Koornoo to the foot of the Pass above Surmal, and which here separates the Sutlej basin from that of the Jumna. This stream runs in a narrow gorge with high perpendicular walls on each side, formed of the projecting ends of the strata. These are observed on each side to correspond perfectly, not only as to the seams and directions of the strata, but also in the mineralogical character of the rock. This rock is an ordinary gneiss of a grey colour, and marked schistose character, the strata are sometimes five feet thick, and between them is a distinct separation or fissure; sometimes they are not more than six inches thick, and these changes occur within a very short distance, the dip is regularly S. 40° to 50° E. The inclination 15° to 25°.

113. In the neighbourhood of the Surmal village, gneiss is still found, occasionally, however, almost losing its felspar and consequently oscillating towards micaceous schist or quartz rock. The route from this village to Kuatar, at the head of the Nocor glen, leads along the high ridge which separates the basins of the Sutlej and of the Jumna. This ridge has an elevation in this quarter of from 7000 to 11,000 feet; some parts are above the limit of forest. It rises rapidly as it continues upwards, and is seen to be crowned with snow-bearing peaks at but a

short distance from the Pass above Surmal. It is generally covered with an enormous coat of debris and of peat, but the rock is visible in more than one place. It is gneiss, occasionally small granular, occasionally with bent laminæ, and resembling the passage into micaceous schist. The dip is as often S. E. as N. E., nor did there appear to me any clue by which I could trace the connection of their opposite dips, which are many times repeated even in a very short distance. Beds of hornblende rock are frequent; this rock is very often quite amorphous, and has but little of any appearance of a schistose structure. It occasionally contains mica and even quartz, as well as felspar, and may thus be said to be identical in composition with the syenites, but it never loses the characteristic appearance of hornblende rock, and the above minerals are always in small quantity.

114. In the descent from the Kedrolo Pass to Kutar, the gneiss is latterly found to lose its felspar, and in the neighbourhood of that village it is an ordinary well-defined micaceous schist. From hence this latter rock continues in the bed of the Nocor river, lying at so low an angle that it is difficult to observe the dip or direction. I should have observed that the outline of the great ridge and its ramifying branches, from which the Kedrola Pass forms the descent, is peculiar. It is sharp and serrated, while that of the mountains east of Kutar, and even the branches of the former, as they fall in the scale of elevation, are observed to assume smooth rounded outlines, with scarcely any sharp peaks or breaches. But if the smooth ridge is seen to rise to any thing like the elevation of the serrated ridges, it also becomes serrated like them, while again on sinking, it takes the rounded form. This fact, combined with the low degree of inclination which the strata bear, would seem to justify in inferring the superposition of gneiss on micaceous schist, nor is there any thing so unusual in the fact, however contrary to a once generally received system, to occasion any hesitation in admitting the truth of it.

115. In the bed of the Nowr river, besides fragments of the mica slate, the rock in situ many large blocks are seen of gneiss of a type which I did not observe any where in this quarter in situ. Judging however from the connections of this rock in other places, I would infer that it must also be in abundance here, forming most probably those serrated crests which crown the mica slate ridges. This rock may be called a porphyritic gneiss. It is composed of rather a middling grained

paste, in which I believe the three ingredients are found, and in this paste are included angular nodules of crystalline felspar; this arrangement gives a very beautiful appearance to the rock when polished. It is the same rock which has been noticed in the river Kalee below Ookeemuth, and also at Wangtoo bridge. It appears very often to form the transition between granite and gneiss.

116. The micaceous schist continues to the village of Kohaen, situated below the foot of the Tekkar, but every where covered by a thick coat of debris. In the nullah the tendency of the dip was, if any thing, East; but here it was observed to be South-west. Below the village, a small stream joins the Nowr river. In the bed of this river, micaceous schist is still observable, but on crossing the river on the ascent to the village of Surmal, gneiss is seen resting on it. The dip of both rocks North-east, and the inclination very little. The mica slate has here a greenish colour, but it is not chloritic. The relations between micaceous and chloritic schist do not warrant, I think, our extending the latter title to those rocks of the former class, which have merely a greenish tinge. The lines of chloritic schists are rather connected with the talcose schists, a connection perfectly agreeable to our views of system, since it has been well established that the two minerals, talc and chlorite, are but varieties of the same species, (the prismatic talc mica of Professor Mohs.)

117. From Saraut to Seel, the route passes along the eastern declivity of the ridge which separates the Nowr glen from the valley of the Girree and its feeders. This ridge is every where of the rounded and swelling form which was mentioned as indicating micaceous schist, accordingly it is the only rock observed. It is frequently of an arenaceous composition, and strongly resembling some varieties of micaceous sandstone. This type occurs near the village of Kulgaon, occasionally it is of an earthy aspect, loses its schistose structure, and becomes fissured in every direction. This type projects through the surface in amorphous masses; it very probably contains felspar, though the grain is too small to detect it by any occular examination. I incline to consider it as in reality a small grained decomposing granite, but further examination of its relations to the surrounding rocks are necessary to enable me to pronounce decisively.

118. From Seel to Deolara, the residence of the Ranee of Torbut, the route turns up the valley watered by the stream which joins the Pubbar

river, opposite to Raeengurh. In all this line, mica slate is the only rock occurring in situ. The dip was observed to be N. W., inclination 15°. Several very large fragments of gneiss may be seen near the village of Torbut; one which I noted, had the dimensions of 50 feet by 20 by 10. Whence these have come is not so obvious, for the crests of the range do not bear the serrated outline which is here discriminative of gneiss. Near the Deolora, the type consists almost wholly of mica, very tender, and of a yellowish brown colour. It contains numerous veins of quartz, as this type always does. The new road which has been cut by order of Major Kennedy passes through it, and is covered deep by the highly comminuted debris of this rock, the lightest and most transportable sand that is formed. The annoyance to the traveller's eyes in a light breeze is not to be described, while the sun strongly reflected from the lamina of the rock, occasions a glare which is almost as irritating to the eyes, as the subtile powder which is every instant blown into them.

119. At Seel, the rock is of the arenaceous type, and it contains, disseminated in great abundance, octahedral iron ore in small grains and imperfectly formed crystals. This mineral has a specific gravity of 4.81; but as there are some impurities in the specimen I tried, it is probable this determination is too low. The limits of octahedral iron ore are 4.8, 5.2, while those of axotomous iron ore, which it in some respects resembles, are 4.4, 4.8. But it is very probable that the true limits of the octahedral species, (magnetic iron ore,) do not descend below 5.0, for all the massive or larger crystallised specimens exceed this determination, and that the magnetic iron sand will form a distinct species between the axotomous, (titanic iron,) and the octahedral.

120. The abundance in which these grains are found, may be judged of by the specific gravity of some of the specimens of the micaceous schist in which they are disseminated. This was found to be 3.45. Taking 2.76 as the specific gravity of pure micaceous schist, and 4.8 that of the iron, it may be easily demonstrated that the latter constituted by bulk one-third of the rock, or by weight very nearly one-half.

121. In ascending from Deohea to the Pass of Chount Kagulla, leading into Poondur, micaceous schist alone is observable, but in general in the coating of debris thick fragments of gneiss occur, and it is probable

that the summits of this range are composed of this rock. On the Pass, micaceous schist is the rock; but it approaches in character to gneiss, containing I think felspar, though in small quantity. On the other side of the Pass, however, just at the edge of the steep descent, gneiss occurs in strata very nearly horizontal, the dip being if any thing North-west. This place, which is at the head of the glen in which is situated the village of Meemooa, presents some very romantic scenery. Immense precipices are formed of the columnar masses of gneiss, which here and there stand out from the general rock, and raise their gigantic heights far above the green knolls and patches of debris, enamelled with a thousand flowers that fill up the bottom of the glen. The crests of the surrounding ridges in which the gneiss is gradually lost being concealed by the luxuriant vegetation, are again crowned with noble forests, in which the yew, the horse chesnut, the oak, pine, and sycamore are all conspicuous. At every step the traveller disturbs the Moonal, (Phasianus Impejanus,) which with its shrill disagreeable cry forms the only interruption to the silence and solitude of the scene. It was a beautiful morning in May when I ascended it. The thermometer was only 50°, while in many of the secluded nooks, the springs were frozen. It is in scenes like these, and in such temperatures, that the explorer finds some recompense for the heat, and toil, and dust of less favored situations.

122. Descending into this glen, the gneiss is perceived to have considerable extent, and the valley for a still further distance, is strewed with huge blocks of this rock. At the precipices above described, a brownish tender micaceous schist may be seen resting on it; lower down in the bed of the nullah below the village of Mummora, the gneiss is finally exchanged for that rock, which here again appears to underlie it. It may be seen to form by the broken ends of the strata, corresponding layers on each side of the narrow water-course which it bounds, the two sides agreeing in mineralogical character, in inclination and thickness of strata so closely, that it scarcely requires an effort of imagination to fill up the very narrow chasms, or to join those masses which have evidently been once continuous. The micaceous schist continues in the high ridge on which the village of Pooree is situated, and for a few miles beyond it, when it is finally lost through the junction of the new rock, or is concealed by debris.

123. I have now traced the gneiss to its southern boundary in this direction, and have, in order at once to notice all the different patches of it that occur, encroached on the limits of the micaceous schist, the next rock in the order of description. But no arrangement of these observations can be entirely regular while nature herself so often presents us with irregularities, or at least what appear such in our imperfect systems. In fact the inconvenience is more imaginary than real, for in following out the extent of the next rock, the preceding details will be referred to as filling up part of the outline. No gneiss is found south of the point where the preceding description terminates.

124. It is necessary now to return to the route by the Borund Pass, in which gneiss was traced as far as the place of encampment in the Pubbur valley, about 10 miles above Janglag. The upper part of this valley, I should notice, is of great width, the left bank is steep and precipitous, consisting chiefly of bare rock, the river flowing at its foot. The right bank is an easy slope covered with a thick coat of peat, in which spring up at this season various European flowers, such as ranunculus, anemone, potentilla, iris, with many others that appeared new to me. Tracts of this nature afford the very finest pasturage during four or five months of the year. Very little rock is visible, only occasionally in the lateral glens, where the torrents from the snow have gradually made their way through this enormous mass of vegetable debris, and thus exposed it to view, or where a peak split by the expansive powers of the frost tumbles from its lofty base into the valley beneath, and scatters wide its fragments of every size. One such slip of very great extent may be seen on the road to Junglag, and of this all the fragments are gneiss; some pieces would afford hand specimens that might pass for granite, but viewing it in the large and almost innumerable blocks that lie here, the rock is readily pronounced a gneiss.

125. Descending from Junglag to the confluence of the two principal branches of the Pubbur, we find only gneiss. A fine section is exposed on the left bank of the eastern branch. It lies in distinct and well marked strata, from 5 to 8 feet thick, dipping to the S. E. The route continues along to the right bank of the united stream now swelled to a river, 40 feet wide and 5 feet deep. The coating of debris is of great thickness, but another section of the strata may be seen in

the bed of a small nullah that falls in from the west. The rock is gneiss, the inclination is small, and the dip obscure.

126. Hence, ascending and passing by the villages Dewtee and Sustwar, gneiss is still found projecting in many large masses; the mountain side being more steep, and consequently having less debris lying on it, no good observation of the dip was obtainable. Gneiss still continues up the lateral glen in which Kutsar is situated, and thence descending to Tikkaree near the latter place, fragments were observed of a dark blue colour and small grain, and in the eagerness to change the sameness of constantly recurring gneiss for some novelty, were supposed at first to be so, but the first stroke of the hammer corrected the mistake, and shewed it to be gneiss; a little unlike, however, the ordinary types of that rock. In the bed of the Kutsar glen, blocks of the porphyritic gneiss before described were observed, some of which had all the characters of a gneiss.

127. From Tikkaree to Senowlee, a distance of nearly 16 miles, the route is in the bed of the river, and in all this line there is but one instance of the rock in situ being exposed. It is a fine grained grey gneiss. In the bed of the river, fragments of all sizes are seen, but they consist almost exclusively of gneiss and quartz rock, some few of hornblende rock, and a very few of granite. The river bed is often wide, and in these cases is accompanied by a bank or flat of some extent, consisting of rounded stones. This bank is often 30 feet high, not less than half a mile in length, and 200 yards perhaps in width. These level spots are all cultivated, and it would appear, that they are particularly fitted to the culture of the poppy, which is carried on in this valley and its ramifications with great success.

128. This was the first instance of these beds observed in descending from the source of the river. Near Massoolea, where there is much level ground, occurs an immense accumulation; a lateral torrent which cuts through it to join the Pubbur, shews at once its enormous thickness and its composition; stones of every size, from 2 feet diameter to the smallest pebbles, all perfectly rounded, imbedded in gravel and sand; most of them are quartz rock, perhaps two-thirds of the whole, the other third consists of gneiss and hornblende rock, with a few of granite. These beds are so far different from the open level spots found in the upper part of the river vallies, in as much as their surface

is perfectly flat, while that of the others is rather undulating and irregular. The latter too are composed almost wholly of angular local debris, covered with a thick deposit of peat, while these, as already described, consist entirely of rounded fragments which project often at the surface.

129. From Sinowlee the road ascends one of the ramifications of the Chag Sheel ridge. At the commencement of the ascent, micaceous schist is found of a dark blue colour, and splitting into very thin straight laminæ. It is much stained with oxyde of iron. Gneiss succeeds to this rock, but in small quantity, and is again exchanged for a micaceous schist, with something of a talcose aspect, and of a lead blue color. This rock continues assuming more of the talcose character, and it is I think certainly a mixture of prismatic and rhombohedral talc mica with quartz. The laminæ become undulated, and it abounds in garnets. A vein is observed parallel to the layers, the centre of which was either granular quartz or a mixture of quartz and felspar, the sides were marked by prisms of hornblende thickly and confusedly disseminated. Many veins of glassy quartz, both white and yellow, were observed, but so fragile that no good specimen could be detached.

130. The rock continues to the village of Chupar, containing frequently veins, if they be so called, of gneiss. The veins never ramify, and they are always parallel to the laminæ of the containing rock; below Chupar gneiss is again found in mass, and beyond it again talco-micaceous schist, enclosing a vein similar to that described Art. 129, consisting of granular quartz or a mixture of quartz and felspar, with crystals of hornblende disseminated. This vein has a porphyritic structure, is a most singular rock, and affords by the definite nature of its character, a clue to the connections of widely distant masses. It will be seen hereafter of what common occurrence it is within this tract, and yet it is a rock I have never seen except in these mountains. The dip is pretty uniformly in this neighbourhood, N. or E. of N. wherever it appears uncomformable, it is but for a short distance.

131. Beyond the talco-micaceous schist, one with straight laminæ, containing garnets and oxydulous iron is met with. In descending from Bulor into a lateral glen, the glandular type of gneiss before noticed as occurring below Broang (Art. 80), and at other places, is met with, and in the bed of the stream is seen a talco-micaceous rock with

undulated laminæ. This rock is singularly hollowed out, whether by the action of the weather or by the dropping out of the loose materials of veins, that may once have traversed it, it is difficult to say, perhaps the former opinion is the more probable one; and yet as these hollows traverse the laminæ of the rock, it is not easy to understand why they should be subject to decomposition so partially.

132. From Murdal the rocks appear to be of an anomalous character. In proceeding along the declivity of the range which here forms the left bank of the Pabur river, there is an oscillation between gneiss and micaceous schist, the rocks occasionally assuming the type of the former, occasionally of the latter rock. The gneiss appears sometimes to contain clay slate as an ingredient, and in one spot of limited extent, is carburetted in a high degree, this modification was noticed, also as occurring above Gowree Koond, in the valley of the Kalee, (Art. 95.) In the bed of the stream below the village of Twalta, gneiss is found of a legitimate type, dipping to N. E. and having an angle of inclination of from 30 to 40°. This rock continues the whole way to the village of Dorchan, where may be seen some types of a granitic character, but viewed in all their relations, little hesitation is felt to class them as gneiss in general, this character only applies to small portions of the rock, and even there may be seen in the same continuous stratum to pass into the most ordinary gneiss, and often in a distance of a few feet. The laminæ of this rock are much undulated, and owing to the arrangement of the materials, it presents a striped appearance, the stripes following a waving outline. In some specimens, I observed the spangled mica at right angles to the laminæ, an arrangement that might too hastily be considered characteristic of granite, were it not borne in mind first, that they preserve their parallelism in layers, which the mica in granite never does; and secondly, that it is an appearance not uncommon in micaceous schist, as I shall hereafter have occasion to shew, contrary to the opinion of one of our first geologists.

133. In the descent to the Kotee gneiss accompanies us nearly the whole way dipping to the north or a little west of it, the inclination being but little. It is however seen to include a bed of magnesian clay slate, the approach to which is indicated by laminæ of that rock being contained in the gneiss. Adjoining the bed of clay slate, is one of quartz rock. The actual junction of these rocks is concealed by

debris. The change however takes place in the direction of the strata, and does not occupy 400 yards in lateral extent. The gneiss which succeeds the quartz rock continues as far as Gokul, a village in the same glen. In the ascent thence to the pass above Seras, the rock in situ is not observable; for a considerable distance fragments of hornblende schist are found, but not numerous; after crossing the stream a new rock is met with, which occupies some extent. It is a white rock of a saccharoidal aspect, occasionally so frangible as to crumble under the pressure of the finger, yet at the same time it has many and distinct changes, but nothing like a schistose structure. It is most probably a bed in the gneiss. It is composed evidently of talc and quartz or felspar, or both; some parts of it have so completely lost the mutual coherence of the particles, as to form apparently a bed of white clay; no doubt this would prove an useful ingredient in any attempt to manufacture a superior pottery.

134. On the summit of the Pass is to be seen a gneiss of an earthy character, and containing not only clay slate, as an ingredient, but carbonate of lime. Below the Pass occur fragments of chloritic schist, in such abundance as to justify the suspicion that there are extensive beds of it in the neighbourhood near; the village, a compound rock of an argillaceous character containing superadded carbonate of lime, imbedded pieces of quartz of a lenticular shape, and perhaps felspar; most probably the transition of the earthy gneiss above to an argillaceous schist; another specimen is a well defined clay slate with veins of carbonate of lime, chloritic schist of a dull green colour, and subgranular composition, united to the imperfect schistose structure, also occurs, after which quartz rock in all its types occupies the road in the descent to the Tonse River, and for some miles in its bed, proceeding upwards: when I say in all its types, I mean rather of colour than any thing else, for excepting in this particular there is no rock which possesses such uniformity of character, at least in this tract. It is sometimes bluish grey from clay slate, sometimes greenish grey from chlorite. Occasionally it is talcose, occasionally micaceous; the dip is pretty uniformly from N. to N. E. and the inclination from 25° to 30°; a very remarkable instance of the disruption of the strata occurs in the descent, something like that noticed Art. 94. The interval is also occupied by a stream, but of very disproportional dimensions. It is about

four feet wide and six to twelve inches deep, (15th of June after many days heavy rain,) the breadth of the opening from precipice to precipice is 200 feet, and the perpendicular depth about 100. The dip and mineralogical character correspond on each side, so as to leave no doubt that they were once continuous. The rock, as quartz rock almost always is, is one of great tenacity and hardness, and it seems very difficult to assign any adequate cause for the removal of so large a mass. There does not appear any dislocation or disturbance of the strata, nor any trace by which it can be judged, that the mass removed could have been the materials of a vein of less persistent character; many other instances of this kind will be noticed as I proceed in my description.

135. The Tonse is here crossed by a Sanga which measures 101 feet in the clear. The velocity in the middle of the surface was 12 to 13 feet per second, and the depth from 5 to 7 feet. These data give the discharge about 2000 feet per second. In the Doon before joining the Jumna it was determined to be nearly 3000 feet. In its immediate bed are found very large rounded blocks or boulders some even 3 feet in diameter. As in the bed of the Pabbur River, so here also they consist of gneiss, quartz rock, and hornblende rock. At the confluence of the small stream in the bed of which lies the road from Seras, there occurs a very extensive piece of flat ground, but whether it be composed of the boulders, and loose gravel noticed in the bed of the Pabbur is doubtful. Small deposits were however observed in the immediate bed of the river, having a thickness of 5 feet. The open and flat spots are very numerous in this part of the river's course, but of what materials they consist is rendered uncertain by the covering of vegetation, which clothes their slopes even to the water's edge.

136. From the bed of the Tonse the route proceeds up a lateral glen called Gurogar, from the village of that name, a very picturesque valley having considerable width, and much level ground in many different points of its course. The sides are sloping and covered with forest, which with the luxuriance of the vegetation spread over the floor of it effectually conceals the rock; in one quarter numerous fragments of quartz rock may be seen something of the character of the rock noticed in Art 129, as found on the ascent to Bouchakadhar. It contains talc, and is frequently very tender almost friable. They are scattered over a smooth grassy knoll, nor is it immediately obvious

whence they come. The mountains on this side have flat declivities, without any rock visible, and are covered with fine forests; on the opposite side, it is true they are precipitous, and appear to consist of this very rock, but as the river forms a deep chasm between, and not a very narrow one, it is not immediately understood how they should have fallen on this side: perhaps they had occupied their present place before this chasm was formed.

137. The valley widens considerably at its upper extremity, but constantly presents the easy grassy declivities, or patches of forest, which so entirely cut off all access to the rock. The ascent is easy to the Dharma pass, which separates this valley from that of the Koomoolda, commonly known as the Ramasera, (note, Sera is always applied to those vallies where rice may be cultivated.) The latter is a valley of some note, and is thought by the mountaineers, of these otherwise, rugged districts to be a smaller kind of *des*,* but their praises and description of it are greatly exaggerated; there are several vallies in Kumaon and to the westward of greater extent. Its extreme width cannot be taken I think at more than a mile, and the length of the wide part, — miles; towards its mouth it narrows considerably, and the Koomoolda, the stream which waters it, finally joins the Jumna by cutting its way through a narrow ridge which lies transversely to the valley, and which has all the appearance of having once formed a barrier to its waters.

138. On the Pass were found fragments of quartz rock occasionally containing talc, and of chloritic schist. The latter rock with bent laminæ and oscillating towards talcose schist, was found in situ half way down the Pass. In the valley again gneiss once more makes its appearance in very thin laminæ, and dipping to north. This gneiss is very probably connected with the mass which rises up into the lofty peak Kedar Kanta, in the sides of which both the Gurogar, and Rama vallies have their origin; on crossing the valley quartz rock and chloritic schist are the only rocks to be observed, and of these even very little, owing to the arrangement of the surface and the deep deposits, either of debris or peat, which every where conceal the rock. One very large mass was observed consisting half of quartz rock, half of chloritic approaching to talcose schist, there was nothing like transition observable between the two substances, the line

* The term applied by the mountaineers to the plain.

of junction being strongly marked; the quartz rock was perfectly amorphous, not a trace of schistose structure was to be observed, the laminæ of the schist were considerably bent or undulated, it contained fragments of the quartz rock, some of which were coloured green, some retained their white colour; no fragments of the schist however could be detected in the quartz rock; this mass which appeared detached was surrounded by several smaller blocks, some of which were found to be quartz rock, some chloritic schist.

139. The route passes round the head of a second valley, which falls into that of the Kumoulada, and crossing the lateral separating ridge descends into the valley of the Bunal, another glen containing a good deal of level ground, though not equal to Ramasera or the Gurogar glen. In the descent above the village of Kande, gneiss was once more found, but down the valley, the mountains, at least their summits, appeared to consist of limestone; this gneiss was talcose, approaching to earthy, and it is again found below this village in the neighbourhood of limestone beds, and containing a bluish semi-transparent mineral in grains similar to that described (Art. 126.) Here the gneiss formation is finally taken leave of, being succeeded by talco-argillaceous schist.

140. We must now proceed to the valley of the Kalee, and trace the southern boundary there also. The former account stopped at Ookemuth on the Kalee. In a glen a mile south of it, is seen a schist full of those flat veins or circular masses of quartz which are so common in micaceous and argillaceous schist; this rock dips 45° NE., and has an inclination of about 30° to 40°. Between the villages Jukh and Oakee again, gneiss is met with; below in the bed of the river is a mass of calcareous tufa with vegetable impressions. It is of a light buff yellow colour, is rather porous with a semi-crystalline grain. It is a very pure carbonate of lime, and affords an excellent cement by burning, which was used for the stone temples erected one at Kedarnath, at the foot of the great Soomeeroo Peak,* the other at Ookee Muth where the Raool, or chief priest, resides.

* This temple is situated at the source of the Mundaknee, a branch of the Dhaolee, in one of those expanded vallies described in Art. 95. The elevation of the place is — and it is unnecessary to say that during many months it is deep in snow, and consequently not habitable. There is even no village within 15 miles of the place; it it rather larger than the generality of these structures, and is handsomely built of hewn stone.

141. Chloritic schist is seen again at Kandara in the Greenduala glen, which furnishes a middling sized stream to the Kalee; beyond the chloritic schist-gneiss is again found near the village of Baroo, Amorphous patches of earthy granite may be observed, so soft and crumbling as to yield easily to the spade. On the summit of the Pass a talco-chloritic schist obtains, and continues to the mines at Pokree, fragments, however, of hornblende schist being scattered about in some numbers; beyond this point no gneiss was observed in proceeding south; we may therefore return to Mumdal below the Toaugnath Pass, where the account of this formation left off. (Art. 103.)

142. This village is situated in the high bed of the Dulalee river, which has its rise in the schist of the Toongnath mountains, and joins the Dhoalee just below Gopisur. The route leads down the glen to turn into the valley of the Dhoalee; very little rock in situ was observed, indeed only one patch, which was of too little extent to say precisely whether it was granite or gneiss, the toughness being such as to set at defiance the hammer, and consequently prevent its effecting a fracture of the rock, so as to judge of its mineralogical composition. It was a roundish amorphous mass with a few irregular seams projecting but little above the surrounding surface, and thus, from its want of sharp corners, increasing the difficulty, occasioned by its toughness, of detaching a specimen. Fragments of hornblende rock, of quartz rock, and of gneiss, are abundantly scattered over all this tract. One block, probably part of a vein, was observed, consisting almost entirely of that variety of hornblende called actynolite; part of the containing rock still adhered, being a fine granular mixture of felspar, quartz, and mica, the first ingredient in greatest quantity. The actynolite has rather a confused structure; apparently large concretions formed of radiating bundles of prisms. The specimens obtained were not remarkable for beauty.

143. A more remarkable phenomenon was the occurrence of a huge mass, composed apparently of very similar ingredients to the secondary sandstones. It was a solitary rock which stood in the bed of the Dulolee, the top being covered with grass and shrubs; strictly it might be called a conglomerate, containing many large boulders or rounded stones. The base was rather fine grained, consisting almost entirely of quartz sand, and apparently held together by the slightest

coherence. The friability and want of consistence of the substance, prevented the retention of any specimens, as they fell to pieces immediately on being detached, though the rock itself, of considerable size, seemed persistent. I am inclined to think it was merely part of a diluvial deposit and not a legitimate sandstone, no specimen of which I have ever observed in such a locality. In reality though the sandstones are often friable, and have little coherence, yet I have never seen any which exactly resembled this rock.

144. At Sikol, in the bed of the Dhaolee, I found large masses of quartz rock stratified, probably with great regularity, but the fissures of the strata so intermixed with cross cleavages, that it was difficult to separate them, and say which really was the plane of the strata. The colour of this rock was greenish, it is also seen near Masooa, rather a large village near the rope bridge by which the Dhaolee is here crossed. The dip was N. E., inclination about 60° to 70°; close by the bridge it appears to pass into micaceous schist. Further on in the valley of the Mundaknee, it appears to pass into chloritic schist.

145. I must not leave the Dhaolee, however, without saying some thing of those great accumulations of boulder stones, the very sight of which strikes the traveller with astonishment, and forces him to admit the action of some great rush of waters. These diluvian beds are here seen on a scale, which sets at nought any theory that should derive its agent from the body of water at present occupying that channel. These deposits seem always to be found in those parts of the river's course where the valley widens considerably, at least it has been so in all the instances I have yet had to notice. In the immediate bed of the river, the fragments consist of two kinds, the one perfectly rounded, the other subangular. The rounded fragments consist of gneiss, granite and hornblende rock, the other of quartz rock and mica slate, the two latter being the rocks in situ in the immediate neighbourhood of the rounded fragments; these are of all sizes from boulders of four feet in diameter to the small grains of sand. That the river in its greatest floods, and in some particular parts of its course possesses the power of moving these stones, is certain, from the deep hollow noises heard every now and then. That it can do little more than merely move them is equally certain, from the fact of these boulders always occupying the wide parts of the valley. There are tracts here of a mile in length, and

probably 300 feet wide, (the depth is not known), consisting of these huge stones, great part of them now far above the reach of the highest floods. It is not to be understood, if they had been moved by causes still in operation, why none of them should have travelled a little farther.

146. Ascending to Sooralee from the bed of the Mundaknee, chloritic schist is found established, extending for some miles beyond the village to the foot of the Okrooaree Pass, which separates the Purgunnahs of Budhan and Dussolee. It is as usual much intermixed with quartz rock; some specimens of a straight laminar structure have an emerald green colour, and an almost metallic brilliancy. This is a beautiful rock. On the descent from the Pass gneiss is found of a small grain, a very compact rock. The dip is N. 80° E. the angle of elevation 60°, hence passing by the village of Koon to Choptah, quartz rock and chloritic schist prevail irregularly mixed. The dip generally N. E., the inclination 25°. At Chobtah, they are exchanged for an earthy micaceous schist, which however must be of very limited extent.

147. Below this village, on the road to Jak, the rock is of a less definite structure, being an irregular mixture of dolomite and talc; sometimes the grains are small and the mixture intimate, sometimes they are larger, and the aggregation of a granitic character, *i. e.* each mineral perfectly distinct, though mutually impressing each other. These distinct concretions become so large, that each mineral may be found forming the substance of distinct blocks. This type of rock occupies but a small space, being found only on the right bank of the glen below Chobtah; on ascending the other side, fragments of a granitic rock are met with, but of peculiar mineral character. The ingredients appear to be a dark bluish grey felspar, quartz and talc, the grain is small, the rock exceedingly tough and hard, with an amorphous structure, although some specimens shewed something like a transition into the schistose. This rock was not seen in situ, only in fragments, and has near been observed in any other locality. It is a very beautiful rock, and would be extremely ornamental if cut and polished.

148. Near Jak, beds of hornblende schist occur, apparently graduating into quartz rock; on the quartz rock, which contains felspar, rests a bed of chloritic schist of scaly composition and unctuous feel. These two rocks are perfectly distinct, and the line of separation strongly drawn. The dip is N. 60. E. and the inclination 40. Below them in

the descent to the Pindar much quartz rock occurs, dipping always N. E., but having frequently a second set of cleavage planes equally distinctly marked. The only method of recognising them is the greater or less permanence, the false stratification if it may be so called, often vanishing within short distances. At the foot of a precipice formed by a beautiful natural section of a quartz rock containing felspar, is a patch of grey rock, amorphous, without any trace of schistose structure, and projecting in large round masses, very similar to those which granite is seen to affect. It is probably a mixture of hornblende and felspar. A whitish rock of a small grain, and similarly amorphous, is seen in contact sending veins through it, and reminding one strongly of the description given of granite veins. This white rock is similar in mineralogical character to the stratified rock above noticed, consisting of a mixture of quartz and felspar. The fragments in the bed of the stream are chiefly gneiss and hornblende rock; they are frequently increased by calcareous spar.

149. On descending into the valley of the Pindar a greenish grey schist is met with at the rope bridge. Character intermediate between hornblende and chloritic schist. It probably belongs to the former title, though the fragments and other indications beyond this place point to a formation of talcose schist. Fragments are also met with of gneiss and of hornblende schist. At Zubburkat, the rock is a gneiss, of a fibrous columnar structure, dark grey colour, and earthy aspect. It probably contains, if not hornblende, some magnesia or a mineral, probably talc or chlorite. It also contains grains of the blue semi-transparent mineral noticed (Art. 139.) Beyond this village immense blocks of a well defined gneiss are met with, resting on the mountain side, and some few of hornblende rock, but such is the thickness of the covering of debris and vegetable mould, this being the side of easy slope or quarter of the dip, that no instance of the rock in situ occurs till we approach the village of Chelinga; here may be seen a strata of gneiss, dipping N. 85° E. and at an angle of 40°. This gneiss agrees in character with that constituting the large blocks just noticed, and has an affinity to that seen at Zubburkat. It is a small granular mixture of black mica, greyish white felspar, and quartz, with distinct foliated grains of felspar superadded. The quartz is obscure, and indeed in all these mixtures of small grain, it is not easy to detect the nature of ingredients

so intimately mixed, without using some method of mechanical analysis, similar to that proposed by M. Cordier.

150. In the ascent from the village of Chelinga to the Goruldum Pass, no rock in situ is visible, but fragments of granite occur, of various sizes, strewed over a small flat at the commencement of the ascent. The source of these is not obvious. On the summit of the Pass quartz rock and chloritic schist, passing into micaceous schist are found in strata, the dip of which is a little obscure, but which seemed to be N. 60° W. Of the quartz rock, it is doubtful, whether it be not a transported block, but the schist is evidently in its place. On leaving the Pass in the descent to the village of Koolem, an earthy decomposing granite in amorphous patches is met with, of the same character as that noticed above Baree, in the valley of the Mundaknee, (Art. 100.) This rock is a very remarkable one, and requires a little detailed description. The proportion of felspar compared to that of the other ingredients is very great, and it appears to be singularly subject to decomposition, so much so, that the rock may be dug like a bed of clay or vegetable mould; the quartz and felspar, on a first appearance, form one uniform mass, in which, however, they are to be distinguished by colour, the quartz being greyish white and the felspar yellowish, and by their state of disintegration. The mica is of a dirty brownish green colour, and is disposed rather irregularly, as well as scantily. The laminæ are never parallel, a character by which it has been proposed to distinguish granite from gneiss, and which if it hold universally, will form an useful distinction, as being easily recognised.

151. On descending into the valley described in Art. 149, no rock is visible for a considerable distance, the soil being of great depth, and frequently overspread with forests. In the beds of streams however, may be observed occasionally the edges of strata, both hornblende schist and gneiss, and there are several patches of the decomposing granite also. In the ascent from Hath to Retorah villages, gneiss may be observed, at first of a very regular character, bluish grey, and strongly resembling the most legitimate gneiss of the Himmalaya. The gneiss appears gradually to pass into micaceous schist, which at Retorah is white, fine granular, and almost might be called slaty quartz rock. On the summit of the Hackena Pass, which leads into the valley of the Cossillah, it is of a dark greenish brown colour, very micaceous, and very

tender. The dip of the rock at Retorah was irregular, and the gneiss in the neighbourhood equally so, the strata having many undulations, but the rock observed in the bottom of the valley had a dip N. W.

152. Descending from this Pass quartz rock of an arenaceous composition is found. It contains beds of chloritic schist. Beyond this, near Mala, argillaceous schist becomes established, of great variety of aspect, of a purplish, greenish and light grey colour, straight, fissile, with rhombhoidal cleavages, and of a soft consistence, comprising every variety almost of the brightest colours. It contains beds of limestone, which are often highly argillaceous. Farther down in the valley of the Cossillah, micaceous schist is met with, and then an extensive patch of gneiss, which stretches across the valley, and is probably connected with other masses shortly to be noticed. Afterwards the micaceous schist again re-establishes itself, and continues to Almorah. Here for the present we shall break off this description, and return to the route from Sacen, in which gneiss was traced as far as Naneik, and to the bed of the Ramgunga below the village, (Art. 106.)

153. The route proceeds by Ratik, gneiss accompanying us the whole way; some fragments of a very peculiar rock were found, composed wholly of a substance which might be called intermediate in character between rhombohedral and prismatic talc mica. It was of a dark brownish green colour, and the foliæ of the mineral were placed in every direction, having the appearance of a confused aggregation. The same rock occurs rather abundantly in the ascent to the Soor Doora Pass, but always in fragments, while the rock in situ continues to be gneiss as far as the village of Soor. Beds of hornblende schist, and of micaceous schist occur in the descent to the bed of the Sirjoo river; the gneiss being, however, the containing rock, and continuing to some distance beyond the village of Soope.

154. Here the rock begins to change, the gneiss appearing to pass into a fine grained mixture of talc and quartz, which may also perhaps contain felspar. This is succeeded by quartz rock, which again becomes talcose, and incloses small beds of talcose schist. It passes into chloritic schist also, the quartz becoming at first green. The latter rock contains veins of quartz, and on one a particular concretion of so remarkable a shape and appearance, as to have the strongest resemblance to a rib-bone. In endeavouring to detach it, the resemblance was des-

troyed by fracture. On the Pass of Chowr Bunaik, the talcose rock is fairly established, being occasionally schistose, occasionally amorphous or massive. It is of a white colour and beautiful nacreous lustre. Descending thence, various mixtures of this mineral, (prismatic talc mica,) with quartz, are found sometimes inclining to a green colour, and apparently allied to chloritic schist, sometimes to a blue, and passing into argillaceous schist. Alternating beds of the green schist and quartz rock were observed, very regular and well-defined.

155. In the neighbourhood of the village of Kurrimee, the rock is a mixture of white granular dolomite and talc. The latter is sometimes found in beautiful nacreous scales, disposed in nests or nodules, at other times intimately mixed with the particles of the dolomite. In the latter case, the rock is extremely friable, and resembles very strongly the dolomite of the Alps. This rock is succeeded by a schist of an argillaceous character, very soft and tender, and of a dark blackish grey colour. The schist is occasionally green in the ascent to Tobne Binag, where the view of the mountains discloses several beds of talcose schist of a whitish colour; descending to the village Bugur in the bottom of the glen, limestone is the rock. It is often very impure, being highly charged with argillaceous or siliceous matter. It is regularly stratified, dipping N. 48° E. at an angle of 60°. The strata are sometimes curved.

156. This limestone continues in the ascent to the high Pass of Cheeoonga Binag, the whole of which ridge is composed of it. With occasional patches of schist of an argillaceous character, it still accompanies us by the village of Ingthana to Bynsaree, in the route down the glen in which those villages are situated. The strata are sometimes fissured and cracked in every direction, and in some cases so fragmentary, that large masses have fallen out, thus giving rise to extensive caves. From Bynsaree, the route passes up a lateral glen to Soomchala, crossing an elevated ridge. On this ridge and the immediate ascent to it, argillaceous schist is found of a reddish brown colour, earthy composition, and splitting readily into rhombohedral fragments. This rock is sufficiently exposed also in the descent to Soomchala, where it is remarkable for its many changes of colour, within a small space; as also for the rhombohedral cleavages passing into the straight schistose.

157. As far as Darimket, the route lies in a succession of glens, in which no trace can be found of the rock in situ at that village. It ascends, and immediately a talco-micaceous schist is met which continues to the foot of the descent into the valley on the other side. This latter is one of the many branches which fall into the great one of the Gaomootee, described, Art. 65, and as such, partakes of the open and level nature of the latter. At the foot of the descent fragments of hornblende rock occur in great abundance, and a little further, the rock in situ is found to be an earthy gneiss, extremely soft and crumbly. This rock continues to disclose itself in different parts of the river bed as far as Byznoth; and at the foot of the ascent to Retora a grey gneiss of very perfect character is seen dipping N. E. In the ascent to Retora, this route coincides with that described Art. 65.

158. We have now to take up our account of the gneiss at the village of Dampa, Art. 105 where it is described as of a remarkably regular type, and disclosing itself in extensive masses distinctly stratified. From Dampa to Munsaree, this rock continues, and near the latter place and above it, are enormous blocks of this rock scattered about in the wildest confusion. Thence ascending to the Betoolee Dhoorah Pass, the same rock is occasionally found, and occasionally beds of hornblende schist. At Munsaree there occurs a bed of a very beautiful rock, being a mixture of white granular limestone and talc, (prismatic talc mica,) the latter is occasionally diffuse. Amongst this the carbonate of lime occasionally occupies distinct layers, passing into the argillaceous schist. This rock furnishes excellent roof slate, being very fissile. In the bed of the Gurjeea river below Munsaree, the rock is an earthy brown, tender, micaceous schist in descending the bed of the Gurjeea, as succeeding to the gneiss.

159. Descending from this Pass, quartz rock occurs in extensive masses distinctly stratified, dipping N. 15° E. Other fissures at right angles, at distances of five feet, are extremely distinct, the whole mass being thus divided into rhombohedral or cuboidal masses. This quartz rock is seen sometimes plain, sometimes green from the addition of chlorite, and sometimes blue, probably from an admixture of argillaceous schist. On the Kalee Moonnee Pass and the descent to Girgaon, the rocks are rather of an anomalous nature, and comprise beds of very various and varying composition. Talc slate, yellow, white and blue

carburetted clay slate, blue ditto, talcose quartz rock, and talcose limestone are the most marked types, and they succeed each other in the most sudden and unexpected manner. In general, however, the formation may be said to have a talcose character, that mineral forming more or less of the composition of each rock, but I think that it is surmounted, or at least surrounded, by the same gneiss which accompanies us from Munsaree, and which appears in all the larger masses and the more elevated ridges. In the bed of the nullah below the village, rounded blocks of this rock are seen of an enormous size, which confirm the above idea. Beyond this point, it is not found till we approach Almorah, and the masses in that neighbourhood being connected with the granite beds there, will be better described when we come to the details of the latter.

160. The preceding comprises all my observations of the localities of gneiss within these mountains, with some trifling exceptions hereafter to be noticed. It will now be necessary to proceed to the next formation in the order of succession. It is of a schistose structure, but very variable in mineral character, comprising micaceous chlorite, talcose, and even argillaceous schist. My observations are not yet sufficiently multiplied to determine, whether all those schists form one member in the succession of rocks, or whether the three first are to be considered as most intimately related, and the argillaceous band as the distinct term in the geological series. Some anomalous appearances, which are inimical to the latter view, may perhaps be explained by the intrusion of the granite masses in the middle of argillaceous strata, but it would be premature at present to decide either way. We may for the more convenience of description, consider them all as members of the same formation, as each in its turn is conterminous with the gneiss.

161. Beginning with the most western route, we may take up the description where the micaceous schist in succession to gneiss was again exchanged for chlorite schist. Near Laké, the latter rock may be seen, though from its transitions it ought perhaps rather be called a magnesian clay slate, (talco-argillaceous schist.) It has a N. E. dip. It extends to the foot of the descent into the bed of the Salung river. There may be seen an impure limestone associated with a clay slate, the two rocks being found not only in alternate layers, but also occasionally intimately mixed in the same layer. The fragments in

the bed of this river consist of granite, gneiss, micaceous schist, and hornblende rock, all of them substances at present found in situ only at a considerable distance.

162. Ascending to Reowthul, numerous indications are observed of a limestone formation; clay slate does not entirely disappear, but the higher ridges in the neighbourhood, judging by the outline and general appearance, are evidently limestone. This rock affords one of the instances in these mountans in which disposition of form and colour is an unerring guide to the nature of the rock, forming a series of irregular terraces or ledges, the faces of which are always precipitous, and stained with black and yellow, the outline of the summit presenting a rather flat curve; it is impossible to confound the limestone of these mountains with any other rock. There is certainly a local physiognomy in rocks, if I may so express myself, which enables a person familiar with them, frequently to determine correctly their nature, from the mere view of the mountains in which they are formed. But there is no truth in the opinion that would extend these local phenomena to a wider sphere, so as to make them instances of a general law.

163. At Reowthul, there are several smelting houses for obtaining iron from a hydrated peroxide, (prismatic iron ore,) which is found in the neighbourhood. I had not time to visit the place whence the ore is obtained, but I examined the specimens of it which they had brought for smelting. It is a light scoriaceous yellowish brown crust, and very similar to deposits of the same ore which I have seen in other localities as originating in streams, permeating argillaceous schist, and strongly charged with ferruginous matter. The iron is said to be in repute.

164. From this village the route passes round the brow of the range to the Pass immediately above Surara, and in this line wherever the rock is seen it would appear to be limestone, with some trifling exception in the occurrence of a micaceous argillaceous schist. At Surara again, the rocks are all limestone, presenting that appearance so common to this class, of huge amorphous masses united to others often honeycombed or irregularly varied in surface or regularly stratified, or even schistose. Yet I would say on a large view of the phenomena, that this rock seems to be always most regularly stratified when most impure, and vice versa. Another appearance remarkable in this limestone is the aries

that seems to attack lumps small of it, changing the outer surface to the colour, grain, and consistence of chalk. This change is the more remarkable in a rock, which like this is of a blue colour, and possessed of considerable hardness.

165. In the descent from Surara to the bed of the Syrij river, limestone is the only rock seen, ascending thence to the ridge which forms the right bank the same rock prevails of a less pure type, and occasionally of a schistose structure. In the lateral glen in which the village of Ureea is situated, the rock appears to be mica slate, or a transition between that and clay slate; the limestone is in general impure; when otherwise, it appears to undergo that superficial caries already noticed. It must be rather an extensive bed, for most of the surrounding ridges were also observed to be composed of this rock, as recognised in its characteristic ledgy precipices. This limestone is also seen in the descent to the Bangur, and also in the bed of that nullah, distinctly stratified and dipping N. E., the reverse of the micaceous argillaceous schist near Ureea, which is S. W.

166. On ascending from the bed of the Bangur, an anomalous rock is seen, in amorphous patches of a greenish colour and considerable hardness, very possibly ferruginous quartz rock. A black type of the same rock occurs in fragments in the bed of the nullah, and with disseminated iron pyrites, (rhombohedral iron pyrites,) argillaceous schist then establishes itself, being occasionally of a magnesian character; occasionally (below Sookowlee,) of a micaceous. The route here passes over the several ridges which ramify from the Chandpoor peak, the rock of which is micaceous schist, and this line appears to be the junction of the two formations, to judge by the frequent transitions and oscillations. It may be observed, that the strata appeared pretty regular, and with exception of the rock at Ureea, appeared to dip conformably.

167. In the vicinity of Sokanda, the schist assumes a micaceous character. Near Dharee, limestone protrudes in limited quantity, and we have then the argillaceous schist with its usual variableness of character continuing to the bridge over the Tonse at Mywar. It is at one time a blue smooth laminar slate, (talc argillaceous schist,) again a fine grained slate approaching to compact (argillaceous schist,) which is succeeded by a fine grained greywacke, slate (micaceous

argillaceous schist). Just above the bridge, nodules of limestone are seen, but the rock appears to have no extent.

168. In the bed of the river, a very perfect type of argillaceous schist is seen, distinctly stratified, and dipping conformably. It passes into a rock, having the strongest resemblance to reunited angular debris. It is in this rock that the Uyar lead mines are situated. The rock is so soft, as to afford great facilities in excavation, but unless well supported by wooden framing, it is liable to the accident of falling; has happened more than once, and several miners have been crushed. The ore is a steel grey fine granular galena, (hexahedral lead glance,) and is often found in veins traversing quartz; it is accompanied by iron pyrites, (rhombohedral iron pyrites.)

169. At this place the river is crossed by a bridge formed of a single rope, on which a block with the passenger or baggage attached, traverses. It is a very tedious, though perfectly safe method of crossing a river. On the right bank about one and a half mile lower down is the lead mine of Mywar, belonging to Tounsar, one of the reserved districts. That at Uyar belongs to Sirmoor. At Mywar, the same ore is found and accompanied by the same minerals, and the containing rock is there also a clay slate, though occasionally very calcareous. The galleries are very numerous; in some, sulphur is obtained. In others, the vein is a blackish friable earth, in which the galena is in nodules.

170. The route to Borrela from this place turns back to the northward, ascending along the right bank of the river. In crossing the Ventijar, which here falls in the Tonse, argillaceous schist is seen in its bed in situ, while the round stones are all limestone. These boulders continue to the height of 300 feet above the bed of the river, and are united with a calcareous conglomerate, which is, however, of a very limited extent. Argillaceous schist is thence the prevailing rock, but mixed with occasional patches of limestone; above the village of Joktan the latter rock establishes itself in larger masses, constituting whole ridges, and extending with very little interruption thence to Borela.

171. It is in this rock, which in its lower strata appears to pass into argillaceous schist, that the lead mines of Borela are situated. The ore is in every respect similar to that found at Uyar and Mywar, and is also accompanied as there, by iron pyrites. The number of galleries here, as well as at Mywar, is truly surprising, and shews the perseverance of

these people, even with their imperfect means. They told me they were in number eighty, many of them of great length, and yet the village is small, and does not contain above forty inhabitants of every sex and age; but there are several other villages that have a joint proprietary right, the assessment being made on the small purgunnahs or hundreds, as they might be called, and not on the individual villages.

172. The limestone of Borela continues to Haje, with very little interruption, and through a varying level of at least 1,500 feet. It very often contains veins of a pure white calcareous spar, sometimes it is fœtid, and then it always appears to be less pure. In this latter case, it is occasionally found to contain veins of white granular limestone, and not unfrequently also, to pass into a flint slate or schist. It has its subordinate and limited masses of local breccia, and conglomerate accompaniments, which this rock is never seen to want. It is a good deal intermixed with quartz rock, and has occasionally, as might be expected, a silicious character. With regard to its stratification, it is when at all impure, distinctly marked by parallel seams, and when pure, as often amorphous. This indeed is a remark I think universally applicable to limestone. A very remarkable curvature of the strata is seen on the ascent from the Mator nullah, which separates Haje from Borela; some indications of argillaceous schist were also observed here.

173. Near Haje, the rock may be called a well characterised argillaceous schist, which afterwards becomes micaceous. This is succeeded by a series of types of quartz rock of very various character. The most remarkable feature in this rock is the suite of colours it exhibits: grey, green, red, purple, and brown from the extreme shades, and in their transitions, a great variety of intermediate tints are produced. In general, it has a granular composition with considerable hardness. The structure is occasionally cleavable in three or more directions, occasionally it is subschistose. In the latter case, the rock is observed to pass into an argillaceous schist. In general, this quartz rock owes it colours to indurated clay, or a basis of clay slate, and it contains superadded to this ingredient, scales of mica, never in any abundance. The composition is never of that decidedly granular appearance which distinguishes the sandstones; frequently it is evanescent where the proportion of quartz is a little less predominant. I think this rock might

be considered as a greywacke; some of its transitions into argillaceous schist are doubtless entitled to that designation.

174. On the border of this rock, we find another of so anomalous a character, as to require some illustration from investigations in other parts of the line of strata. It consists principally of indurated clay and quartz, and contains grains of a green pellucid mineral, very much resembling some varieties of actynolite. It also contains mica in notable proportion. It is in fact one of the many aspects under which the above described quartz rock is found to vanish. I have sometimes thought that this rock has some connection with one occurring on the road from Bheemtal to Almorah, and which will be afterwards described. Like this, it is connected on the one side with quartz rock, on the other with clay slate. In this quartz it is succeeded by a small patch of slaty limestone, which speedily gives way to the prevailing rock of distinct argillaceous schist.

175. This schist presents a great variety of types, as may be seen on the road to Deao. It is sometimes compact, sometimes granular, often heterogeneous in composition. The granular types are seldom perfectly fissile, some not at all. In those which are so, the laminæ are almost always undulated. It is further remarkable for the quartz veins by which it is intersected in every direction, not only in that parallel with the laminæ of the schist, but also transversely, and in every possible angle of obliquity. These veins, as has been often remarked, never appear to interfere with, or disturb the arrangement of the parallel layers. In one instance, where dip has occurred, a bed of local debris (alluvium of descent) of fifty feet in thickness is observed resting on a highly carburetted type. It is not improbable, from this and other indications formerly observed, that graphite exists in this neighbourhood. I ought not to omit noticing, that the dip wherever observable was between N. and E.

176. This schist continues in the descent to Kalsee, and under such protean aspects, as renders the study of its relations extremely interesting. It is at one time a green slate, with smooth laminæ, which by a gradual change, passes into a rock, that in hand specimens could not be distinguished from a greenstone. The transitions into this rock are remarkable for affecting a rombohedral cleavage. Within a few yards it again appears as a shattered slate, consisting of very thin and scarcely

adhering plates confusedly united, as if they had been crushed, or at least suffered some violent pressure. The ordinary type is seen to pass into a veined one, the veins being quartz, and this gradually into a quartz rock of a dark colour, highly charged with the indurated clay of the slate, and still intersected, as that was, by veins of pure quartz. The laminæ of the most perfect slaty varieties are very often bent; small patches of limestone, evidently the traces of included beds, occur along the whole line.

177. At Kulsee, the rock is still argillaceous schist of a very perfect type, dipping E. of N., that is, at the bungalow belonging to Major Young on the hill; but in the descent to, and in the town, the rock in situ is concealed, and it is not till after having passed it a mile or so, that a new formation (sandstone) is observed to be established. The strata dip S., and a little further on, are vertical. From this position they gradually passes to a dip E. of N., but possess still a high inclination. The character of the rock is perfect, and leaves no doubt that the argillaceous schist has here terminated, and is succeeded by a totally different formation. I shall therefore defer my details of the new rock till I follow out all the details of the former one, and trace it in a similar manner to its boundary in every other quarter in which it has been examined.

178. I shall take up my description at the point below the village of Kande in the Burral district, where the last patch of gneiss was found, (Art. 139). It was noticed that the ridges above appeared, by their outline and arrangement, to be limestone; a few traces may also be seen in the bed of the stream, and fragments of the local conglomerate which always accompanies limestone. The rock then becomes a talco-argillaceous schist, being frequently distinguished for its beautiful pearly lustre and pleasing colours. This type is further remarkable for its smooth gently curved laminæ, and the minute undulations or furrows of their surface. These latter I have almost invariably observed in slate that contains a sensible proportion of magnesia. Besides this well marked variety, there occurs another of an earthy character, which gradually passes into hornblendic schist.

180. The dip of the strata in this glen, (Burral,) was uniformly W. and N. W., and therefore not conformably to what I suppose the general dip of the formations throughout these mountains. Nor is it an

irregularity confined to a small extent of country, for the surrounding ridges and peaks are all obviously conformable in dip to that observed in the valley itself. In the Rama Sera glen again, it was observed to be,* which is something more approaching to the usual dip. In this case the principal effect due to the disturbance of the strata, (if they really be disturbed,) would be found in the Burral glen. It is to be observed, that both the Burral and Comoulda rivers spring from the furrows which intersect the sides of the great Kedarkanta peak elevated — ? feet. This peak is remarkable for its shape, and for the arrangement observable on the summit. The shape is that of an immense truncated cone, which appears to have an oblique position, owing to its greater slope on one side, and precipice on the other; the summit is flat and of some extent; at one end is a considerable hollow, in which are wedged together, in utter confusion, enormous blocks of gneiss, the rock of which the mountain consists. The strata appear to dip N. W. What connection the peculiar character of this peak (if any) may have with the irregularity of the dip, it would be vain to enquire without a more detailed examination of the vicinity.

181. At the mouth of the Burral glen is an extensive flat, communicating with a similar one in the valley of the Jumna, and very little higher than the present level of the latter. It is observed to terminate in the bed of the Jumna in smooth rounded elevations, which on the river side are cut down vertically, and exhibit, in the precipice facing the river, their structure in the most complete manner. This precipice is about 120 feet high, and is composed of loose gravel and sand, with numerous round stones of every size sticking in it, some of them half projecting. On the opposite side of the river appears a similiar bank, composed of similiar appearances, and of the same height. The intermediate space, to judge by local appearances, must have been once filled up; for so narrow is the gorge, that no possible slope at which they could lie would clear them of the river bed. Indeed, the one is washed by the waters of it, and at the foot of the other, the path is not more than a few feet wide.

182. The right bank sinks, as I have said, gradually into the broad and level flat at the mouth of the Burral glen, the slope being, like the latter, covered with verdure. The left bank continues of moderate

* Blank in MSS.

width to a point below the affluence of the Burral, and then gradually subsides about half a mile. Below this point occurs a third similar flat, doubtless composed of the same materials, and containing about half a square mile of level ground. It is worthy of remark, that the three are, as nearly as the eye can judge, of the same level. It should also be noted, that in the two, the structure of which appear, nothing like strata or a division, nor distinction of deposits occurs; the great and small boulders are indiscriminately mixed in every part, and the whole has the appearance of being the effect of some very powerful, but sudden or short-lived cause. The fragments most abounding are quartz rock of all colours, next to this is hornblende schist, with very few of granite or gneiss.

183. The last rock observed in the Burral glen was a blue talco-argillaceous schist, with a pearly lustre. In the bed of the Jumna, close by the suspension bridge, a mass of limestone occurs. On crossing the river, a rock of limited extent is met with, and of very anomalous character. It is probably a mixture of chlorite quartz and felspar, the latter not abundant, or the green ingredient may be some variety of hornblende. The structure appears to be laminar, yet the fracture is such as to indicate the amorphous. It is a tough rock, and breaks with sharp corners. It is succeeded by extensive strata of a talco-argillaceous schist, the prevailing colour of which is an olive brown. The dip appears to be N. W. the same as that in the Burral glen,

184. From Burket to Bimsa, the prevailing rock is chloritic schist, often inclining to argillaceous, often soft and decomposing, intermixed with beds of quartz rock which generally incline to a green colour. The earthy, or decomposing and the more perfect straight laminar types, are often found in the compass of a few feet, nor can there be any doubt of the unity of this formation when we view it in nature; although a collection of the specimens, unless extremely numerous, might exhibit some very striking contrast. Frequently, the laminæ are extremely thin, quite flaky, and in this case they are seldom separable of any size. From such a rock, it is impossible to detach a specimen, for on the application of the hammer it flies into showers. When the colour inclines to green this rock is generally soft, when to blue it is hard. No good examples of strata are met with on this line, the rock seldom appearing but in surface patches of no great extent.

185. From Bimsa the road ascends a lateral ridge, and thence descending upon the village of Tevan, crosses the Bunnee glen near Kateel. On the summit of the ridge, or rather just below it, there is an exposure of the rock, (in a space little exceeding ten square yards,) of the following very dissimilar substances :— 1. a light bluish grey mixture of talco-argillaceous schist and quartz, this changes to, 2. a more perfect schist, with bent laminæ, the colour still bluish or grey, the aspect a little talcose ; 3. a true chloritic schist, with similar bent laminæ ; 4. a dull green earthy compound without lustre, has a subconchoidal and uneven fracture, splits into thick flags, and is subcleaveable ; it is probably a mixture of hornblende and felspar, or of chlorite and felspar, or possibly all three ; 5. a light bluish green talcose schist, with curved and straight laminæ and considerable lustre. These types will also serve for a description of the rock as far as the ford over the river, occurring in various propositions and successions, which it would be a waste of time to attempt to devolve, the whole being united in the clearest manner, and constituting but one formation.

186. The ridge just crossed in its prolongation, puts on the appearance of the limestone precipice described, Art. 181, and on crossing the Bunnee river, there is little doubt but that these appearances are indicative of a limestone bed. It continues for about two miles, when argillaceous schist establishes itself, extending over the Gooddur Kuttal Pass to Moolla, a small village in the Gooddur glen. This schist is certainly not at all talcose in its aspect. It is of a fine granular or earthy composition, is very soft, and is remarkable for splitting into prisms, not laminæ or slates. They are sometimes of considerable length, slightly flexible, and would form very excellent slate pencils. It is of a great variety of colours, black, bluish, greenish, yellowish, olive brown, reddish, &c. &c. It contains numerous beds and veins of quartz. Below the village of Moolla, it passes into, or is replaced by a true chlorite, dipping N. W. with an inclination of 35°.

187. From Moolla to Horinsee, the argillaceous schist prevails, none of a chloritic character being visible. Close by the latter village, there is a mass of rock deserving of examination. It appears to be in one spot of a fine blackish greywacke schist, with scales of mica disseminated ; the composition fine granular, the structure well marked schistose. It is in contact with, and passes into a reddish brown rock of

coarser composition, with a structure amorphous, or at least only subschistose. Adjoining the latter, a greenish grey rock of fine granular composition, the structure entirely amorphous, and having a high specific gravity; consequently containing either hornblende or augite. The three types are all included in a single mass of no great extent, and on passing them, argillaceous schist of the usual character is found.

188. From Horensee, the route passes down the Bhudree glen, which is of some width, and encloses a good deal of level ground. In consequence, the rock is not often visible. Close to the village of Kol, there is a sudden descent, in which strata of schist appear intermediate in character between argillaceous and micaceous schist. It is accompanied by quartz rock, which as usual, forms a series of transitions into the schist. A little beyond Koree, a pale bluish grey subschistose rock, a composition probably of indurated clay and quartz rock, comes to the surface. It is succeeded by a dark blue argillaceous schist, containing nodules of quartz, the laminæ of the slate being bent round them; a bluish grey rock of a subschistose structure, not very quartzose, becomes then established. If it were not that it wants the decided appearance of a mechanical origin, I should feel strongly inclined to call this a greywacke. But the erroneous application of the latter name is the more to be guarded against, since it has become certain, that some of the rocks which have been distinguished by this appellation, are identical with the red sandstone, a rock of which no trace is found in this quarter. Under the title of argillaceous schist and quartz rock; it cannot lead to any false conclusions, and as such, it may be described until our nomenclature of rocks be more discriminative of them than it is likely for a long time to be.

189. It continues as far as Koodsoon in the valley of the Aglar, forming the whole of the ridge which separates the Bhudree glen. In the bed of the Aglar, a very similar rock prevails, but on the ascent it acquires the more characteristic aspect of a true clay slate. Infaceous conglomerate is also seen in isolated masses, and occasionally a blue limestone. Near the village of Ramon, the latter rock becomes established, to the exclusion of the slate. It is, however, of very various aspects, sometimes it is a black, hard, non-effervescent rock, fœtid when struck, and possessing scarcely any resemblance to limestone. This is its condition generally in the vicinity of the masses of gypsum which are here found; at other times it is highly siliceous, and though bearing

the appearance of limestone, might from its non-effervescence, be called schist; the pure blue limestone is, however, also found, and in considerable quantity.

190. The gypsum which is associated with this limestone, is of a saccharoidal aspect, the colour being beautifully white, and the grain fine. No crystals, except the most minute, have been observed. It is found neither in beds or veins, but in superficial amorphous patches, presenting an appearance of considerable singularity and interest. It is always connected with the black non-effervescent rock described in the preceding paragraph. The latter has very often the appearance of reunited fragments, and the gypsum sometimes contains nodules of it. Without doubt some connection exists between the origin, or at least the present place, of this gypsum and this very singular rock, always found in contact with the former, and not observed hitherto anywhere but in the immediate vicinity of it. There is not the slightest appearance of stratification in either rock.

191. From Ranon to the summit of the ridge, (Mussooree Tuba,) limestone prevails, and the varied and picturesque disposition of this mountain sufficiently attests the character of the rock. In all countries it has been observed, that not only are the limestone districts most fertile and productive under the labours of agriculture, but that also when abandoned to the hand of nature, they furnish the most picturesque and beautiful scenery. The summit is composed of the same rock, and constitutes one of the most romantic spots within the circuit of the mountains.

192. Advantage has been taken of the elevation, and the consequent coolness of the climate, to establish a nursery garden at Saharunpore. This is intended for the purpose of naturalising the more hardy plants of the interior, that otherwise would languish and die, under the fervors of a tropical sun if too suddenly transplanted. It promises to be eminently successful, though as it had only been just begun when I visited it, this opinion must rest on other grounds than experience; no doubt a favorable feature in the plan, though accidental, and not a disposing reason for the original choice, is the nature of the rock; the argillaceous and micaceous schists, the only rocks besides limestone from which the selection lay, furnishing a very poor and meagre soil for almost every description of produce.

193. From the garden, the road descends obliquely along the face of the range to the village of Juree Panee, in this line the limestone is lost almost immediately, and argillaceous schists succeed. They are of various colours, many of them very bright, red, yellow, green, grey, olive brown, purple, &c. This change of colour is characteristic of this rock, which is further remarkable for its different degrees of consistence, being at one time soft and diffusible in water like clay, at others hard, and though not furnishing good roofing slate, yet very similar in mineralogical character to that substance.

194. At Juree Panee, limestone again appears, but in small quantity; some specimens were observed of it containing veins of fibrous gypsum. These were of the most regular type, and had no resemblance to the black scoriaceous rock before noticed, as associated with the gypsum near Ranon. The argillaceous schist again establishes itself, and continues to Rajpoor at the foot of the descent. In this line it is rather harder, in general, than that above described, and inclines more to blue, purple, and green colours. It contains masses of quartz rock often strongly impregnated with the matter of the slate. At the foot of the descent, the structure appears to change to that already described Art. 184, as consisting of thin folise or leaves scarcely adhering, and of very limited size.

195. The mountains which bound the Doon to the north, and which stretch from the Jumna to the Ganges, are all composed of argillaceous schist. Beds of limestone occur similar to those already described, but never of any great extent. Gypsum also similar to that at Ranon is found, and under similar relations at two other places, and it is probable, will be eventually discovered at many more. In the bed of the stream in which the Sunsar Dhora, or Dripping Cave, is situated, and about a mile higher up, may be seen the remains of a very large bed of this substance, the greater part having been removed by quarrying. It lies in the same kind of superficial amorphous mass, and is associated with the same fœtid anomalous black rock as at Ranon. There are two varieties which lie in contact, and between which, a kind of transition takes place. The one is of a beautiful saccharoidal aspect, of a snowy white colour and fine granular composition. The other is of a dirty white colour, approaching to yellowish grey, and the composition is finer, almost impalpable; nor are the minute crystals discoverable in

it, which may be seen to constitute the grain of the other, being in fact dull and earthy, like chalk. It is the more abundant of the two, and indeed may be had in almost any quantity. It would probably answer for the preparation of plaster of Paris, though certainly not for statuary.

196. The other locality is in the bed of a small nullah, which falls into that in which the Dripping Cave is situated. There are some springs in the bed of this stream, which have a strong odour of sulphuretted hydrogen, and I should notice that the water of almost all these streams deposits carbonate of lime. The gypsum at this locality was described to me as forming a mass incumbent on clay slate, and not in contact with either limestone or the black rock so often mentioned. This mass had a flattened form, and might be called a bed; a perpendicular fissure in the slate was filled with gypsum continuous with the upper mass, thus giving the idea of a deposit. In my attempts to find the place I was not successful, but I met with many loose masses, and some of rather impure appearance, entangled with the angular debris which had rotted from above, and settled into banks of different heights at the foot of the mountains. It was associated in such a manner, as to leave no doubt that it had been in a state of fluidity when it assumed its place there, and thus we might pronounce with some certainty on the comparative ages of these masses of gypsum, which in this instance at least must have been posterior to the formation of this local debris.

197. We have now again descended to the Doon, where a totally different order of things prevails. It may be useful before proceeding to the Eastward, to notice different detached points at which the same formation of argillaceous schist has been observed. At Riki Khes and along the banks of the Ganges, as far as Deoprag, no other rock is seen. In the route too from Dehra to Teeree, the residence of the Gurhwal Raja, it equally prevails, the several types corresponding accurately to those already described. In particular may be seen the soft variety of various bright colours in the ascent from the village of Manjgaon in Sikimana pergunnah. Excellent roofing slate is general throughout this quarter, nor are the houses ever covered with any other materials; along the whole valley of the Aglar, it was equally general, occasionally presenting however a patch of limestone. The Byrath range, which

shuts in the Umloo, is also composed of it, frequently containing beds of quartz rock. In the valley of the Tonse, argillaceous schist is traced as high as the village of Kande. In the route from Calree to Jytull, little other rock is seen excepting limestone, which in the neighbourhood of Kangra is abundant.

198. From Jytull again to Subhattoo, the road, passing along the summit of a ridge, carries with it, the whole way, argillaceous schist. In this tract, no limestone beds are found, but quartz rock is common from Subhattoo to Bar; in descending to the plains the same rock continues. In passing to the north road to Kotgurh, it is equally constant, at least as far as Lunla; how much further it continues in that direction, or where the junction with the mica slate takes place, I have no means of judging. From Subhattoo to Joonug, the residence of the Ranee of Kyoontal, it is equally constant, and extends probably much further. In the route from Nahun to the Choor mountain, clay slate prevails to within a very short distance of the latter, containing extensive beds of limestone, which in detached masses stretch along the crest of the Sacen range, dividing the valley of the Girree from that of the Jullal; connected with their beds are probably the masses which form the summits of the Rajgurh and Krol mountains; at the feet of these the schist reappears, continuing to extend as far as Subhattoo. Finally, the valley of the Sutlej between Koomharsen (or a little below it) and Soonee contains this formation.

199. It is time now to return to our details on the Kedarnath road, which were broken off at Almorah, (Art. 152.) At that place we have seen micaceous schist is the rock. But the details of it I shall postpone for the present, to trace out the limits and relations of the argillaceous schist in descending to the plains. There are two routes in which these have been examined, the Pass by Chilkeea, and that by Bhumooree. In the first of these, micaceous schist extends a few miles south of Turkhet, the second stage in the route from Hawal Bagh to Chilkeea. Between Turkhet and Pepul Point, it is gradually exchanged for an argillaceous schist of peculiar character. It is occasionally quite soft, white, and talcose, being rather meagre than unctuous. The micaceous schist again makes its appearance after a short interval, and then a very fine-grained gneiss in the ascent to the Bukar Mundal Pass, on the summit of which is a dirty brown-coloured micaceous schist

of an arenaceous composition, which is succeeded by a magnesian clay slate accompanied by quartz rock. The former frequently contains patches of a soft white clay, which evidently originates in a decomposing talcose schist, as the latter occurs in contact with it.

200. The quartz rock is most abundant as we approach Peepul Point, and immediately above the place of encampment there occurs a set of appearances which I think deserve description. It is so seldom in these mountains, that we can trace the junction of two rocks, that no opportunity should be lost where it is accessible of recording the phenomena. Fig — will render the following description more intelligible; it is anomorphous rock, apparently one of the numerous types of argillaceous quartz rock. It is seamed in every direction, as this rock very often is, but exhibits no trace of stratification. C. which adjoins it, is perfectly distinct, the line of junction being strongly marked. It is a white arenaceous rock covered with brown spots, crumbly, and with little consistence, but feeling gritty in the mouth. It is probably quartz, or a mixture of quartz and felspar, and the iron-stained spots may arise from decomposing pyrites. It passes below into a tolerably hard rock. D. is a series of thin folize or leaves (they can hardly be called slates) of argillaceous schist, of a plumbaginous aspect; they are soft, and soil paper. The series in its progress upwards gradually diminishes in thickness till it disappears; it is a quartzose argillaceous schist, stratified distinctly, the strata lying parallel to the preceding, nearly vertical. This latter, like A, are types of the ordinary rock, which seems to oscillate just here, between quartz rock and argillaceous schist.

201. The character of the rock C. (I can hardly call it a vein,) affords strong promise of the existence of graphite in this quarter. This mineral belongs to formations of the earliest æra, as anthracite has been referred to the suppositious transition class, and coal to the æra of secondary rocks. It is remarkable too, that the deposit from which graphite of the best quality is procurable, and which indeed furnished nearly the whole civilized world with the variety used for pencils, that of Borrodale in Cumberland is situated in a clay slate on the border of primary mountains. There does, it is true, appear some doubts as to the real nature of this formation, for some insist that it comprises rocks of the trappean type; however this may be, it is not the less certain that argillaceous schist is known often to contain very valuable beds or veins of graphite.

202. From Peepul Point to Okuldoona, the route is in the bed of the Casilla river, the latter being crossed eleven times; every where it is full of the rounded stones so often noticed, and their accumulations are sometimes observed to attain a height of 150 feet even, above it. It may be stated, generally, that where the river bed, or valley is narrow, there they attain to the greatest height; and where sufficiently wide the extent is greater, but their height less. What the depths of these accumulations in the immediate bed of the river are, I have no data to determine accurately, but there are several reasons for believing it to be very great. They seem to be all of a very uniform character, modifications of quartz rock, more or less impregnated with clay slate.

203. The rock in situ here is of a rather singular character, but it will be here afterwards seen, that it is found in many distant parts of these mountains. It is in fact a quartz rock, but contains talc instead of mica. The strata are very obscure, although it is traversed by numerous irregular seams. In one instance I observed a mass of clay slate of a lenticular shape, inclosed in it, the length of this included nodule was about 10 feet, the thickness one foot; something like transition was observed at the junction. This rock has a considerable extent in the stage to Ookul Doonga. It is succeeded by a black amorphous rock of almost impalpable composition, which is traversed by veins of quartz. This passes into a talco-argillaceous schist with thin laminæ, but so tender, that no specimens are obtainable. Quartz rock of an ordinary character next succeeds; the strata very irregular and contorted. It is of a reddish colour, and almost compact, and in mineralogical aspect strongly resembles the boulder stones found at the foot of the hills. Fragments of the talcose quartz rock which I have just noticed, and which is not seen in situ in the intermediate space, have been observed at Dhikoolee, a distance of at least 18 miles. This rock is so remarkable, as already noticed, that its fragments are recognised with the greatest certainty, and we are thus enabled to trace the course which these boulder stones took, as also to judge of the distance they were transported.

204. Ookul Doonga is situated on rather an extensive flat; the bed of the river is composed, as already noticed of these rounded, stones. The rock is not therefore visible for a distance of a mile and a half; it is then seen in the river bed, and has the character of a micaceous fine-grained sandstone, stratified distinctly, but not at all schistose, or at

least not readily fissile. The fracture is difficult to obtain, as it splits in various directions with a kind of cleavage, on the face of which it is difficult to discern the mineralogical structure; the strata are frequently curved, and the dip sometimes reversed. On it lies a rather thick bed of a rock of an argillaceous character, rather one of the shales than a schist. It is loose and unconsolidated, having the appearance of a soft and tender rock which had been crushed; nothing like marks of stratification are observable. Its colours are various, and with this shattered appearance, characteristic; i. e. green, white, black, purple, red, yellow, all of decided tone, and changing often within a limited space. On this lies the diluvian deposit of rounded stones and gravel, which notwithstanding all the inequalities of the ground, and they are great and numerous, has its upper surface perfectly even and almost level. It is to be remarked, that wherever these beds are visible in their lowest limit, they are always found resting on these shattered masses of shale, and never in any instance on the sandstone.

205. In this rock we take leave of the argillaceous strata which we have now to follow out in the route leading from Almorah to Bhumouree. The micaceous schist beds, the details of which, as before observed, we will postpone till we come to the description of the granite, continue beyond Powree, the first stage, to within a short distance of the halting place, Ramgur, on the summit of the Sohakatee Pass. It is exchanged for a very hard bluish grey rock, with much of the external aspect of limestone, but non-effervescent, or very rarely so, and in a low degree. It is marked with stripes of a darker colour, breaks with a sub-conchoidal fracture, the grain of which shews it to be a composed rock, but so small is it, that there is difficulty in determining precisely what are the ingredients. Mica and quartz are evident, and a dark mineral, which may be either indurated clay or hornblende; some specimens contain also carbonate of lime. It forms a lengthened mass in the micaceous schist, being observed to descend to the bed of the Ramgur, and rise on the opposite side, holding an oblique course across the valley for a considerable distance, which is easily traced, owing to the peculiar surface character of the rock. From all the characters of the mass I am very much inclined to consider it as a vein.

206. Below the Pass, we have a white schistose quartz rock of rather arenaceous composition. It may contain a small quantity of felspar.

In the bed of the Ramgur, the rock is of a light grey colour, with black specks disseminated. This rock evidently contains talc, (prismatic talc mica,) as well as quartz, and perhaps some felspar. Near the Bungalow, the character becomes more regularly that of gneiss, and at the foot of the ascent to the Ghagur, specimens are obtained which however, unlike the Himalaya gneiss, are yet equally entitled to the name, at least in the present state of our terminology. This gneiss which constitutes the whole of this range, at least in this quarter, is deserving of a detailed description.

207. This rock may be said to be characterised: 1. by its small proportion of felspar; 2. by the predominance of a talcose or argillaceous ingredient; 3. by the singular types under which it sometimes appears, or in other words, its transitions into very anomalous rocks. It is of a schistose rather than a slaty structure; has a talcose aspect, varying in colour from a greenish to a yellowish grey, soft though tough, and of the peculiar composition which entitles it to be called gneiss, though of so small a grain as to occasion the separate ingredients to be not always easily recognisable. Besides the felspar and talc, it contains quartz, and occasionally hornblende, (Hemi prismatic augite spar.) The two most singular types into which it passes are; 1, a white schistose rock probably composed of talc quartz and felspar, and 2, a dull reddish brown amorphous rock of earthy composition, and of a cleavable structure. This passes into a harder type of a darker colour, which is equally remarkable for its cleavable structure, and want of the schistose. This latter is found on the summit of the Ghagur, and has all the appearance of a perfect greenstone.

208. Below the summit on the south side, the same talcose and schistose gneiss is again found as in the ascent from the north; but in the descent to Bheem Tal, it appears to pass into an argillaceous schist, which occasionally seems to oscillate towards hornblende rock. In the latter case, instead of being schistose, it is always cleavable, the joints of the cleavage being of a copper brown colour, and exhibiting no marks of the internal composition, which can only be observed in the cross fracture so difficult to obtain in this rock. At the Pass near Sumket, which may be considered as the foot of the Ghagur, a rock occurs very much resembling some greywackes. It is a granular mixture of quartz and clay slate. At Bheemtal, the cleavable rock is prevalent.

209. The strata of which the Ghagur is composed, dip very regularly, at some points varying between E. and N., the inclination generally small, though sometimes as high as 40°. The cleavable types are, if at all, very indistinctly stratified, but they are traversed by rents or cleavages in every direction. The two types may be seen everywhere passing into each other, nor can there be a doubt of their geological identity; yet it is impossible to have specimens of greater dissimilarity in mineralogical aspect than are furnished by these rocks, a proof, if it were wanting, of the mischief of adopting the geological relations of rocks as the basis of our classification.

210. Between Bheem Tal and Bhumouree, some interesting phenomena are to be observed. The rock continues to be in its general character an argillaceous schist; some specimens of a purple colour and very perfect type being procured a little below the former place. In the vicinity of this is seen a small amorphous mass of a tufaceous character, and dark greenish grey colour; and at no great distance again, a huge block of the most compact quartzose conglomerate. In this latter, the cement is of a hardness and compactness which rivals the imbedded portions. No other sample of this rock is seen, the mass is evidently not in situ, but there are no circumstances in the vicinity to give any clue to its origin.

211. In the bed of the Nullah, half way down, round blocks are seen of a greenstone, in which the crystals of hornblende, (Hemi prismatic augite spar,) are distinct. The specific gravity of this rock is 2.9. That of the purple slate is 2.58. The latter passes into a dark blackish rock of a fine grain, and less perfect schistose character, the specific gravity of which is 2.7. The determination of these evidently points it out as a transition between the greenstone and slate. Fragments of toadstone are found in the same neighbourhood, having the same, specific gravity of 2.7. These consist of a dark, greenish grey ground, with white oblong spots, occasioned probably by imbedded crystals of felspar. The base evidently contains hornblende or augite, but the composition is impalpable, and to appearance, even with a magnifier, homogenous.

212. A little below this a rock is found something resembling the transition between the greenstone and the schist, but of a lighter colour, it may probably be called a fine greywacke. It is distinctly

stratified, dipping 10° N. W., the angle of inclination being 44°. It gradually passes into a most perfect micaceous sandstone, which is found occasionally to contain small nodules of greenish grey clay. The transition is observed to a great advantage, as the whole of the strata are exposed, nor have I seen in any part of the mountains an appearance that more interested me.

213. A little below this, we descend to the Balleea Nuddie, where the sandstone is again found, and resting on it various coloured and shattered rocks, described in Art. 204. In the bed of the Nullah, the fragments are, some limestone, some clay slate of a hardness approaching to that of jasper, but the greater part quartz, more or less impure. Near the bridge may be seen blocks of the blackish amorphous rock before noticed, and which in one solitary instance has been observed to have a partially cavernous structure; some of the cavities being filled with a zeolitc mineral, (Kouphone spar.) This rock certainly appears to pass into the purple argillaceous schist, but as so often remarked, access is wanting to the junction of the rocks in order to establish this fact with certainty.

214. In this vicinity, (a little below the Buleea Nuddie,) I picked up fragments of a perfect greenstone of a large grain, very similar in fact to that of a granite. The ingredients were compact felspar and quartz. I have never found any thing like this rock anywhere else, nor have I been able to trace it to its original site. Sandstone, irregularly mixed with conglomerate, then continues to Bhumouree, where also it is to be seen, (in the bed of the Nullah,) dipping to the North at an angle of about 25°. Bhumouree is situated at the foot of the hills, in the Bhabur or elevated part of the Teraee.

215. I must now return to a route, the details of which ought to have been given before the last two, but the omission is not one of any

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of the gneiss to very near the summit of the ———— Pass, below which it is replaced by chloritic schist: fragments of hornblendic schist being also very common. The former continues to near Pokree, occasionally giving place to talcose schist, occasionally to talcose quartz rock. Near some of the old galleries of the copper mines worked here, are beautiful specimens of an emerald green straight laminar slate with high

* MSS. defective.

lustre. It passes so gradually into talcose schist of the palest colour, as to leave no doubt of their being but coloured modifications of the same rock. In the rock in which the galleries at present worked are situated, a flesh coloured schist is found, of a mixture of talc and quartz. It passes into a subschistose rock of a similar composition, the latter ingredient being in greatest quantity; in fact a talcose quartz rock. This is exchanged a little lower for a dark olive green soft rock, of a schistose structure, but not laminar, the aspect of the fracture being scaly. I think it consists chiefly of hornblende.

216. The copper mines here are situated in the quartz or talc slate just described, a rock of so soft and tender a nature, as to form a very strong objection to the efficient working of them by its frequent failures in the different galleries. At the time I visited the place, they had all fallen in, and consequently no specimens of the ore were obtainable, except such as could be gleaned from the rubbish lying at the mouths of the several galleries. These pointed to vitreous copper, or the sulphuret, the richest ore known. Copper pyrites was also observed, and blue and green copper in small quantity; whether the ore is in the form of veins or beds, it is impossible to judge in the present state of things. The water which issues from the galleries has a specific gravity of ————, is impregnated with the sulphate, and deposits sulphate of copper on the stones over which it flows. These mines evidently have been very productive, to judge by the extent to which they have been worked.

217. On the ridge from which the descent to Boomot commences, micaceous, or perhaps rather an impure talcose schist occurs. It contains a good deal of quartz, below this a decided talcose schist appears, of a greenish hue. In the bed of the torrent, at the foot of the ridge, blocks are found of hornblende rock, containing pure hornblende in bundles of needles, and glassy actynolite, in contact with a reddish felspar. I did not, however, succeed in detaching any good specimens; some rolled pieces of hornblende were found, having the closest resemblance to charcoal, in all save specific gravity. In these, the apparent fibre was most commonly curved, the lustre always dull. The rock from hence to Boomot is entirely talcose, being either a granular mixture of talc and quartz, (talcose quartz rock,) which occasionally becomes quite soft, and disintegrating; oc-

casionally a perfect talcose schist, which oscillates, as the rock always does, towards chloritic schist. A granitic mixture of hornblende and quartz is also found in limited quantity, the type in fact of a greenstone.

218. At Boomot, which is situated on an extensive flat, we find the rounded stones so often described, the flat being entirely composed of them; the height above the river is 200 feet, and the extent considerable. The rock in situ is seen, however, at the third of the ascent, and it is chloritic schist, which appears on the other side to pass into greenstone slate. On the left bank a larger flat is seen, being upwards of two miles long, and half a mile, or more, wide in the broadest part. This is also composed of the same rounded stones; these beds can never have owed their origin to any body of water so limited in quantity as the present supplies of this river; and besides these table lands are in reality 200 feet above the present bed. There occurs here an appearance which is of considerable interest; there are two levels, and a considerable difference between them in height, the lower table being nearest to the river. This condition of things certainly reminds one of parallel roads, as they have been called, in some of the glens in Scotland. Similar appearances have been observed by Captain Hall in Chili. The resemblance is the more interesting, because I believe it is now a generally received opinion, that the latter owe their origin to the successive burstings of a lake, at distant intervals of time.

219. On crossing the suspension bridge, a rock very like greenstone slate is found, it passes into the chloritic schist observed below Boomot, and through that, on this side, into a perfect talcose schist, of white, yellow, and blue colours, &c. On the flat no rock is visible, but again in the bed of the stream, which comes down from Dhunpore, the granite rock, which I have called greenstone, is again detected, occasionally passing into a greenstone slate. It contains nests of indurated talc or potstone. The schists are always conformably stratified, that is, they dip to N. E., but the greenstone is generally amorphous. The schistose rocks continue, often verging on chloritic schist, and interstratified with quartz rock as far as the route lies in the bed of the Nullah, which is of great depth and narrowness, the sides of mural steepness laying open, in beautiful natural sections, all the particulars of the rock worthy of notice.

220. It was observed, that sometimes the change from the green schist to the quartz rock was sudden; sometimes a real transition is seen. In general, the schist has a stronger resemblance to the chloritic types, though it is also found a perfect hornblende schist. The dip and inclination of the strata present great local irregularities, the former being sometimes reversed within a few hundred yards, and the latter not unfrequently 90°. The direction appears to follow a curved line, being in the first instance observed as conformable, *i. e.* N. W. It is then seen to run N., from which point it gradually changes to N. 35° E. In the first case the dip was as usual N. E.; as the direction changes, the strata become wedge-shaped, and assume a vertical position, till at length it is found that the dip is reversed, being finally S. E.

221. From the bed of the Nullah, the route ascends to Dhunpore, where are worked the most valuable and productive copper mines in the mountains. The rocks which are found in the ascent to the Koangola Pass and descent thence are various in character, and a more enlarged examination of this neighbourhood is required to determine their true relations to each other. In the ascent to Dhunpore, quartz rock is the prevailing substance, which passes on the summit of the ridge into a very thin slaty rock of a yellowish colour, exceedingly hard, and composed apparently of quartz with some talc. The laminæ of this are not above a tenth of an inch in thickness. They separate with greatest clearness, are often bent or curved, are rather brittle, and consequently not obtainable of any size. This type might be called slaty quartz rock, in contra-distinction to schistose quartz rock. It passes into the pure amorphous type; argillaceous schist, then succeeds, variously intermixed with limestone more or less pure. The former occurs here of an intense black colour, similar to that of basanite. It has a schistose structure, but never separates into thin slates, the attempt to obtain such generally producing a conchoidal surface, or at least one more or less uneven. It is moderately hard, of a fine grain, receives a good polish, would form a most superior description of writing slate, and is not even inapplicable to the purposes to which basanite is applied. It has a cleavage, or set of natural joints, the surfaces of which present the appearance of a slight iridescence, or pavonine tarnish. This cleavage is most commonly, or at least very often, transverse to the direction of the schistose

structure. It is in contact on two sides, with an argillaceous or siliceous limestone, which in its immediate neighbourhood passes into a perfect rotten stone. What the nature or cause of this caries is, which so often appears to attack rocks of the greatest solidity, no one has yet explained in a satisfactory manner. The unchanged rock is of blue colour, impalpable in composition, with a conchoidal fracture, and in appearance resembling perfectly the most regular limestone. It is, however, a very impure one, being highly charged with argillaceous or siliceous ingredients, or perhaps with both, occasionally it even strikes fire with steel, and approaches the nature of schist. In its passage into the rotten stone it is observed, first to change a little in colour, becoming gradually more tinged with the peculiar mud colour of the latter, which is so far different from the rotten stone of Derbyshire, as to be of a more yellowish than a brownish tinge. The grain is observed gradually to make its appearance, and the rock to be full of joints or cleavages, till at last it is found of a dirty yellow colour, fine grain, very friable, and with a specific gravity of only 0.9. A series of specimens connecting the two extremes has been collected, which shews the progress of the change with great clearness; a rotten stone of bright colour appears to originate in a real argillaceous schist.

222. The rock in the neighbourhood of Dhunpore is, as I have already stated, a quartz rock, it is distinguished for its peculiar shattered and fissured aspect, no trace of stratification being observable except on the great scale. The irregularity of the strata is great, and the change of dip frequent. A mass of red dolomite appears in the middle of it east of the village, and it is in this latter rock that the copper mines are situated. This dolomite is evidently connected with the siliceous limestone on the Dhobree side, in which also a mine is worked, but the produce is inconsiderable. This mine is remarkable, however, for furnishing lumps of limestone, apparently changed by a similar process to that which produced the rotten stone, the result in this case being a perfect chalk; such a change in the surface of limestone fragments is common, and has been noticed in the preceding details; but excepting at Dhobree, I have never met such large pieces so perfectly changed to chalk. These fragments are used as a flux in the reduction of the copper ores.

223. On the Telkhunnee Pass, a brown schist is found, and thence descending to the village of Bissona, various modifications of the same passing occasionally into argillaceous quartz rock. Near the village, a granular rock is seen composed of quartz and indurated clay, having much the aspect of a greywacke. Here a mass of reddish limestone is found imbedded in the slate, in extent about 50 yards by 10, and capable of furnishing a very beautiful marble. Schistose rocks continue to Kirsal, where traces of limestone occur in local conglomerates, in tufaceous masses, and even as an ingredient in the more compound schists. The prevailing type approached to that of stone slate, being of a composition almost impalpable, moderately hard, and of colours varying from greenish grey through yellowish grey, to reddish and purpleish grey. These specimens are seldom of a perfect slaty structure, the cross fracture is easily obtained, and it is often conchoidal. Below Kirsal, these schists assume more of a chloritic or talcose character, and become more decidedly compound at the foot of the descent. Argillaceous schist is established of a very regular type, though it is found intermixed with the green schists also, which are of a chloritic character.

224. There is another route tending from the Boomot suspension bridge to this point in which the rocks have been examined, and it will be more in place to record the particulars here. This route ascends by the village of Acend, in which the talcose schist observed in the vicinity of the bridge is exchanged for quartz rock, containing, it would appear, nests of indurated talc. At the village, a decided chloritic schist is found. The dip in all the schistose rocks is conformable, but in the quartzose or granular types, the strata are obscure. Between Acend and Jak the same rocks continue with an occasional appearance of brown tender micaceous schist. From Jak to Bendoolee, the transition into the latter is more frequently observable, and it also assumes an argillaceous character. The granitic rock which I have for distinction sake termed greenstone also occurs, forming as usual a transition into the green schist.

225. From the village, the route descends to the bed of the Bendoolee Nullah, the rock being still chloritic schist, verging on argillaceous, and enclosing huge masses of quartz rock, the relations of which to the schist appear very interesting, and deserving of further developement. From what I could observe, it struck me, that these masses were

very large veins, their breadth being inconsiderable compared with their length, and their course oblique to the direction as well as to the planes of the strata; nothing like the marks of stratification can be seen in them, but they are traversed by seams in every direction, very similar in this respect to the smaller and less equivocal examples of quartz veins. One of these masses is observed to descend the mountain side into the bed of the stream and ascend the opposite side, always keeping the same direction, limited in breadth, and easily traceable by the eye for many miles.

226. In ascending the bed of the stream which descends from the villages of Ketee and Mulsee, and here joins the Bendoolee river, the chloritic schist is gradually exchanged for more decided argillaceous types. These are sometimes straight laminar, easily splitting into slates, sometimes sublaminar and schistose, in which case the cross fracture is easily obtainable. The former are more frequently of an iron black, the latter of a purplish, reddish, or greenish hue. The two routes here coincide; below Ketee a green schist occurs, remarkable for having two sets of divisions distinctly marked, forming an angle of 45° with each other, the one being parallel to the schistose structure; above Ketee again, quartz rock of a bright Orkney yellow occurs, fissured and seamed in all directions, so that a specimen of any size cannot be obtained. The slates too in great part when tried under the blowpipe, fuse into a slag obedient to the magnet. These indications point to an iron mine which is in the neighbourhood, but which I had not an opportunity of examining. The dip in this glen is always N. E., but the strata are nearly vertical, being frequently observed from 70° to 80°.

227. On the summit of the Pass Dewaluc Khall, quartz rock occurs, and descending thence to Murara, it is found to contain talc; fragments are observed here, which are a mixture of compact felspar and quartz, but the rock has not been observed in situ. Below Murara, micaceous schist is established, the dip being S. 35° W., and inclination 24°. It is full of small garnets; traces of felspar may be found in it, and I am not without an opinion, that gneiss is to be observed on the summit of the ridge just passed, although in the immediate route quartz rock alone may be visible. The micaceous schist continues to appear along the bed of the Ramgunga. Near Agura, a mass or bed of limestone,

of a siliceous or magnesian character occurs; it contains crystals of dolomite, (brachytypous lime haloide,) and traces of green carbonate of copper (hemi-prismatic habroneme malachite,) also of copper pyrites (pyramidal copper pyrites.) A mine was formerly attempted to be worked here, but either from want of skill or perseverance, was abandoned without any profitable result.

228. A rock occurs here, but in no large masses, which may with perfect propriety be termed a gneiss. It is of a curved or undulated schistose structure, and the composition is heterogeneous or mixed. The ingredients are so disguised, that it is difficult to speak with perfect precision, but it appears to me to contain quartz, felspar, mica and indurated clay. The second ingredient is the most doubtful, and exists in least quantity. Close by this rock is found one of a brownish yellow colour, structure amorphous, composition simple or uniform, and earthy like chalk, tender and friable, traversed by veins of a darker colour, but the same in every other respect. This rock also occupies but a limited space, and is succeeded by a micaceous schist of a blackish blue colour, apparently much charged with argillaceous matter. I should note, that the summits of the surrounding ridges are limestone, recognised with great certainty by their peculiar outline, and mural precipices stained with yellow and black.

229. The preceding particulars apply to the immediate neighbourhood of Mehul Chowra, the halting place below the Pass of Prendooa Khal. In the ascent to the latter, quartz rock and siliceous limestone are found; still higher up, a purple argillaceous schist, containing mica, which graduates into a yellowish white micaceous schist; fragments were found of iron stone and of indurated talc. On the Pass, limestone often highly siliceous or argillaceous prevails, and it is accompanied, as it always is, by its local conglomerates, and its tufaceous deposits or incrustations. On descending from the Pass, a great deal of the same rock is observed, but down in the river valley, it is seen to rest on argillaceous schist, the limestone still continuing to run along the summits, and occasionally descending lower down. It is in the junction of these two rocks that the beds or veins of iron ore occur, which are annually worked, during the healthy season, by emigrants from other parts of the country, who all quit the valley in May, when it is said to become unhealthy.

230. These mines are said to produce metal of a better quality than any others within the mountains, and this circumstance I attribute to the ore having generally a proportion of calcareous matter, which it is well known is one of the best fluxes, the ore itself being of the most common kind, red iron ore, (rhombohedral iron ore of Mohs.) The clay slate in which most of the galleries are situated, is of a peculiar character. It is generally of a reddish or purplish hue, fine grain, not compact, splits into wedge-shaped schist, and with remarkable facility. There is also a cross cleavage which prevents the acquisition of large pieces; the spotted delineations which are sometimes observable in it, when viewed hastily, resemble imbedded nodules. They are always of a lighter colour than the general ground, being usually white or peagreen. The shape is elliptical; when they become very numerous the slate passes into an amorphous rock, which has all the aspect of a conglomerate.

231. From Katsaree to Mehul Chaura, the route turns up a lateral glen, the bed of a feeder of the Ramgunga. The debris is however thick on the mountain sides as well as in the valley, and the rock can only be guessed at; limestone is seen occasionally at the summit of the ridges. Between Mehul Chaura and Dooara, however, the rock appears in the bed of the stream. The first occurrence is that of the purple scaly schist, which seems of a nature intermediate between micaceous and argillaceous schist. It dips to the East of South. This is succeeded by an earthy and subschistose gneiss, which dips S. W. 10°, micaceous schist is then found, and resting on it a granitic gneiss which is connected with the series of granite beds so often alluded to, and which will be described presently. The fragments in this valley consist of clay slate, quartz rock; and latterly mica slate, gneiss and hornblende rock, as also chloritic schist.

232. We may now return to Punnae, Art. 67, from which place is another route that has been examined, leading down the valley of the Aluknunda. The granitic rock which I have called greenstone, was noticed, as occurring in the bed of the Dhunpore Nullah; beyond that point the talcose-granular scaly rock is seen to occupy great extent, similar to that which has been described, Art. 221

It is remarkable here for containing much larger concretions than usual; some of them have a perfect resemblance to rounded nodules im-

bedded, and indeed they can be detached from the including base. The rock is therefore certainly of the nature of a conglomerate, and this fact is further proved by the occurrence of rounded nodules of clay slate in an adjoining quartz rock. The concretions of the talcose granular scaly rock are always quartz, but of a peculiar resinous lustre, very unlike ordinary quartz, and in colour always inclining to blue or purple. This rock is a good instance of the deficiency we labor under, from our scanty nomenclature of rocks. It is very well characterised, and has consequently been recognised by me in many and very distant localities, yet we have no name by which to designate it, unless we call it quartz rock. It is singular, that in two of the localities where it has been traced, pieces of clay slate are found imbedded in the adjoining rocks, a phenomenon I have no where else observed. It here passes into the more ordinary quartz, which is occasionally chloritic.

233. The rock at Nugrasoo is the same quartz rock, and it possesses the usual fissured aspect so often noted as characteristic, it being very difficult to detect any thing like the appearance of strata even on the great scale. In proceeding to Tirnee, at one of the lowest points in the route chloritic schist is found dipping to the E. at an angle of 56°. Whether a solitary included bed or connected beneath with the extensive strata observed near Punnae, Acend, Jak, and Bendoolee, (Art. 224) is difficult to say, for want of that full access to the junctions of rocks which so often interferes with observations in the mountains. From the little I have myself observed, I am of opinion, that chloritic schist is more generally a member of series than a single formation in itself, at least when we speak of the more decided types, they being seldom found of any extent compared with micaceous or argillaceous schist. The quartz rock passes into the talcose granular scaly rock, thus proving its geological identity; but this would no more absolve us from giving it a name, than it would the several other rocks that graduate into each, but which yet have their distinctive appellations. An imbedded nodule was observed here, (being the largest seen,) weighing at least two and a half pounds, and it was readily detachable after fracture. The existence of conglomerate rocks amongst primary strata has been contended for by many geologists. De Saussure and Mr. Weaver are amongst the best authorities I can just now recollect. Assuredly the aspect of these rocks is at once sufficient to separate them from the

secondary conglomerates, nor could the merest tyro on being shewn both, hesitate to discriminate between them. The most obvious distinction is the less earthy or mechanical appearance of the basis and the greater rarity of the imbedded pieces. Is the conglomerate structure, such at least as it is found in crystalline rocks, one which can in any instance be explained by chemical composition, as affected by the many disturbing causes which may well have been supposed to influence the results? In particular, can we derive any explanation of such a phenomenon from the galvanic energy which we may suppose would be developed by the interstratification of so many heterogeneous, and consequently in some degree anti-polar substances? Assuredly this cause has had more effect than is generally attributed to it in many of our geological phenomena. Whether the present be one which falls within its domain, remains to be determined.

234. Limestone begins to shew itself in detached masses and fragments; and before reaching Tirnee it occupies considerable extent, and is seen crossing the river valley in well marked strata, which dip N. E. It is generally very impure, being mostly argillaceous. At Tirnee, I found blue argillaceous schist; on ascending a ridge the limestone again appears, always argillaceous; descending thence, argillaceous schist is once more established, and continues to Poondaroo village, opposite Roodur Prag, the confluence of the Kalsee with the Aluknunda. It presents some curious appearances, which require a little detail. It is at first of a perfectly white color, soft and earthy, similar in fact to chalk, in all save its schistose structure, and in this respect it perfectly resembles the hard blue slate into which it gradually passes. Below the point where this change has taken place, a mass of the greenstone I have so often had occasion to notice may be seen. There is not any transition to be seen between this rock and the blue slate, but it passes into a green slate, whether chloritic schist or greenstone slate, is difficult to determine. The specific gravity is rather in favor of the latter. That of the greenstone is 3.0, it contains therefore evidently either hornblende or augite (hemi-prismatic augite spar.) Besides this, a light yellowish green mineral may be observed, very much resembling serpentine.

235. In its lower limits it appears to pass into a green quartz rock, coloured no doubt by the same mineral to which it owes its character.

This quartz rock is permanent for a long distance, but assumes various changes of colour. It occasionally appears to pass into a tender green slate, occasionally to oscillate towards the greenstone, and even to hornblende rock. It is sometimes so hard, as to defy the hammer completely. One type appeared to contain felspar, another, a schistose fissured grey rock, containing a few amygdaloidal cavities. It passes into a greenish grey rock, with rombohedral cleavage, and fine granular composition. These several changes extend as far as Hurkonda glen, in the neighbourhood of which argillaceous schist is again met with, and occasional masses of calcareous tufa and local conglomerate, shewing the proximity of limestone. The schist continues nearly to Soocet, near which a mass of quartz rock occurs. It is seen to descend to the river bed and across it, rising on the other side in strata nearly vertical, the direction E. and W. and the dip if any thing South. The slate again appears, and in the immediate neighbourhood of Soocet, where the valley narrows, it is exchanged for limestone of a very cherty type. It contains crystals of dolomite, (macrotypous lime haloide.) At Soot, the schist is once more established, but appears to have changed its character.

236. It may be seen in the bed of the small Nullah which runs below Soocet, of a perfect talcose aspect, the colors bluish grey, the structure straight laminar, the lustre metallic pearly, and so soft, as to be scratched by the nail. It dips S. 5° E., at an angle of 48°. It is succeeded, in proceeding towards Sreenuggur, by a greenish grey talco-argillaceous schist, approaching to the character of chloritic schist. The laminæ are sometimes very much contorted, being in one particular instance bent up into a saddle-shape, even within the compass of a specimen. This rock is always recognisable by the minute wave-like undulations with which the laminæ are marked, and which are peculiar to it. The dip is South along the whole line to Sreenuggur, but the rock so seldom visible that much stress cannot be laid on this determination.

237. Enormous beds of diluvium, or rounded stones and gravel, may be observed here, forming the floor of a valley remarkable in this rugged country for its extent and beauty, though it be but five or six miles long, and no where a mile wide. These accumulations rest on different sides of the river in different parts of this line, so that small as it is, it is not even continuous. Their height above the river bed is ge-

nerally 60 to 100 feet; but with regard to this point it may be observed, that in the widest vallies these beds have least height, and vice versa. Their face generally forms a precipice, in which all the several sizes of stones may be seen sticking in a loose basis of gravel and sand. Sometimes two or three terraces are formed, the last being of inconsiderable height above the bed of the river. In the latter, may be observed the same kind of stones that compose the terraces, leading to the inference that the present opening was once filled up, and that the river must have flowed so much higher than its present level. It is a very remarkable circumstance too in these beds, and shews that there is some connection between their accumulation and the system of rivers, that they increase in extent as the river advances towards the plains; very limited deposits occurring in the upper part of the course.

238. The magnesian clay slate is found at the suspension bridge over the Aluknunda, south of Sreenuggur, while close to the town, in the bed of the river, a rock approaching to the character of micaceous schist prevails. Perhaps it may more properly be called micaceous quartz rock: it also dips to the southward. On ascending from Sreenuggur are seen the accumulations of rounded stones above the present bed of the river, as determined by Barometrical observation. The rock is the magnesian clay slate, which continues the whole way to Pooree, a village on the high range which shuts in the Chipul river. It oscillates both towards micaceous schist and towards talcose, its affinity to the latter being greatest, but no genuine argillaceous schist is produced in any of its changing types. The dip is in general conformable, *i. e.* between N. and E., excepting immediately on the ascent from Sreenuggur, where it was observed to be S. 10° E., the inclination being 60°.

239. From Pooree to Olee, the road passses along the range abovementioned, crossing over it near the latter village which is situated a little below in the bifurcations of a glen. Half way the slate is exchanged for quartz rock which appears stratified, dipping 65° N. E., at an angle of 50°. Here also this rock possesses the veinous character, appearing to traverse the other strata in masses much more remarkable for their length than their breadth. It is seen to cross the valley here, and continue its course on the opposite side; occasionally it appears to contain felspar. It passes into a green type, which gradually changes

to the greenstone so often noticed; but which occupies a very limited space. The quartz rock again becomes established, and continues from Olee to Bidholee, and thence to Milcee, which is situated in the valley of the Nyar river. Near the latter village, a subschistose argillaceous rock occurs, and in the ascent up the valley of the Pilgad, which joins the Nyar below Milcee, the tendency to an argillaceous character increases. In this part of the route, two types seem to divide between them the rocks observed; one may be characterised as argillaceous quartz rock, the other as quartzy argillaceous schist. The first cleaves into rhombohedral fragments, has a conchoidal fracture, the composition impalpable; the second has a schistose structure and small granular composition. They run naturally into each other, and may be considered, geologically speaking, as the same rock. The first is seldom stratified, always seamed; the second is generally stratified, although the strata are irregular and appear under that relation termed wedge-shaped. One observation gave the dip N. 45° E. with an inclination of 36°. Not far from this the dip was observed N. 80° to 90° E., inclination 40°. The quartzose type prevails to some distance above Bidholee, and is gradually changes in the ascent from the bed of the stream to an argillaceous schist of more decided character. The latter passes into chloritic schist, which conducts us to strata of gneiss connected with the series of granite beds, to which we shall presently come.

240. In the meantime, it will be necessary once more to look back and take up the thread of our description broken off in Art. 159, and to trace the argillaceous strata in another direction at the village of Girgaon where the last traces of gneiss were lost, although in the river-bed beneath occur numerous blocks of that rock. The character of the formation which succeeds is argillaceous, including, however, extensive beds of limestone; sometimes there is a kind of transition observable between them. This continues without much variation as far as the hot spring below Rumaree on the Ramgunga, into which the Jankoola river (below Girgaon,) falls. At the bridge over the Ramgunga the rock is clay slate, and dips N. 15° W., at an angle of 35°. The ridges appear to consist of limestone stratified distinctly, and dipping also N. W. Above Rumaree, argillaceous schist occurs of a lead blue colour, containing quartz; fragments of a conglomerate are then met with, and latterly in the ascent to the Pass above Sama, a brownish granular

schist, which might be called a greywacke. On the summit of the Pass, there is no rock in situ, and fragments of micaceous schist are to be seen. Thence to the village of Sama, we are accompanied by ordinary blue limestone distinctly stratified, and of a sublaminar or slaty structure, which is not, however, developed without weathering.

241. From Sama to Buret, the same rock prevails, frequently remarkable for the white vein by which it is traversed. Sometimes the two colours, form alternate layers, the rock having thus a striped appearance. It is occasionally very argillaceous, and passes into a shattery thin laminar rock, very like that described in Art. 226, the only difference being a black or blue colour, instead of red, green, or purple. In this state, it no longer effervesces with acids. In the bed of the stream leading down from Sama, the fragments are either blue limestone or crystalline dolomite, or of clay slate a very few; but at the bifurcation below Mawgaon, immense blocks of gneiss, similar to those observed below Girgaon, are to be seen. Their source is evidently in the glen, which here joins the Suma glen, and they shew the proximity of the boundary of the gneiss district.

242. From Buret to Kubkot on the Surjoo, limestone still accompanies, as passing down the Ramgunga to its confluence with the Surjoo, and then down the latter river. It appears to be stratified distinctly on the large scale, the strata being always best marked where the rock is most impure. They appear sometimes to be vertical, and the direction, as far as it could be ascertained, is S. 20° E. Sometimes it contains talc in notable quantity, and then the rock is highly fissile. The rounded fragments in the bed of the river are numerous, and many of these are white crystalline dolomite, (macrotypous lime haloide.) Near Kubkot, the dip was observed to be Southerly, so that there must be evidently some great irregularity here. The sameness of the limestone features continues to Gryket, also in the bed of the river, the surrounding ridges bearing testimony by their appearance to their identity with the lower strata, occasional patches of argillaceous schist then diversify it, although it is still the prevailing rock. The fragments in the river bed consist of limestone and quartz rock. A small patch of black argillaceous schist is found a few miles above Bagesur, the place being further remarkable for the deep bed the river has worn in the limestone, hollowing it out into caverns and deep holes, in some of

which it has a depth of perhaps 30 feet or more; although at Bagesur, some miles below this point, it is fordable, being scarcely three feet in depth. The tendency of this rock to be worn into caverns and hollows is a very curious feature, nor am I aware that any satisfactory explanation has been given of it. The dip at this place was observed to be S. 30° W., and the inclination 52°.

243. Hence to Bagesur, one of those extensive flats so often formed in the river beds prevails, nor is any rock in situ discoverable; at that place the strata are quartz rock, and they dip N. E. The river bed is full of rounded limestone fragments, but below the confluence of the Goamuttee, which originates in the valley described in Art. 65, the fragments are as often gneiss and quartz rock. Another extensive flat reaches from this point for nearly two miles, and debars access to the rock. At its termination, calcareous tufa and conglomerate are seen, but not apparently of great extent. A third flat then occurs, and after passing it, argillaceous schist is established, and it continues in the ascent to the Cheer Nullah, a small stream which comes down from the range separating the vallies of the Surjoo and Cosillah. We have then a limestone of a yellow color and fine granular, containing a large proportion of talc, and a little higher up, nests of indurated talc are found of a light buff colour. Thence, argillaceous schist and limestone are irregularly mixed, the latter forming the summit of the range. It is of a magnesian character when pure, being in fact a compact dolomite; but is generally so much charged with siliceous matter, as to become a kind of chert. In its pure magnesian state too, it has no inconsiderable resemblance to the latter rock. The colour is a bluish grey, which occasionally changes to flesh colour. It contains veins of galena, (hexahedral lead glance.) The strata when observable, appear to dip N. 60° E., at an angle of 60°.

244. In descending from this range, argillaceous schist is again met with of a very soft type, and of various bright colours, similar in fact, to the rock observed in the Cosillah, (Art. 152.) The strata are so irregular in dip that no mean result can be attained. It sometimes contains quartz. In ascending to the Kurnyud Pass, micaceous schist occurs, and occasionally with felspar; fragments of gneiss are abundant. Descending from this Pass into the Suttralie glen, we find an earthy gneiss, very similar to that described in Art. 134, which prevails in the

Goamuttee valley. This rock dips S. 33° E., at an angle of 38°. Here also may be seen a brown amorphous rock, of a very anomalous character, the true relations of which further enquiry is wanting to develope. A little further, micaceous schist, covered with an aluminous efflorescence, dips S. S. E. This latter rock continues to the foot of the ascent, occasionally taking in a little felspar. In the ascent to the Pass above Bhynsoolee, gneiss is again found in strata nearly vertical, containing beds of hornblende schist, and having here again come upon the tract connected with the series of granite beds, we shall once more leave off, and pursue two other short lines of route, which yet remain to be described previously to entering on those details.

245. The first of these leads from the bridge over the Kalee at Joolghat to Lohooghat, the cantonment of the 2d Nusseree Battalion of Ghoorkhas. At the bridge, strata of a very pure limestone occupy the bed of the river, and form unexceptionable natural piers for this structure. The dip was N. E. In ascending, detached masses of compact limestone and conglomerate, (enclosing pieces of quartz rock and clay slate,) are seen; a good deal of stalagmitic and stalactitic incrustations are noticed, shewing that masses of limestone are doubtless prevalent, though from the nature of the surface not always visible. At Booralee, or a few miles before coming to that village, a purple argillaceous schist makes its appearance; some of the types are granular, and might be called a greywacke schist. It also passes into a compact slate of a light yellow or greenish colour, very similar to hone slate; as such it has been used, and found to answer. These rocks occupy the road as far as Petorahgurh, and the dip is generally N. or a little W.

246. At Petorahgurh, patches of limestone are found in it of a pure type and blue colour. This rock, as has been often observed in limestones, has a sublaminar structure, weathering so as to have often the appearance, in detached pieces, of a series of layers or thick leaves joined together. It sometimes divides into thin slabs, which are, however, very unlike the slates of an argillaceous character, as they admit of a cross fracture with great facility, which is as usual conchoidal, and not hackly like that of the latter rock. The schist here is very variable in aspect, yet never loses its argillaceous character. At the cantonment, it is quite soft, and might pass for a yellowish clay were it not disposed in slates, which however will not bear handling, as they fall to pieces

immediately being minutely intersected by cleavages, the effect of which is to resolve them into rhombohedral fragments on the slightest impulse being communicated. The small hill on which fort Loudon is built consists of this rock, and on its summit, lay some very large boulders of a very tough and hard greenstone, the removal of which occasioned the Officers employed in clearing the ground, not a little trouble.

247. This rock I call greenstone, for it has not the smallest resemblance to hornblende rock in appearance. I have already mentioned its frequent occurrence in tracts of argillaceous schist, and I shall endeavour here to collect all the particulars I have observed with regard to it. It is a composite rock, consisting of two distinct substances, the one a dark olive green, the other a lighter colour, more perhaps of a greenish grey. The structure is small grained granitic; that is to say the minerals are obviously distinct, while yet they are in perfect contact throughout. The fracture is subconchoidal, taking its character in the small from the size of grain which it discloses. It is very hard, and in toughness I know not its equal. The specific gravity is upwards of 3.0, sometimes as high as 3.2. It is very fusible under the blow-pipe, and will bear drawing out into threads similarly to glass. If there be really a distinct species of felspar which has been hitherto described as the compact, I should be inclined to view the lighter coloured ingredient as an example of it. The dark one is either hornblende or augite, but the grain is too small to allow of a satisfactory determination.

248. This rock is not seen here in situ; these blocks being the only traces of it, but in other places, as already detailed, regular gradations occur, uniting it with the most ordinary schistose rocks, very frequently the transition is made through quartz rock; altogether it is a very interesting member of our mountain strata, and the full developement of all its relations is a task the execution of which I expect will throw considerable light on some interesting questions in geology.

249. From Petorahgurh in the descent to Surjoo, argillaceous schist is the prevalent rock, indeed the only one, with the exception of a few beds of limestone. It is mostly of the type just described, (Art. 246), but some others are also met with. In particular one, having a suite of colours between olive and bright red, in hardness about equal to gypsum,

splitting generally into slates of moderate thickness, but which are often curved, smooth to the feeling, and having a slight degree of lustre. I think this type owes its peculiar character to the magnesia it contains. It is found between Petorah and Goon; near the latter place, it is succeeded by a yellow rotten stone, which has apparently originated in an argillaceous rock of a less schistose character, or perhaps even in calcareo-argillaceous strata. It is remarkable for its rhombohedral cleavages, breaking into fragments of that shape on the application of the hammer. It is of arenaceous composition, and its specific gravity is very low, about 1.5. In its vicinity are found small masses of a soft argillaceous limestone, of a light olive colour, which might perhaps be of use in lithography. They form the only type of limestone I have met with in these mountains which hold out any prospect of being available for the purposes of that art. In general, the lithographic stones used in Europe are derived from the secondary strata, and even in these, the properties essential to the most perfect specimens seem to be peculiar to a very small tract in Germany, neither France nor England having yet furnished stones to compete with those of the former country.

250. The soft magnesian clay slate of different colours, which is found near Goon, also prevails at Doodar. On the ascent to the Thakil Peak, which lies a little to the left of the route from Petorah to Lohooghat below that village, a bluish grey schist, of a shining lustre is found, traversed by white veins. In ascending from Doodar to the Peak, the rotten stone noticed near Goon, and of a bright ochrey colour occurs, but undistinguished by the peculiar structure of that rock, the present one giving an amorphous irregular fracture. Above this, lies a fine greywacke schist of a dark blackish grey colour, which passes into a rock that strikes fire with steel. The summit of the peak is a silicious limestone that occasionally passes into schist. It projects in amorphous weather-worn nodules, and is full of veins of flint (var. rhombohedral quartz.) This is not a common mineral, at least in the form of veins, to be found in limestone. It is of two kinds: the one a dark brown, exactly similar to the ordinary gun flints, the other a white opaque substance, occasionally becoming translucent, and not very unlike the mineral called cacholong. These veins are more persistent than the bulk of the rock, which indeed appears

to be singularly subject to atmospheric wear; the consequence of this difference of durability is the projection of these veins on the surface of the rock, giving it a singularly rugged appearance. It is probable also, that particular parts of the rock not veinous in appearance, partake of this durability, and thus occasion that nodular aspect so characteristic of this limestone.

251. Is there any connection between a primary limestone with veins of flint, and the chalk strata enclosing rolled pebbles of the same mineral? The occurrence of flint pebbles in chalk has always appeared amongst the wonders of geology to the uninitiated. The difference of composition between chalk and primary limestone is perhaps as great a one, and not a little difficult to account for. The primary limestones we see, however, are subject to a caries, which as far as it goes, produces a perfect chalk. In that state it is obvious that the action of any of the numerous causes of the disintegration of rocks will be more powerful. If we then suppose that the flint being set loose, splits into numerous fragments of all sizes, and will, by the same cause that transports the loose chalky matter, be worn down on its edges and at last rounded, we shall perhaps have an explanation not at all improbable. If this be not an exact account of the phenomena, it at least, by shewing how natural and simple the process which might have produced the actual state of things, serves to take off some of the edge of our wonder.

252. In descending to the Surjoo from Goon, we find argillaceous schist occasionally of the same character as that observed in the ascent to the Thakil Peak, (greywacke schist.) It is, like that, of a dark grey colour approaching to black, and is remarkable for splitting into prismatic fragments on being struck. A good deal of calcareous stalagmite occurs, and a soft white or light grey schist, intermediate between clay slate and talc slate. Latterly, limestone is abundant, and in the bed of the river we have gneiss and quartz rock, with fragments of hornblende rock in addition to those of limestone and the two preceding. The gneiss continues from the bridge upwards, at first of a fine grain afterwards coarser, and containing superadded amygdaloidal concretions of felspar, similar in fact to the type described, Art. 80. Beds of mica slate and of quartz rock are contained in it; the latter furnished the only observation of the dip which was S. 30° E. and inclination 60°. At Burakot, argillaceous strata again prevail, and furnish some very anomalous rocks

in their several changes of type. A dark grey almost amorphous rock with fine granular composition, conchoidal fracture, very hard, but rather brittle, which occurs near Burakot, is one of the most remarkable. Were it not for the decided absence of the arenaceous structure, I should be inclined to term it a greywacke. It contains, I think, carbonate of lime as one of the ingredients. It passes into a perfect roofing slate, which is found in great abundance just below the cantonment. Here we come upon the line of route which belongs to the description of the granite formation, and we must therefore return to Petorahgurh, to finish the details of the route thence to Almorah.

253. In the ascent to the ridge just above Petorah, the new road gives excellent views of the strata, and it were much to be wished we could elsewhere gain the same access to the rocks as we do here. The soft and clayey rock of the cantonment appears to pass into a dark black rock of sublaminar structure. It breaks with an uneven, irregular, rather than a conchoidal fracture. It is often stained in the interior of a light ash grey colour, very similar in appearance to a piece of half-burned charcoal. At the summit of the Pass dolomite of a large crystalline grain occurs. It contains veins of indurated talc, (var. prismatic talc mica,) and also of very fine large rhombohedral crystals of dolomite, (macrotypous lime haloide.) The indurated talc is of various colours, but most commonly jet black, a variety not noticed by any of our mineralogical writers. It assumes a very good polish, and would form a very beautiful material for small ornaments for a table or chimney piece. It is not however in any quantity.

254. The dolomite is evidently a bed in the slate, for almost immediately on descending the Pass, the latter rock again occurs. It is here of a white colour, and of micaceous composition, but still slaty in structure. It is again exchanged for the black rock with light grey stains. The debris here consists of a very fine ochrey clay of a good colour, and which might be useful in the arts if prepared properly; besides the bed of dolomite, beds of talc slate are found, and in this rock is situated the copper mine, which is, however, worked on a very small scale, producing only 50 Rupees per annum. The argillaceous schist continues down this valley, (Shor Goorung,) irregularly intermixed with dolomite, which is very often compact, containing veins of the crystallised mineral, and very often appears to pass into the slate. It can seldom be seen in

well-defined strata, rather appearing like amorphous projecting masses, unless when impure, and then the strata are as well marked as those of the better defined schists. In two instances, the dip was observed N. E., inclination 20°, and N. N. E., inclination 32°. The first of these was a purple arenaceous rock, containing a good deal of carbonate of lime, the second was an almost pure compact dolomite of a light grey, and remarkable for its conchoidal fracture, toughness, and hardness.

255. In the descent to the bed of the Ramgunga, chloritic schist of a perfectly pure type occurs, being in fact green talc slate; it contains metallic copper disseminated, but no attempt has been made to work it. In the bed of the river a schist occurs, which may well be called talcose schist, being a mixture of quartz and talc. It bears the same relation to talc, (prismatic talc mica,) as rhombohedral talc mica. It is in this particular place schistose, and distinctly stratified; but in other quarters, it passes into a massive rock, bearing the same relation to it, which ordinary quartz rock bears to the above schist. It is in fact a talcose quartz rock, as we may call the ordinary type micaceous quartz rock. The titles talcose and micaceous schist might be confined to the schistose types of this compound rock, and that of talcose slate, to the slate composed entirely of indurated talc. This would introduce some precision into our account of rocks. In like manner, chloritic slate should be reserved for the pure mineral, and chloritic schist for the compound types. Without a reform, terminology will never make any real progress.

256. From the bed of the Ramgunga, the route ascends to Gungolee Hath, on the valley of that river from that of the Surjoo. The talcose schist passes into a quartz rock in which the talc is gradually lost, until it at length very closely resembles a sandstone in appearance, argillaceous schist then establishes itself, but whether by transition or per saltum, the state of the surface does not admit of deciding. The dip was observed to be N. 7° E., inclination 45°. Towards the summit of the ridge, magnesian and siliceous limestones begin to prevail, and the crest is entirely composed of a flesh-coloured dolomite, with purple clouded delineations, which I think would form a very handsome material for various ornamental works, as it takes a very high polish, and is not more difficult to cut than ordinary marble. It is traversed by veins of a purplish brown calcareous spar with curved

cleavage, and so strong a pearly lustre, as to be at first mistaken for dolomite spar, (macrotypous lime haloide,) but its specific gravity and ready effervescence with acids, shew it to be rhombohedral lime haloide: veins of a resinous quartz; bluish, black and white, are also observable.

257. In descending to the Surjoo, a little blue limestone is seen, and one patch very beautifully variegated with yellow veins of carbonate of lime. The prevailing rock, however, is argillaceous schist; a good deal of what might, in following up the distinction, (Art. 246), be called clay slate also prevails, soft and distinguished by its series of colours as well as by its patches of a different colour from that of the ground. At the bridge, the rock dips S. W. In ascending from the river, an impure hornblende rock begins to appear, remarkable for its numerous cleavage places, which render it so difficult to distinguish the lines of the strata. Hornblende and actynolite schist are found, and a white massy rock, which from a cursory examination, I supposed to be a compound of tremolite and quartz, as the three substances, hornblende, actynolite and tremolite really constitute but one species, (hemi-prismatic augite spar,) there is nothing improbable in this opinion. I have to regret in this, as in many other instances, the want of access to the specimens collected, in drawing up this paper, which prevents me from revising particulars of this description, stated hypothetically in my note book.

258. The hornblende schist ceases a little above the village of Neoolgoon, and is succeeded by gneiss, which is of a porphyritic type, containing superadded prismatic nodules of felspar. This mineral in every case appears to be of greater durability than the basis or ground, and the nodules consequently remain projecting after the other has in a measure disintegrated, giving the rock an exceedingly uneven and rugged surface. The dip was observed to be S. W. Near Jagesur, this gneiss is succeeded by micaceous schist, dipping to S. S. W., with an inclination of 60° above Jagesur. On the Pass the dip had changed S. W. This rock continues to Almorah, and presents nothing very worthy of remark along this line. Near Chandeswur, it dips to S. S. E., with an inclination of about 15°. A few miles from this, it contains beds of brown iron ore, (prismatic iron ore,) which are said to furnish a very good metal. The ore contains a little manganese, rolled pieces composed of grains of quartz sand, and octohedral crystals of magnetic iron ore (octohedral iron ore,) are

found scattered about the surface of a hill in the vicinity of this mine, but no trace could be obtained of a deposit in situ. These pieces are all natural magnets, and have two or more poles according to their shape. Under Kaleenath, the schist becomes highly carburetted and soils strongly; some pieces are white, and on the summit of the ridge where the carburetted type entirely prevails, nodules of graphite are found. The dip in this vicinity changes to N. 44° and N. 22° W., the inclination being 45° and 30°. The rock is latterly extremely like a sandstone, and so friable, that no specimen is obtainable.

259. A short line yet remains to complete the details of the schistose band of rocks, previously to entering on the description of the granite beds. It is the route followed in an excursion from Petorahgurh to visit the copper mines. At Seera, argillaceous schist prevails for the first few miles, to which succeed dolomitic rocks of very variable appearance and grain. Occasionally, they are of very loose aggregation, and crumble to pieces in attempting to procure a specimen, occasionally though these latter are chiefly fragments. In the bed of the river they are so hard and tough that the hammer will scarcely make any impression on them. In every case the grain is crystalline, but very various in size, even within the limits of a hand specimen. Clay slate occurs of a deep iron black colour with straight laminæ, very hard and very brittle. It has a kind of iridescent tarnish, sometimes, on the face of cleavage. Near Kinder Besool, the limestone rocks, less decidedly dolomitic, continue mixed irregularly amongst patches of slate.

260. The route now ascends to Dhurmgurh, situated on the ridge which overlooks the Seera valley, carrying clay slate along that line, and then descends to the mines, which are immediately below the Pass. They are situated in a formation, or bed I should rather call it, for the former term is too general, in which indurated talc, (potstone and talc slate of geologists,) and crystalline granular dolomite are irregularly mixed. They must indeed here be considered as the same rock, geologically speaking, for they mutually interfere, and hand specimens may be obtained in which both substances are separately observable as well as in mixture; access is wanting to the junction of this bed with the surrounding slate, so that its exact nature cannot be ascertained, that is to say, whether it be really a bed or vein. The copper ore is most commonly copper pyrites, (pyramidal copper pyrites,) and it is

associated with iron pyrites, (hexahedral iron pyrites.) These minerals, particularly the latter, are often found imbedded in the potstone. Some part of the galleries are cut in the dolomite rock, part in the potstone, as the two rocks are continually interchanging, so that a gallery begun in the former will, after 20 or 30 yards, be found to be in the latter. The copper evidently traverses both rocks, and as far as the miners' accounts can be trusted, is in veins.

261. Till the publication of Professor Moh's system, great confusion existed on the subject of these two mineral species. We have in some of our most approved system-mongers, long and laboured articles, consisting of many pages of description, tending to shew, that massive talc was something different from potstone, and these again from soapstone; yet if we examine their several qualities, we shall find them identical. Professor Mohs, with the judgment which he has shewn throughout his work, at once rejected futile distinctions that were without differences, and has not hesitated to connect, as mere varieties, scaly talc and potstone. The truth of his views, if they required confirmation, would be found every where in these mountains, where an uninterrupted series of gradations may be traced, from the most perfectly amorphous potstone, through talc slate to the scaly mineral, usually considered a distinct species. Previously to the publication of that excellent work I had found so much difficulty in reconciling the contradictory accounts of mineralogists, that I determined to form a collection of the various types of this mineral, and in consequence, had satisfied myself, that there is in reality no difference whatever in essential character amongst the varieties, which hitherto have figured as distinct species. The inaccurate determination of specific gravities by early writers, servilely copied by their successors, has been partly the cause of this and many other of the opprobia of mineralogy. The following determination of this element, obtained from the specimens above alluded to, will serve to shew, how absolutely the same it is in the different varieties, and to confirm the accuracy of the limits fixed by Professor Mohs, viz. 2.7, 2.8.

White potstone, (Seera Mine,)	2.712
Black ditto, (Shergarury,)	2.76
Greyish ditto, (Seera,)	2.76
Yellowish soapstone, (Kuree,)	2.79
Do. very steatic, (ditto,)	2.74

Indurated talc, (Government Collection,) 2.77
Ditto, a second specimen, ... 2.7765

All these had precisely the same degree of hardness.

262. The dolomite has been equally well discriminated, and correctly fixed by the Professor. The accounts of previous writers only serve to confound the student with tenfold perplexity, from which he is only extricated by his clear views, and precise determinations. That they will very much tend to raise the character of a science, which till his book appeared was but empiricism, is obvious. Of their utility to the student I can myself bear witness, and this very mineral, as well as calcareous spar affords many instances. The limits of the latter are fixed at 2.5 and 2.8, of the former at 2.8 and 2.95. The following are some determinations I made :—

Grey compact dolomite, ...	2.826	Pass, road to Bagsar above Belowree.
Greyish white dolomite spar, ...	2.850	Goorung.
Yellowish grey ditto, ...	2.99	Bed of Mahepore.
Dolomite spar large rombohedrals, ..	2.83	Shor Gorung.
Compact dolomite, purple, ...	2.83	Gungolee Hat,h.

Of these the third only exceeds the limits, and this by so small a quantity, that it is very likely a revision would bring it equally with the others under those limits. The veins of purplish brown calcareous spar, which are found in the Gungolee dolomite, have the external characters of dolomite spar quite perfect; that is to say, pearly lustre, opacity, and curved or ill-defined cleavage. Being also contained within a magnesian rock, I naturally placed it amongst the specimens of dolomite, but in determining its specific gravity as one of the above list, I found it to be only 2.67. A re-examination and the test of acids satisfied me, that it was really calcareous spar. This is one amongst a hundred instances in which external characters alone are found perfectly inefficient to discriminate minerals, nor is there any thing in the history of science more truly surprising than the pertinacity with which mineralogists have hitherto resisted putting their system on the secure basis of numerical determination.

263. Below the mine, very beautiful massive talc of a snowy whiteness occurs, mixed with unequally white crystalline dolomite. The former is, however, intermixed by rents or fissures, preventing the acquisi-

tion of a small piece even applicable to the purposes of the arts. It passes into a yellowish grey talc slate, in straight laminæ a very beautiful rock. The white indurated talc is also found associated with nodules of quartz, the former being disposed in layers round the latter. A blue limestone succeeds in nearly horizontal strata. It contains disseminated talc. We have then a talco-argillaceous schist, and thence siliceous limestone, and white fine granular dolomite in various intermixtures and transitions to the foot of the great Dhuj Peak. Nearly half way up, we observe a talco-calcareous schist in moderately thin laminæ of a yellowish colour, the dip being to E. It is crowned by a purplish grey micaceous schist of well marked character. In descending on the other side, a very beautiful white fine granular dolomite, clouded with green tints, is found, a rock that would furnish a very elegant marble. Argillaceous schist is then established, and continues very nearly to the descent into the valley under Petorahgurh. Limestone then occupies the ground just at the edge of the descent, and on this side the valley, argillaceous schist, as before noticed, is again the rock.

264. It is now time to consider the granite beds, and we may do so in the most regular manner, as well as fill up some details still wanting in the schists, by pursuing a line from Chumpawut to the point where we left off in Art. 231. This route forms almost a straight line, and it is singular enough, that it is parallel to the direction of the mountain land and of the strata, as may be seen by examining the map. Such a coincidence, to say the least, is curious, and cannot fail to excite in a speculating mind a desire to trace in this common relation, some evidence of a community of origin. At Chumpawut, the most eastern of our beds of granite makes its appearance. It would seem to be precisely the same rock that in Cornwall is called granan, being a loosely aggregated amorphous mass, with the ingredients and structure of granite, but so soft, as to bear being dug like clay or mould. It is remarkable for its great proportion of felspar, and small quantity of mica. This soft ground is strewed over with large imperfectly rounded blocks, of a very hard and beautiful granite. It is of a smaller grain than the granan, and much more crystalline. The felspar is white, the mica black, and the quartz yellow or brown. The blocks are sometimes observed to have a superficial layer or crust separating

from them, not in any thing like a decomposing slate, but equally hard and equally beautiful with the body of the mass; nor is it easy to understand, what is the cause of this separation. Some further details will be brought forward when we come to the Dhee bed. At present, we may go on to say, that the eastern boundary of the Chumpawut bed has not yet been traced. To the West, it is succeeded by micaceous argillaceous schist, which passes immediately into well-defined argillaceous strata. These continue to Lohooghat cantonment.

265. It is scarcely necessary, after the long details already given of this rock, to enter into any more; it may be therefore sufficient to say, that it is a fine, granular, grey, compact, blue, chloritic, arenaceous and earthy, most probably the result of decomposition, as though perfectly soft and little differing from clay, it has yet the laminar structure distinctly marked. Near the cantonment in the bed of the stream by the bridge, it approaches to a greywacke, and is full of quartz veins. It contains, I think, felspar, certainly mica and quartz, but the composition is arenaceous. It dips to N. E., and at an angle of 54°. In the cantonment as before noticed, excellent roofing slate abounds, of which circumstance the officers have taken advantage in building. The granular type containing much quartz, and sometimes chlorite, continues as far as the bed of the stream below Furkah. There a quartz rock is seen distinctly stratified, dipping N. E. 15°, at an angle of 54°. This rock contains felspar, and might almost be called a quartzose gneiss. Ascending hence to Farkah, the granan begins to establish itself, till at that place it is perceived that we are arrived at another granite bed, situated almost exactly in the hypothetically drawn line through Chumpawut, parallel to the direction of the strata.

266. The character of the rock which composes this bed, is precisely that already described. The same excess of felspar, the same soft crumbly material, in fact a perfect granan. In the vicinity of Furkah, there is a mass of limited extent, consisting almost wholly of felspar, which it would seem is stratified; but with this exception, the whole of the country for many miles, presents the same roundish projecting amorphous masses. The large blocks are not so common in this tract as at Chumpawut, but towards Dhee they become very numerous, and of enormous size. Here it is that the circumstances of their desquamation may be best studied, and some light thrown on their nature and

origin. The ground is still the same granan, equally soft, equally abounding in felspar as at the two former places; but the blocks are of superior hardness, and have not any sign or trace of disintegration. The crusts may be seen in every stage, just beginning to separate, or having made considerable progress; a large layer, of a thickness seldom exceeding half an inch seems waiting any impulse, or perhaps the further action of the same cause to detach it entirely. These form the only means of obtaining specimens, so hard and so round are the blocks where this phenomenon is going on. The view of the process in all its different stages satisfied me at once that these boulders originated in the granan being but the harder and more durable nodules of a soft rock, which has gradually wasted away, and left them as monuments of the extensive waste the surface has undergone. This view is confirmed by an examination of a very large one that lies to the S. W. of the temple, and which presents a set of appearances worth recording. It is of an irregular sphero-rhombohedral shape, and not less than 60 feet in diameter. It rests on the granan, and its connection with the latter is the circumstance which forms the interest. The block itself is very hard at its base; it is well-defined by a seam which separates it from a layer of a softer granite that is divided by seams into numerous flakes, which all follow the curvature of the boulder. It is not the change of hardness that forms the boundary of the latter, but a distinct seam or separation. The flakes immediately adjoining it are very thin; they gradually increase in thickness as they diminish in hardness, till in a space of five or six feet the seams disappear, and the soft granan of the surrounding surface is established. The rock is in some measure overhanging, the soft layers having been cleared away probably for the purpose of forming a cave or shelter for the numerous flocks and herds that graze here at particular seasons, so that the structure and arrangement of the thing is perfectly exhibited. My figure may give a clearer idea than any verbal description can.

267. The correct boundaries of this granan tract have not yet been fixed on every side, but it is inferred that the extent of it is very limited in a North and South direction. In proceeding to visit the iron mine at Muglig, which is in the latter quarter, I found it pass into a very regular micaceous schist, in a distance of 6 miles. This schist dips to the North, that is, towards the granite, and at rather a

high angle, of 55°. At Kande, a small village about that distance below Dhoora Peak, mica slate is established, and continues to the mine where it contains a bed of limestone, in which rock the mine appears to be situated. Some of the best specimens of calcareous spar are obtainable here, though great part of the limestone itself is very impure, containing 20 per cent. of foreign matter. At the mine, it appears to be stratified, and dips 55° N., at an angle of 34°. The ore is in the form of a vein, to judge from the miner's descriptions. It is of a brownish black colour, granular composition, very hard, and breaks with a conchoidal fracture. It is not magnetic, or at least only very slightly. The specific gravity is 3.7 to 4.0, but as it is obviously contaminated with some foreign ingredient, this determination is too low. It is most probably (the pure part) titanitic iron, (axotomous iron ore.) It is very imperfectly smelted, and sold in a spongy impure state, at the rate of a maund for a Rupee.

268. A remarkable feature in the granan is the number of veins it contains. These consist almost wholly of felspar and quartz, the former mineral forming the larger proportion, for it is always of an opaque aspect, apparently impure, very cleavable, so as to prevent the acquisition of specimens of any size. This structure I think it owes to its impurity, and that it is the intervention of the quartz which occasions its separation into fragments. There are other veins which are to be observed also in the hardest blocks This is a granite of a finer grain, which is sometimes seen to traverse the great boulders, or large round fragments, and they are like most veins separated by a strong line from the surrounding base or ground. Some few imperfect quartz crystals have been found. Epidote has occurred in company with ill-defined large crystals of white opaque felspar; schorl is found in abundance. In one instance it forms a very large vein in a bed of quartz rock. But the most interesting inhabitant of this singular rock is yet wanting to complete its resemblance to the granan of Cornwall. Tin has never been found in it, though as the oxide and sulphuret of this metal are so unlike the general run of metallic ores, it is possible the non-discovery of it may be owing to the ignorance of the people concerning the value or appearance of such mineral.

269. The granite continues to Sarput-ka-Dhoora in a direction a little beyond which it gives place to gneiss, and this to mica slate,

which appears to pass into a greywacke. About half way between this spot and Dhol, (the regular stage,) a number of rocky masses occur, very striking both by their magnitude and apparent disorder. They are all fragments of gneiss strata, one (the longest) has something of a pyramidal shape, very similar to a rock noticed by Dr. Macculloch (also of gneiss,) in Skye. It here performs the part which he supposes the Skye rock would, were it transported to the plains of Hindoostan. It is worshipped under the title of Nag Deo. It is at least fifty feet in height, and twenty to thirty broad at the base, and has no fissure or line of strata, or separation throughout. Gneiss in situ is also found in this neighbourhood, mica slate again succeeds, of an ordinary type, and continues nearly to Dhol.

270. At Dhol, it passes into a singular rock requiring a little detail. This rock is of an earthy composition, and quite soft, though preserving the appearance of strata, and of laminar or schistose structure. It contains in its transitions into ordinary mica slate more or less of this mineral; but in its best defined types very little, if any, is to be seen. It is of various colours: black, red, yellow, grey, white, always bright and well defined. The black is the most abundant, the white the least so. It is very absorbent of water. In a piece weighing 205 grains, it amounted to 28 grains; on another of 191, 30 grains; allowing for the absorption the specific gravity was found to be 1.95 and 2.01. The black variety generally dull, but occasionally with some lustre, is infusible, burning under the blowpipe to a white ash. Some portions, however, do fuse into a black slag, attractable by the magnet. It is slowly soluble in borax, occasioning effervescence, but imparts no colour to the bead. The red variety under the blowpipe turns black, and with a continuation of heat, part fuses into a magnetic slag, part burns to a white ash; muriatic acid, whether concentrated or diluted and even with the assistance of a boiling heat, has no effect. Of the existence of a very large proportion of carbon in this rock, the foregoing particulars leave no doubt. The inference that it contains beds or veins of graphite is a natural consequence, rendered almost certain by the occurrence of the mineral in a similar rock to be noticed afterwards. The great variety of rather decided colours in it gives this district a peculiar appearance. So bright are the reds and yellows, that I think very excellent colours might be manufactured from them. The

people of the country had their attention excited by this circumstance, and attempted to obtain iron from it, which they supposed to be indicated by the red, yellow, and black colours. Failing in this, they do not appear to have sought for any thing else.

271. The micaceous schist again assumes its ordinary character on the road to Bandunee Dihee, and is observed to dip N. E. 25°, at an inclination of 35°. On the summit of that Peak, which forms a plane 200 by 20 yards, strata of garnetiferous schist are seen projecting. The dip 30° N. E., inclination 35°. In the descent to the stream, it changes to a talco-micaceous schist, of a pale lead grey colour, very soft, and almost steatitic, with curved laminæ, and passing into a white clay. It contains nodules and grains of glassy quartz. The dip is North, the inclination 30°. In the bed of the stream, the strata which are of the ordinary character, dip 14° S. of E., the inclination being only 17°. Ascending thence, we have micaceous schist, which continues to the cantonment; the dip being generally between N. and E., and the inclination small. This schist is remarkable for its great variety of type, even within the limits of so small a space as the cantonment; 1. yellowish brown, scaly, tender; 2. quartzose, grey, in tolerably straight but thick slates, the two materials being disposed in layers; 3. less quartzose, in thick large schists, with an undulated surface; 4. blue or dark grey approaching to the character of gneiss, and occasionally containing very small portions of crystalline felspar; 5. a soft arenaceous mass, which on exposure to the air, falls into sand. These are amongst the most remarkable. The addition of garnets introduces many other varieties. This schist is also to be noted as containing veins of granite of a very regular type, and also of felspar in a semi-disintegrated slate, and of snowy whiteness. The latter might be also called a granite, as it contains quartz, and even mica; but the former is in small quantity, and the latter consists of a few solitary scales disseminated.

272. The ridge on which Almorah is situated, rises into the Peak of Kaleenath, and in the ascent thereto the above described schist is observed to pass into the same kind of soft earthy black rock, which was described at Dhol. It was here that the graphite was discovered, (alluded to in Art. 270,) lying on the surface in lumps, the fragments of kidney or egg-shaped nodules. The largest specimen obtained, however, was an oblate spheroid perfectly rounded, and having

a diameter of about three inches. This latter contained small veins of quartz. The aspect of this graphite till scraped or abraded was dull; in the latter case it was metallic. The composition was fine earthy. The fracture uneven, specific gravity —. It appeared to be of a middling quality as applicable to the arts. At the time the discovery was made, I was on the point of leaving Almorah in prosecution of some other views, and I have not since had an opportunity of prosecuting a search after larger supplies by excavation.

273. The mica slate again resumes its ordinary aspect on passing the Peak, and near the village of Betholee has a dip to S. W., being immediately succeeded by a strata of gneiss with a similar dip. This mass is probably connected with that in the valley below, noticed, Art. 269. If so, it would appear to be more of the nature of a vein having considerable longitudinal extent, while a few yards bound it in breadth. In the ascent from the village to the Pass it is again lost, being replaced by micaceous schist. But on the descent gneiss reappears, accompanied by hornblende schist, and extends for some distance. Perhaps after all, these two patches are connected beneath the surface, the micaceous schist of the Pass lying on them. It is possible even that they may both be connected with the Jagesur gneiss, as the latter may be with that observed at Ramesur, and again on the other side with the rock in the valley of the Goomittee. Well devised sections would throw light on this point, and probably develope the general arrangements of these detached patches of gneiss.

274. The Almorah ridge towards the southward, terminates in a mass of granite and granite gneiss, the latter being most abundant. By this term I mean a rock, which in structure seems to be intermediate between gneiss and granite. It is remarkable for containing prismatic nodules of felspar, which gives it a porphyritic character. There is also a good deal of the granan, and there are the same blocks strewed over the surface of the hill as at Dihee. In fact, there is no question but it is the same rock as the two patches observed at Chumpawut and at Dihee. It extends in the east quarter across the valley of the Sowal, ascending the ridge on the opposite side, where it is succeeded by the black and red earthy slate already described, Art. 270. To the south it terminates in the descent to the con-

fluence of the Cosillah and Sowal, being exchanged for micaceous schist, which gradually passes into a talco-argillaceous schist, and latterly, a perfect clay slate. To the westward, it descends the valley of the Cosillah, rising into the lofty peak Seahie Dabee, which is nearly composed of it, and bounded on that side by micaceous schist. A few very narrow veins traverse some of the vallies beyond the limits of this patch, but their connection with it has never been satisfactorily traced.

275. The micaceous schist of Almorah occupies the descent to the Cosillah, with the exception of the narrow strip of granite just noticed. The road to Hawulbagh is in the same rock, and it continues in the route up the valley of the Cosillah, till it is exchanged for the patch of gneiss noticed in Art. 152. On the road to Gulee Busoor, it also prevails, being most commonly of a bluish colour, and containing garnets abundantly. This rock is further remarkable for being traversed by a vein of a singular nature, no name or description of which I have even met with. Near Hawulbagh an instance occurs: It is of a porphyritic character, consisting of thin needles or prismatic bundles of needles of hornblende, imbedded in a white granular paste of felspar and quartz. On the Pass above the village of Aeena, leading from this valley into that of the Sugos, the rock is of an earthy type and very singular aspect. The dip of the schist here (on the Pass) is N. E. 22°, the inclination 50°. Below the village of Aeena, it occurs of a lead blue and full of garnets, the dip being N. E. In this neighbourhood are many of the porphyritic veins just noticed. Micaceous schist more or less differing in character continues to Mernee, near Dhoora Hat'h, great irregularity being observed in the dip with frequent reversals; near the Sugos it is S. W., which on going a little farther is exchanged for a N. E. dip. In the bed of the river it is again S. 25° W., inclination 34°. The porphyritic veins are abundant in this neighbourhood. The S. W. dip continues to the junction of the mica slate, with a gneiss which lies conformably; but which is the superior rock, it is impossible to say for want of access to the line of junction, especially as the change takes place in the direction of the strata.

276. This gneiss is introductory to a large patch of granite similar in character to the three beds already described as occurring at Chumpawut, Dihee, and Almorah, and what is still singular, in the same straight line with them; the direction as before observed, being parallel to that

of the strata and of the mountain land. There remains nothing to add to the particulars already given of this rock at those places, as it is here precisely the same in grain, consistency, overlying, amorphous appearance, &c. It appears to pass on its borders into a gneiss. The change at Mernee has just been noticed. Another takes place in the descent to the glen to the N. W. that leads into the valley of the Ramgunga, (Art. 106.) To the N. E. it is I think connected with the gneiss in the Cosillah, (Art. 152.) To the south it is succeeded at no great distance by micaceous schist, but the boundary line was not seen. The schist was observed to dip N. 27° E., inclination 41°. To the west it passes into the pseudo-porphyritic gneiss, noticed at Almorah, and which near Mythana is succeeded by a black micaceous schist. Near Palee, however, the gneiss is again seen, containing nodules of quartz, and some very singularly lustruous veins of a material, the same essentially as the basis, only much harder. At no great distance on each side, micaceous schist is recognised.

277. In the descent to the Ramgunga, micaceous schist reappears, and continues as far as the confluence of the Beneegunga. In the bed of the former river, the number, size, and variety of the rolled stones is quite surprising. They occur at a height of 200 feet above the present bed of the river, and many of them are of a totally different nature from any of the rocks in the immediate vicinity. The micaceous schist continues in the Beneegunga; at its mouth it dips 32° N. E., the inclination 31°. Beyond Tamba Dhar, it is again succeeded by gneiss, which is distinctly stratified, and dips N. to N. 13° W., at an angle of 52° to 57°. It is worthy of remark, that part of this rock is a perfect micaceous schist, containing no visible traces of felspar, yet there is no separation, nor any transition in the usual sense, nor disturbance of any kind. To the eye, it seems to be part of the gneiss, but on examining it, the characteristic ingredient is found wanting, while in the remainder of the mass, it is obvious enough lying in lenticular imbedded nodules, which on the cross fracture, give the rock an appearance not to be mistaken.

278. Another observation of the dip, a little beyond this point, gave N. 22° W., the inclination 43°. Quartz rock and micaceous schist next succeeds, and continues to Deoghat. At this place, the route turns up the bed of a feeder of the Beneegunga to Ketureea, and in

this line a rock oscillating between granite and gneiss continues the whole way. It appears to divide into cuboidal masses, or rather into parallelopipeds, one of the surfaces of which, apparently coinciding with the planes of the strata, gave a dip of N. 22° W., inclination 36°. Near the Dawk chowkee, it is observed in immense rounded masses lying in the bed of the river, and I think having more the character of granite than the masses in situ. In this the felspar, which is of a greenish grey colour, and its lustre being highly translucent, is very remarkable for the size of its concretions, and their imbedded appearance giving the rock very much the appearance of a porphyritic granite. This rock has an analogue at Almorah, and on the summit of the Choor Peak.

279. The gneiss continues to put on the appearance of being divided by several sets of seams into more or less regular masses, and its structure becomes less decidedly schistose. An observation of the dip gave N. 10° W., with an inclination of 72°. It contains the same felspar that I have just noticed as occurring in the rolled masses of granite, a little beyond the 243rd kos stone* the dip was observed S. 20° W., inclination 50° to 60°. Latterly near Thanna, it gives way to a micaceous schist, remarkable for the great size and imperfect shape of the garnets it contains. The round blocks of granite of great size appear still in the bed of the river. From Thanna to Muse, and again in ascending the high range over which the road to Ran leads, no rock but micaceous schist is seen in situ. Above Masoo, it occasionally contains kyanite, but not in any quantity, or of any size or beauty of appearance. On the summit of the Pass, the same rock is found dipping N. E. at a considerable angle. Half way down the descent, blocks of gneiss in great number and of great size are seen, many of them occupying such situations as will not admit of our supposing for an instant, that they have ever been in motion, or occupied other than their present sites. At the village of Ran, micaceous schist is the rock dipping N. E.

280. From Ran, the route descends to the bed of the same nullah in which micaceous schist is still observable, and thence ascending to Kunyoorbut near the latter place, we come again upon a district of gneiss

* The Goorkhalee Government had erected these stones at distances of a koss along the line of road from Katmoondo to the Sutlej.

rocks, which occasionally appear to pass into the common earthy micaceous schist, occasionally into an amorphous granite. It contains schorl occasionally in nests. The boulders are very numerous, and the granite is in places a perfect granan. The gneiss, when well defined, contains garnets. Hence to Dhout, the latter rock and micaceous schist may be considered the prevailing rocks. On the summit of the Pass above, gneiss is also found of that type, which inclines rather to micaceous schist than to granite. Hence descending, the granite is again met with, but under relations which will bear a little more detail.

281. The appearances I am going to describe may be seen a little to the east of the village Dhooeet. In a geological sense, the rock may be called a gneiss, but it exhibits small patches, (forming regular transitions amongst themselves,) of the most regular micaceous schist, (earthy type,) and again of the most legitimate granite, (granan). These three rocks, so different in composition, in mineralogical character, and in supposed geological origin, may be here observed in the compass of a few yards, all naturally interchangeable, while nothing like a veinous appearance can be attributed to any of them. A long zone or belt is marked by huge boulders of gneiss or granite, (for I could not examine them closely,) strewed over it, and such is the declivity of the mountain side, that we cannot for a moment suppose that they have rolled into their present places. They are in fact like those of Dihee, the harder nodules of a rock many feet in depth, which has disappeared owing to the power of waste. The dip of this rock, which in its gneiss and mica slate types is regularly stratified, is N. 48° to 55° E., inclination about 48°. In the descent from this village, we find the chloritic argillaceous schist mentioned in Art. 116.

282. The whole of these beds are upon the same line, which is, as before observed, parallel to the direction of mountain land and of the strata. In prolonging this line to the westward as far as the Sutlej, only one other locality of granite is met with. This is the Choor Peak, a mountain which rises to the height of twelve thousand feet, and which has no equal or rival within a circle of sixty miles diameter. The shape is that of a long block or ridge running N. N. W. and S. S. E., about one and a quarter mile in length, which rises suddenly on the N. W. extremity into a sharp rocky peak many feet higher. To the S. E., it sinks suddenly into a well-wooded range, where the

rock is with difficulty accessible, but from the indications observable, I should judge it to be micaceous schist. This rock indeed surrounds the base of the high ridge which itself is composed of granite, occasionally of a highly crystalline grain. It appears to contain two different kinds of felspar, one of which assumes that arrangement which may entitle the rock to the appellation of porphyritic. It is a very beautiful rock. The mountain is conspicuous from every other quarter, and in every view of it the summit patch of granite is at once distinguishable from the micaceous schist below by its peculiar rocky aspect and bareness.

283. I have now to give a few details on the occurrence of the sandstone formation which bounds the mountain tract to the South towards the plains. This rock assumes many different aspects here as it does in Europe; upon the whole, the resemblance is sufficiently striking to allow of our identifying it with the newer red or saliferous sandstone, (the red sandstone of English geologists.) It is either a hard red gravelly clay distinctly stratified, or the same clay enclosing rounded stones, or a micaceous sandstone, which in hardness varies from loose sand to a rock that will strike fire. This type is again modified by the admission of rounded pieces passing into sandstone conglomerate. These two rocks form the principal part of the formation. The sandstone is always micaceous in a high degree; it is most commonly of the ordinary colour, but sometimes it is found of a dark bluish grey, in which case it seems to loose its appearance of a schistose structure, and becomes amorphous, breaking equally in every direction. The type is farther remarkable for containing kernels of superior hardness to the base, which itself is more compact, and I might say clayey, than the ordinary sandstone. It also contains less mica. This grey type also passes into the conglomerate structure; besides these, which are the most marked types that have any extent, there are innumerable varieties of very anomalous appearance, chiefly towards the upper part of the rock. The yellowish grey ordinary sandstone often alternates with a rock that might pass for a perfect greywacke. The latter is seldom marked with the strata lines like the sandstone, but is conformable and parallel to it. One of the most remarkable features is the occurrence of ellipsoidal-shaped cavities in the middle of sandstone strata. They are of different sizes. One which I observed measured six feet in its longest diameter, and was quite smooth and regularly curved in its interior.

284. I shall now mention the different places where this sandstone has been observed, adding any other particulars which appear to require it. At Bhumowree, it is seen in the river bed, dipping N. E., at an angle of about 30°; but it has here scarcely any development, and nothing is to be learned regarding it but the above fact. At the Chilkein defile, we have more access to it. It there forms very extensive strata, chiefly of the red clay type, between Chilkee and Dhikoolee. In the bed of the Cosillah, occasionally rounded stones are contained imbedded. The strata appeared almost horizontal, or at least very slightly inclined. At Dhikoolee, the conglomerate character is perfect, the basis being still the red clay, but sometimes indurated in a high degree. The strata here dip to the North. They are covered by a deposit of loose rounded stones. From this point, the rock is concealed till we reach Chookoom, and there we find a greenish grey sandstone with mica dipping S. W. It is covered by a loose shattered rock of various bright colours, indicative as I have observed elsewhere, of this formation; beyond this point, that is above it, I have not met with it.

285. Specimens brought from Kaloo Shaeede's tomb, at the outlet of the Ramgunga, belong to this sandstone. They were of the grey type, with conglomerate structure. At Hurdwar, it may be studied to great advantage, and all its characteristics examined on the Beemghora Pass, where the construction of a beautiful road, by order of Government, has given two admirable sections of these strata. They are here mostly of the sandstone type, neither the red clay or the conglomerate being common. On the opposite side of the river, however, Chundee Puhar is almost entirely composed of these types. A singular circumstance is the opposite dip of the strata observable at these two places. At the latter, they dip on the Hurdwar side S. 35° W., at an inclination of about 30°; while on the other the dip is the N. E., the inclination much the same.

286. This formation has also been examined in the Kheree Pass, leading from the Dhera Doon into the plains. In this quarter, the dip is very regularly to the N. E., or to some point between N. and E. The first strata observable, and which may be supposed uppermost, is the red clay that lies on a stratum of red conglomerate. The Pass is cut through this latter, and a good section of it obtained. The stones are most commonly quartz rock, more or less coloured; pieces of granite

also are observable. Farther on is a perfect sandstone conglomerate; specimens were obtained in appearance perfect greywackes, traversed by quartz veins. The grey type is common, and often appears to pass into a sandy clay, with mica disseminated. Similar phenomena are visible in the Timlee Pass, the other entrance to the Dhera Doon, and in the ascent to Nahun. The Pinjore Doon is shut in to the southward by a low range of hills, composed chiefly of red clay and red conglomerate. West of this point, the formation has not been traced, but it probably extends to the Sutlej, having a greater development where the vallies separate it from the primary strata, and vice versa.

287. There now only remains that I should notice the extent of the deposits, consisting of rounded stones, gravel, and sand. I have already mentioned in the course of the preceding details, the several accumulations that are to be observed in the beds of rivers. But their greatest extent is on the borders of the plain country lying at the foot of the mountain ranges. At Bhumowree, they may be seen resting on sandstone. They reach to Tandaha, a distance of fifteen miles. In great part of this line, the deposit is of enormous thickness, a well having been sunk half way between those places to the depth of 150 feet, without passing through it. At Chilkeeah, they are again seen reaching from the foot of the mountains to Haldoorea, a distance of twelve miles. Here also the deposit must be of great thickness, as ineffectual attempts were made at Chilkeeah also to sink a well; sixty feet was the depth penetrated to, without passing through them. Again at Hurdwar, they have been traced as far south as Bhogpoor, a distance of ten miles, pieces of granite being observable amongst them. On the Kheree Road, they are seen for an equal distance to the southward, and on the Beput Road the same. But the most extensive collection of them by far is in the Dehra Doon, the whole of that valley being, as it were, filled up with them. A well which has been sunk there by the Hon'ble Mr. Shore, attained a depth of 220 feet, before a good and plentiful supply of water was met with; even at that great depth, the nature of the deposit was the same as at the surface. Mr. Shore has preserved notes of the particulars observed in the course of the work, and has kindly allowed me to take a copy of them. I shall here give them, as forming a very interesting contribution to our knowledge of the geology of these mountains:—

Feet.	*Total.*	
5	5	Fine black mould, with a few stones.
4	9	Reddish earth, mixed with gravel.
9	18	Loose sand and gravel, large stones.
2	20	Ditto, with reddish clay.
3	23	Stiff reddish clay.
8	31	Stiff yellow clay.
3½	34½	Sand and gravel, mixed with a little red clay.
1½	36	Stiff reddish clay.
2	38	Sand and gravel.
22	60	Stiff red clay.
2	62	Clay sand and gravel mixed.
16	78	Sand and gravel.
12	90	Stiff yellow clay, with a little sand.
35	125	Sand and gravel, a few round stones.
3	128	Sand, large blocks of conglomerate north and west side.
3	131	Ditto.
13	144	Sand and gravel, with tolerable sized stones.
5	149	Ditto ditto, stones larger.
9	158	Ditto ditto, with pieces of conglomerate.
4	162	Ditto ditto, with enormous stones.
6	168	Conglomerate on three sides, gravel the fourth.
3	171	Sand and gravel most; occasionally pieces of conglomerate.
3	174	Conglomerate, blocks of.
3¾	177¾	Layers of sand and gravel, pieces of conglomerate.
4¼	182	Sand and gravel.
⅓	182⅓	Conglomerate 4 inches thick, under it water, but scanty.
2⅔	185	Sand and clay.
⅓	185⅓	Conglomerate.
18⅔	204	Sand and gravel, rather loose, occasionally pieces of conglomerate, occasionally solid blocks 160 lbs. in weight.
5	209	Sand and gravel, very moist.
⅓	209⅓	Conglomerate, over half the well water.
1⅔	211	Red clay.
7	218	Sand and gravel, very moist, water.
3½	221½	Blackish clay, with angular fragments of clay slate.

288. The extent of these deposits has not been traced so recently to the westward, but no doubt is entertained, that they attain there also an equal extent, judging from the recollection of former journies. Below Nahun in particular, and near Munta Dihee, at the exit from the Pinjore Doon, very clear traces of them are to be seen. That the Pinjore and Kyarda Doons are, equally with the Dehra Doon, composed of them, I have no doubt. It ought to be stated, before concluding, that in the Dehra Doon, the great thickness appears to be in the centre where the ground is highest. Towards the vallies of the Ganges and Jumna, they diminish very much in thickness, and in the beds of those rivers, may be observed resting on sandstone.

289. Southward of these rounded stones, a very extensive deposit of the red clay, which is very similar to the red strata of the sandstone, prevails. It has often small patches of loose sand. This red gravelly clay lies in a blackish clay of a purer character, very stiff and tenacious at different depths in different places. This latter appears to change to a lighter colour as we descend, and becomes more arenaceous, till at length it changes to a grey sand. My enquiries and observations have not yet been sufficiently general to allow me to identify these deposits with any thing like certainty, indeed it is only very lately I have been able to turn my attention to the subject, and the recent arrival of the boring engine I had ordered from England, precluded the possibility of constructing a proper apparatus and scaffolding for using it with effect, unless the operations were delayed till the ensuing year. I was therefore obliged to content myself with such results as could be obtained without the proper means, and was not able, in consequence, to penetrate beyond twenty-two feet in any of the bores I made; but I hope on my return to the field duties, that I shall be able to continue these enquiries with greater effect.

290. In the meantime, it may be interesting to give the particulars of the few bores I made. The first was at Moradabad, but being new to the operation, it took several days to bore sixteen and a half feet, the particulars were as follows:—

Feet.	*Inches.*	
4	0	Superficial sandy loam forming a very productive soil.
2	5	Brick earth. This is the red clay, which prevails so extensively in Rohilkund, and which so often comes to the

Feet.	*Inches.*	
		surface, forming a substance of a singular hardness, and excellent materials for roads.
3	7½	Reddish micaceous sand. The temperature at this depth 16½° was found to be 76° 5′; a thermometer in the shade marking 58°, and the surface of the ground being 56°.

291. The next boring was at Kusherpoor, where the red clay has a very extensive superficial development. It forms the step described in Arts. 59 and 73, which gives so deceptive an appearance to the direction of the fall or declivity. The spot where the boring was made, was about twenty feet below the surface of this red clay, and the following were the particulars:—

Feet.	*Inches.*	
2	3	The superficial red clay.
1	3	Green sandy clay, water.
4	6	Black clay, extremely tenacious.
1	6	Light blue sand. The water was in such abundance, as to prevent any further progress; it speedily rose to within a few feet of the surface. At Huldoon, seven miles north, nearly similar results were obtained.
5	6	A ferruginous sandy clay or loam, latterly becoming more stiff.
1	6	A greenish clay, getting latterly blackish.
2	0	A bluish grey clay, partially sandy, not so tenacious, and quite moist. Gravel under this. The water rose rapidly, and prevented any further proceedings.

292. At Jusspore, nine miles N. W. from Kusheepoor, a third boring was made, but the place was injudiciously chosen, being in a hollow, evidently the dry bed of a jeel. The following are the particulars:—

Feet.	*Inches.*	
5	0	Surface sand, which gradually changes to a stiff red clay.
2	0	Red loose sand, damp.
2	0	Variegated sand and clay, spotted.
3	0	Yellowish sand, changing to light grey, twigs and roots were found at nine feet, water at 12.

293. At the next place we find the same deposits as at Kusheepoor and Huldoon.

Feet.	*Inches.*	
2	0	Superficial loam.
3	6	Clay; temperature 68°.
1	6	Sand.
1	6	Clay again.
1	6	Sandy clay, twigs.
2	3	Stiff clay, latterly blackish.
1	6	Ditto, of a darker colour and more pure.
1	0	Grey sand.

Water rose to within a few feet of the surface.

At Afzulgurh, the following particulars were noted:—

Feet.	*Inches.*	
6	0	Superficial loam small nests, and veins of a semi-carbonised vegetable matter.
2	6	Red sand, a quicksand.
4	0	Blackish stiff clay.
3	6	Stiff clay, latterly sandy.

The quicksand falling in prevented any further operation. The black clay proved to be an excellent potter's clay, and baked without changing colour. It formed a very porous article, and was very acceptable to the potters, who were ignorant of the existence of any such clay in their neighbourhood.

294. At —— the following particulars were noted:—

Feet.	*Inches.*	
7	6	The superficial loams yellowish, and more sandy latterly. It forms an excellent soil, and is known by the provincial term *muteear*.
2	3	White micaceous mixture of sand and clay.
1	6	White clay, a little sandy.
1	0	Brownish black clay, containing semi-carbonised vegetable matter.
2	6	Dark bluish clay, very stiff, when wet almost black, latterly veins of light blue.
6	0	Clay much iron shot, and passing to sand.
1	6	Dark bluish clay, as before.
5	0	Sandy clay, much iron shot.

The temperature was observed to be 73°, once at six feet, and again at eight feet, that of the surface being 59°.

295. I have here concluded the geological details; some few particulars have been omitted in their places, but will be hereafter inserted with fresh matter, which I hope will render it something more complete. I have principally to regret, that the circumstances under which these papers have been prepared, have prevented the execution of the original design of referring in the account of the occurrence of rocks by number to the particular specimen collected. Such a practice will be of very great advantage, and will indeed give the above detail far more authority, than it could possible otherwise have. I shall now proceed to state, in a few words, the general results to which they lead.

Section III.

RECAPITULATION.

296. In the details just given, I have necessarily entered into a minuteness of description, which to the general reader must be tiresome in no small degree. The paper being intended as a record of observations, it was necessary to be particular; but I shall attempt in this section to throw together the general results, comparing them afterwards with received opinions, and illustrating the whole in the best manner my limited reading will permit.

297. It appears then, that in these mountains gneiss occupies the greater part of the surface, forming a band of 24 miles in breadth, and including within its boundaries all the elevated summits, but one, of the table, at Art. 39. Of these all that have been approached sufficiently near to determine the point are certainly gneiss, that is, if distinct, thin, and well-marked strata be any ground for deciding. Other evidence there can be none, as it is impossible, by actual examination, to ascertain what rock is at the summit. It rises then most probably to the height of 25,709 feet,* while the lowest point is only elevated 2,800.

* Captain Webb gives 25,669 as the height above the sea—Journal of Science. The paper by Major Hodgson and myself in the 14th Vol. As. Res. has 25,749. I have taken the mean.

If we suppose the lower strata continuous across this tract, and allow for the inclination, we shall have eight miles for the extreme thickness of this formation, and about six for its mean value.

298. The direction of this zone of gneiss is generally, I might say almost always, North 60° West, being thus parallel at once to the direction of the line of greatest elevation, and also to the general bearing or tendency of the mountain land. The inclination lies between 20° and 30° in by far the greater number of instances. It is, however, sometimes, though very rarely, as high as 50°, and in one solitary instance was observed to be 56°. There are very few reversals of the dip, at least towards the centre or middle of this zone; but along the southern boundary, which is very irregular in its outline, forming various incursions into the adjoining zone of schists, there do occur several irregularities both in dip and inclination, and the former is sometimes reversed. That it is pretty regular in general, however, is proved by the fact noticed by all travellers, of the uniformity of aspect in the sides of slopes and precipices in these mountains.

299. The character of this rock is highly crystalline, and it appears to consist almost always of the regular ingredients, and united in the usual regular proportions. It is surprising how few varieties present themselves in so extensive a tract of country, and in general, these varieties differ more in colour and grain than in mineralogical character. The occurrence of imbedded minerals is rare, and of these only, the most common have been observed, as quartz, garnet, and kyanite. It is almost equally barren in beds, containing only some very small ones of hornblende rock, quartz, limestone, and mica slate. Of the two last, I do not know more than one or two instances of each. In fact, there is a character of sameness throughout this formation, extremely tiresome to the geological traveller, as continually disappointing him in his hopes of meeting with something new and interesting.

300. Veins of granite are numerous, particularly towards the central or highest parts; but no beds have yet been found, the granite of Wongtoo being supposed to be veinous. Towards the boundary, however, there are some patches, which would appear to have some connection with a series of beds found beyond the limits of the gneiss, and surrounded generally by rocks of a more earthy and less crystalline character. These latter beds have been described as occurring at

Chumpawut, Dhee, Almorah, Shaee Debee, Dooara Hath, Palee, Dhoeet, and Kunyoor. They are situated in the zone of minimum elevation, and a line passing through them has a direction of North 60° West, the same as that of the strata and zones of different elevation. West of the Ganges, no such beds are found, unless we suppose the Choor granite, (which is certainly on the prolongation of this line) to be one, and then it will be the only one. Another anomaly which the granite of the Choor presents is, that it occupies the highest point in all the mountain tract, south of the zone of greatest elevation, whereas the eastern beds are situated in the lowest ground. A third difference is in the character of the rock, which in the case of the Choor granite, is highly crystalline; in most of the others, earthy and decomposing. Yet it must be confessed, that they present some differences of aspect in this respect, and that at Chumpawut, Dhee, and Almorah, very hard and crystalline granites are procurable, though at the two latter places in limited quantity.

301. The grain of the veinous granites is, as has been often remarked, large; in variety of composition too, they form a singular contrast to the uniformity which distinguishes the gneiss. In this respect, they also differ from the beds of granite, which are strikingly alike in mineral composition, colour, and size, and arrangement of grain. In these particulars, the Choor granite is almost precisely that of Almorah, though separated by such a wide interval. What distinguishes this granite at first sight is, its porphyritic structure, and it evidently contains two distinct varieties, if not species of felspar.* This variety is seldom found in a crumbly decomposing state. The only other well defined type is that which is so remarkable for its rapid disintegration, in which the ingredients appear to be united in the usual irregular manner. This contains a large portion of white opaque felspar, and it is well distinguished by its granite boulders, the true nature and history of which have been so well laid open by Dr. Macculloch.

302. Smaller veins have not been observed to affect the appearance of the including rock, but the vein at Wangtoo, the only large one

* The existence of several mineral species hitherto confounded under this title, has been now clearly established, and I anxiously look forward to a period of leisure, when I may submit the different granites to a particular examination with reference to this point.

I have seen, certainly is in contact with a rock forming a transition between granite and gneiss. With regard to the beds, they also present in general the appearance of a thin band of gneiss surrounding them, and outside of this is found mica slate. The whole being included in clay slate, no change in the latter rock has even been observed. It is almost unnecessary to say that none of these beds are stratified,* that is, the central nucleus; but as before stated, they appear to pass into gneiss on their boundary. The only imbedded minerals are schorl and quartz, (rhombohedral schorl and rhombohedral quartz.)

303. Conterminous with the gneiss may be found a series of different rocks all possessing the schistose structure, micaceous, chloritic, and talcose schists; whether all to be included under one head, is a point for the determination of which data are as yet wanting. But it is perfectly certain, that there is no such thing as a general and continuous formation of micaceous schist (the next rock in our systems) analogous to that of gneiss; several large patches of micaceous schist occur, but they are separated by equally large tracts of other schists. Perhaps the above three schists might be conveniently considered as one formation, although we should even then find our systematic views disturbed by the intrusion of schists of an argillaceous character. These latter may be seen even in contact with the gneiss. Thus we shall be forced to modify a little our ideas of the exclusive nature of formations, and in admitting argillaceous schist as a member of the series, we shall establish, as succeeding the gneiss, a zone of schistose rocks of nearly equal extent, but not presenting the same appearances of regularity of position, or uniformity of mineral composition.

304. In considering the subject, I have been certainly inclined to view this latter account as most consonant with the phenomena. But it is possible that a more particular examination of the boundary of the gneiss may establish the first view, and in this case, the gneiss with which the argillaceous schist is in contact, would belong to a different era from that of the zones of greatest elevation, whereas I have suppos-

* The stratification of granite, a favourite tenet of one of the rival schools of geology appears to be losing ground every day. Mr. Greenough long ago, in his critical examination, shewed the extreme laxity with which this term stratification had been used. In the sense in which most unlearned people understand it, I apprehend that granite can never be said to be stratified. After all, however, it is a mere dispute about words, and seems, whichever way determined, to throw no light on the subject of the origin of rocks.

ed them to be connected. This is one of the difficulties attending so early an attempt to generalise; for the present it may be sufficient to view all these schists as constituting one formation. This formation will then be found to be of nearly equal extent with that of the gneiss, being in breadth — miles, and stretching, as that does, from river to river, it will terminate in those mountains which form the northern boundaries of the several Doars, and in the line connecting them.

305. In this method of viewing these rocks, it may be stated, that there is but one general formation (of primary rocks,) besides that of the Himmalaya gneiss,* and it is worthy of remark, that they divide the whole tract pretty equally between them. The schistose formation is no doubt stratified, though, it is thought, not so regularly as the gneiss, and its strata are often much more inclined, much more contorted, and present greater irregularities, both of curvature and reversal of the dip. It is, however, to be noted, that mountains of this formation do not present the same facilities for examining the strata, as those which are composed of gneiss. Being in general so much more subject to decay, they have a very thick bed of local debris which effectually conceals the rock in situ, and in such cases, the character is necessarily taken from that of the debris. The effect of this is to give these mountains a rounded and softened contour, which distinguishes them at once from the serrated and bare rocky ridges of the gneiss formation.

306. The mineralogical character of these schists is variable; but this is not only true of the whole formation, viewed as comprising rocks to which distinct titles have always been allotted, but also of the varieties which are referable to any one of those titles. And the many anomalous rocks produced by the intermixture, and transitions of these, form a numerous band, strictly speaking, belonging to none of them considered by itself, and therefore strengthening the view I have taken of the

* In confining the number of primary formations in so extensive a tract to two, I may be thought to indulge in too large a generalisation. It may be said, that many of the beds I mentioned as contained in the clay slate, may be in fact formations. It is proper, therefore, that I should explain what I mean by a bed; for half our mistakes in geology are occasioned by using words in a wrong sense, frequently in no sense at all. By a bed then I mean, a mass not veinous, which is surrounded on every side by the same rock. It may be stratified or not; it is unnecessary to add the term subordinate, as this definition includes that idea. It has another advantage, that it involves no theory.

entireness of this formation. These varieties, at least all those that required it, have been described already with sufficient minuteness. It may be here a sufficient recapitulation to say, that the argillaceous schist, as it covers the greatest extent, so it presents the greatest vacillation in character. No opinion can be more void of foundation than that which supposes the several varieties of clay slate to be arranged under four different, distinct, and well marked types, the produce of four different eras, and distinguishable by characters mainly dependent on colour; so far from dividing into regular zones, or even isolated patches, the different varieties are found in every part of this extensive tract. Excellent purple roof slate; stone slate passing into flinty slate; a black almost arenaceous rock, with patches of white resembling the ash of half-burned charcoal; a white arenaceous rock with scales of mica; a soft schistose clayey rock of various bright colours, and a granular yellow rotten stone; all these are found in a space of not three miles square. From my own very limited experience, I would say, that of all distinctions, colour in clay slate is the most vague, and least to be depended on.

307. This tract of schists contains numerous and extensive beds of limestone, frequently enclosing veins of galena, (hexahedral lead galena of Mohs,) beds of dolomite (macrotypus lime haloide,) and potstone (prismatic talc mica, the massive variety,) either singly or in conjunction, and containing in each case veins of copper and iron pyrites, (pyramidal copper pyrites and hexahedral iron pyrites,) purple and grey copper (octahedral copper pyrites and tetrahedral copper galena,) beds of red and brown iron ore (rhombohedral and prismatic iron ores,) veins or beds of graphite, (rhombohedral graphite mica,) and superficial amorphous masses of gypsum (prismatoidal gypsum haloide.) But the most remarkable of all its subordinate mineral masses is the greenstone, which is so often met with, though limited as to extent. Connected probably with this rock is the series of fragments, obtained near Bhumowree, presenting types of amygdaloid and porphyry. But the whole subject is as obscure, from want of observation, as it is interesting, and the fact of the only series of lakes within these mountains being found in the neighbourhood, enhances the interest extremely. Indeed, it is not a little difficult to restrain our premature efforts to connect these facts with a well-known theory, remarkable for the origin it assigns to these rocks.

308. Southward of the great belt of argillaceous schist, which forms the plainward termination of the series of schists, we find a narrow strip of secondary rocks, mostly, if not entirely, the newer red or saliferous sandstone. This formation presents little to interest us, excepting in the promise which its position here gives of more valuable deposits further South. It is always stratified, and the dip is most commonly conformable to that of the primary strata. At Hurdwar, the strata on opposite sides of the river dip in opposite directions. It differs extremely in character, being sometimes a red clay, which occasionally contains rounded stones, sometimes a regular sandstone conglomerate, often loose sand. It is remarkable for the quantity of mica it contains, and for the series of bright colours it presents often within a very short distance. It contains brown coal (bituminous mineral coal,) but in what quantity is not known.

309. Lastly, we have lying at the southern foot of this sandstone range, and also occupying the several vallies bounded by it, a deposit of great depth, but not disposed in strata, consisting of gravel and sand, including large boulders or rounded stones of every magnitude up to three feet diameter. The extent of this diluvium, as we may call it, is very great, it occupies a track 192 miles in length, and nearly 10 in breadth. But the length is probably much greater, as it is not unreasonable to infer, that it is conterminous with the sandstone range, which certainly extends from the Indus to the Burhampooter. Outside of the tract of diluvium, a red earthy marl is found intermixed with patches of sand, and a blue clay, very similar in character to that of the London clay, is found to underline these. In the neighbourhood of Hansee, a fresh water limestone is met with, containing perfect shells of the genera melania and planorbis.

CONCLUSION.

Section IV.

310. From the particulars given in Section I, may be collected the fact of a considerable difference of physical aspect between these mountains and the Andes, the chain with which it has been most usual to compare them. Instead of the confused and irregular appearance, the

endless and complicated ramifications, the ragged and steep acclivities, the total absence of vallies or level ground, the lofty summits and deep ravines there described, we have in the latter an arrangement of two parallel chains or ridges running for a distance of 500 miles, and enclosing between them a broad and elevated table land, constituting one of the finest countries in the world; again the numerous volcanoes, extinct or igneous of the Andes, the terrible earthquakes, the torrents of mud and water so frequently discharged from openings suddenly occurring, and the uprising of considerable mountains; all these circumstances belong to a totally different order of things from that which prevails in the Himmalaya.

311. The difference in physical features is not greater than that which appears in the geological character of these two rival chains. In the Andes, as we learn from Humboldt, there is an extraordinary developement of porphyry and trachyte, the more elevated points being composed almost exclusively of the latter rock. Trachyte is confessedly a volcanic production, though the rival schools are at variance with regard to porphyry. Yet, M. Humboldt in his latest work, appears to incline to the opinion of its also being of igneous origin.* We may further notice the great deficiency of primary formations.† Granite and gneiss are only found in masses of any extent near the sea coast and at low elevations, while the transition clay slates and secondary sandstones attain a developement and an elevation, of which there are no other authentic instances.

312. In the Himmalaya again, we have seen that neither trachyte nor porphyry, nor indeed any volcanic or trap rocks are to be found. The whole series, as is evident from the details in Section II., is composed of primary formations, and chiefly if not entirely of gneiss,

* Or ought we not rather to admit that the domain of volcanic action has been too much limited, and that these porphyries are, with respect to their origin and relative age, connected with trachytes, as the trachytes formerly confounded with trap porphyries are connected with basalts, and real lava ejected by burning volcanoes? Humboldt Gisement des Roches, English Translation, page 157. Again, "In Equinoxial America, the limits between transition porphyries and real trachytes known to be volcanic rocks are not easy to fix." Idem, page 155. For other instances of this opinion, see page 156 to 160.

† In the Cordilleras of the Andes, of Peru, Quito, Grenada and Mexico, among that innumerable variety of porphyritic rocks of which the masses attain from 2,500 to 3,000 toises in thickness, I did not see a single porphyry that appeared to me decidedly primitive. Humb. Giss des Roches, English Translation, in p. 124.

succeeded on each side by an extensive band of schistose rocks, enclosing a variety of subordinate beds, the whole being of the clearest primary character. Organic remains are, it is true, stated to have been found at a great elevation northward of this chain, but nothing of the kind occurs within the zone of greatest elevation, nor within the mountain tract south of it. It is, however, believed, that with regard to the great elevation of the transition and secondary formations, parallel examples to those of the Andes may be found in the prolongation of the mountain barrier to the north. The subject has not yet been fully investigated, but there are presumptions in favor of this opinion deducible from the arrangement of the strata. The following particulars may be stated as the sum of what is actually known on the subject:—

318. No organic remains have even been found within the tract which I have asserted to consist of primary formations. But they have been brought from a place north of the zone of gneiss, and though there are doubts as to the localities of some of these specimens, it is quite certain that in one instance, ammonites have been observed in great numbers, at an elevation exceeding 16,000 feet.* What makes this occurrence particularly interesting is, the fact of the limestone in which these ammonities are found occurring at no great distance from the boundary of a gneiss, which if it be not actually connected with, is not distinguishable in mineralogical character from that of the Himmalaya.

319. Ammonites, mineralised by clay slate, have been brought by natives, and as they aver, from no great distance from our frontier on the Neetee Pass. I have also seen specimens of belemnites mineralised by calcareous spar.† But neither these, or the preceding more authen-

* I have never had an opportunity of examining these fossils, but the identification of the species would throw no light on the question which is here being considered, as it is generally agreed by geologists, that however uniform the mineralogical character of rocks may be in the most distant localities, yet with regard to organic remains, no assistance can be derived from the *characters of species* in identifying formations, unless in a country of very limited extent. Even the hitherto generally received opinion of the universality of formations begins to be questioned, and a doubt entertained whether the granite of Cornwall, for instance, and of these mountains were formed or even assumed their present places at the same time.

† It has been made a question by a geologist of deservedly high reputation, whether the occurrence of organic remains (speaking generally) should be considered *ipso facto*, a decisive argument against the primary character of a rock, and though authority be against him, yet it is the authority of those who admit of a transition class into which they transfer these anomalous occurrences. Now, as no distinctive characters have

tic observation, where the locality and elevation are actually known, can be considered quite decisive of the fact of secondary formations being found at uncommon elevations. For the occurrence of ammonites and belemnites is by no means universally allowed to be characteristic of secondary rocks; and even by that school which asserts their presence to be destructive of the primary character of a rock, they are allowed to belong to the oldest of the secondary, or what they would call, the transition formation.

320. A more curious fact is that of the bones brought from the neighbourhood of the Neetee Pass, and which Mr. Buckland has recognised as belonging to the same era with those of the caves, the history of which he has so ably illustrated.* As this fact would establish the identity of the deposit in which they are found, with that which he has called diluvian, and which is the newest of all the formations, it would certainly be very interesting to settle accurately the locality from which they are derived. But nothing certain is known on this subject further than the negative fact, that they are not to be found south of the Neetee Pass. Hitherto, they have been collected only by natives, whose reports,—never very precise as to particulars the value of which they do not appreciate,—can scarcely be allowed to settle a point of this interest; even their account, however, places them a considerable distance northward of the limits of the zone, marked by the snowy summits of the Himmalaya.

321. Thus then it appears, that at present all we know of certain is, the occurrence of a limestone with ammonites at an elevation of 16,000 feet above the sea, and at no great distance from the boundary of the Himmalaya gneiss. As to the other organic remains, they are brought from beyond our frontier by natives, but neither the distance or the elevation are precisely known. But granting all that these may seem to prove, as to the great elevation to which secondary

ever been assigned to this class, as have been to the primary and secondary, it is not very unfair to consider this procedure as *something* similar to what is called a *petitio principii*.

* A collection of these bones belonging to Mr. Traill, which I had an opportunity of examining, appeared to me to be perfectly mineralised, judging from their high specific gravity. Now the peculiar character of the diluvium bones is stated to consist in their being not at all, or at least very imperfectly mineralised, differing in fact very little from grave bones of high antiquity, light, porous, and absorbent to the tongue.

formations attain beyond the limits of the tract which is the subject of this paper, it would still be true, that within this tract no such phenomena occur. The great extent covered by primary rocks, and the total deficiency of the trap or volcanic rocks may then serve to express the entire dissimilarity of geological structure between this tract and the Andes,* and I think it a point of considerable interest, and worth insisting on, that no traces of volcanic action,† whether recent or otherwise, has yet been observed in these mountains.

322. We have seen that these primary rocks are always stratified, and that the dip in a great majority of instances is N. E., the direction of the strata being consequently parallel to that of the zone of greatest elevation. The inclination also being small, we may perceive strong grounds for admitting the occurrence of comparatively recent formations at great heights in proceeding along the line of dip. Thus at no very great distance from the crest of the gneiss strata, we may fairly expect, as is the fact, a clay slate, and then a limestone with ammonites, and no doubt did our observations extend further to these, we should see succeeding secondary formations, tertiary, and lastly diluvian, so that upon the whole, there is nothing improbable in the accounts of those who assert the ammonites and belemnites to be found at no very great distance from our frontier.

323. An interesting question is here suggested by the view I have taken of the great central tract combined with this conclusion. We know from Patrin, that the great Altaian chain consists like the Himmalaya of primary formations. Are not these distant and opposite points

* For this reason I have been at a loss to understand, how analogy had taught us the primary nature of the Himmalaya formations. It certainly appears most natural to compare them with the Andes, in order to deduce analogical inferences. The Andes are not primary, the Himmalaya are so: analogical discoveries *a posteriori*, are always to be suspected.

† There is a foolish notion amongst some of the hill people, however, that the great peak, called Nunda Debee, the highest of the range, and consequently in the world, has been known to emit smoke. They suppose the smoke to be from the gods' Choola or kitchen. It is hardly necessary to add, that there is no real foundation for this opinion. The peak is within 60 miles of Almorah, distinctly visible at all seasons, and had any thing of the kind ever occurred, it must have been seen by some of the European residents at that station. It is, however, worthy of mention, that this peak is scarcely ever seen without a small light cloud resting obliquely upward from its summits; such an appearance might be converted by the crazy imagination of a devotee into smoke ascending from his gods' Choola.

connected on each side by rocks of the same character and eras, and is not the interior from which on one side at least these fossils of such different formations are brought, a huge basin or series of basins in which are arranged secondary, tertiary, and even diluvial deposits, surrounded and supported on every side by a gigantic zone of primary formations?

324. It has I know been disputed, whether the same mountain range or chain be, or be not marked by identity of geological structure. Like many other disputed questions, it is one of words, and the solution entirely depends upon the sense in which we use the word range or chain. If we mean continuous line of elevations, in other words a chain of water heads, such is certainly not marked by identity of geological formation. If again, the line of greatest elevation be understood, then we shall certainly find identity of geological structure, but nothing like continuity of surface. Analogy then adds all its weight to the opinion, that the series of primary formations continues quite round the central plateau.

325. It appears then, that the tract with which we are engaged, comprises a very small part of the outward declivity of a barrier of primary formations, the most extensive probably in the world; that these formations have in this particular quarter, a dip directed N. E. or at right angles to the direction of the tract, and that it is probable the dip continues all round to be also at right angles, that is, towards the centre of the great basin which they surround. The crest of these formations we see attains in more than one quarter to a height of 25,000 feet, rising from plains which have a level of 1,400 feet, and this in a distance of 90 miles. Here then, if any where, we may expect to find some clue to lead us out of the labyrinth of geological speculations and hypotheses; some key to the solution of the great problem concerning the origin of the present inequalities of the earth's surface. Could we but obtain access to all the particulars which are to be learned in these interesting countries, geology would very soon assume a different aspect from that which has as yet distinguished her. Perhaps even the small part of it to which we have access, may furnish particulars calculated to throw some light on the principles of a science as yet in its infancy.

326. Saussure has observed, that in mineralogical cabinets, we see every rock have a definite and easily recognised character. No anomalies

or irregularities occur to embarrass us; none of the transitions or mixtures which are found in nature, and which form the difficulties of the pursuit, "La on trouve tout disposé selon le systeme." The same may be said of our most approved geological systems. There we find every rock occupying its distinct quarter, and no hint of the great and perplexing irregularities with which the student of nature has to struggle at every step. We have granite occupying the lowest and the highest points, a covering of gneiss resting on the granite excepting at the very highest points, mica slate over the gneiss, clay slate over it again, and so on in regular array, and with the outgoings of the newer and newer strata. At lower and lower levels, such an account of things is no doubt very beautiful, very systematic, and indeed has but one fault, that it is not true. As countries have been examined more particularly, it is found, that excepting in a few grand points, not one country will serve for an exact type of another.

327. We have seen that in these mountains,* gneiss occupies the greatest part of the surface. Its thickness is considerable, if we adopt the commonly received opinions of stratification.† To this succeed various schists, the true relations and connections of which are very obscure; micaceous, talcose, chloritic and argillaceous in different places are conterminous with the gneiss. In the schists and in the zone of least elevation, we find a series of patches of granite disposed along a line parallel to that of the direction of the mountain band and strata. Beyond these again, we see an extensive zone of clay slate, in which occasional patches of gneiss also are found, and outside of the whole very limited examples of the secondary strata, which are finally lost in the plains.

328. Here then is a very different arrangement from that just

* Professor Jameson in one of his latest works mentions the Himmalaya as an example of a granitic chain. It would be interesting to know on what authority he founds his opinion. I have seen more of these mountains than any European, and the only granite within the above tract (beyond which we cannot without great violence apply the term Himmalaya) that I have ever seen consists of fragments in the beds of rivers. I have never had any doubts, and if I had, the occurrence of these fragments would remove them; but that there are occasionally veins and perhaps larger patches of granite as in other parts of these mountains, but I have never within this tract met with any rock, in situ, but gneiss and its contained beds.

† There are, however, some good reasons for rejecting this indefinite continuity of the strata underneath, at least in the direction in which they appear on the surface.

described. The great extent of gneiss, the limited occurrence of granite, its situation in the zone of least elevation, the want of a regular consecutive order in the super-position of the schists; these are sufficient to shew the total dissimilarity of nature and system. But we shall find much greater differences than these, as we descend to the details. It has been supposed, that in every chain of mountains, the strata dip outwards, that is, from the summit the dip on opposite sides is in an opposite direction, and it is obvious that such must be the state of things, supposing the origin of the stratified rocks to be as Werner has taught. But in these mountains this is by no means a description of the fact, for the strata, abstracting local exceptions, have but *one* dip, and that is, on one side towards the chain, on the other from it. The same arrangement obtains in the ghauts of Rewah and Bundlekhund, that is, their dip is only in one direction; and it is worthy of remark, that the precipitous side in that chain is also directed towards the great diluvial valley of the Ganges, which is thus bounded on opposite sides by the perpendicular faces of the strata.

329. Such being the arrangement which obtains, it becomes difficult to understand clearly the order of super-position of the rocks that are found south of the gneiss tract. It is no doubt a very singular feature in the structure of these mountains, and is the more interesting, as being apparently in direct opposition to opinions which have been so generally received. In the accompanying diagram,* it is evident that the gneiss strata at A. prolonged, would be over those at B., which succeed the gneiss in travelling southward, and this remark holds good throughout down to the plains, for the strata always dip conformably or sufficiently near, so as to establish this conclusion. Were the effect to stop with merely placing clay slate or mica slate superior to the Himalaya gneiss, there would not be the actual difficulty; for we know, that within certain limits, there is no exact and universally true order of super-position, though the contrary is stated by systematic writers, (Art. 12.) But in this particular case, the most generally received position in geology would be violated, for by supposing that no dislocation or separation of the strata has taken place, we should have clay slate,

* We trust, as before stated, that the figures and diagrams will be recovered with the geological map, when we shall not fail to give them to the public.—Ed.

primary limestone, mica slate, and lastly gneiss, all resting, and in this order, on a secondary conglomerate !

330. Are we then to say that this latter is really the case, and that even those facts most generally received, and as yet disputed by no school or sect however sceptical, are often all but partial and local occurrences, and not examples of a general law applicable to every country? Or is there any way of viewing the subject by which we may escape from so startling a conclusion? Will any dislocation, subsidence, or elevation of the strata explain the difficulty? I think not; for besides the enormous extent of the fault which we must suppose to account for the schistose strata, (at least eight miles in thickness and thirty in breadth,) appearing to dip beneath the gneiss strata, a fault which startles the imagination by its magnitude, we have also to believe, that at each junction of two different formations, a similar fault occurred. This is an assumption evidently gratuitous, and not having even a seeming of probability to recommend it. And in two instances, probably in many more, the appearances as described leave no doubt as to the fact of the newer rocks lying under the older; that is, if we suppose the strata continuous underneath. In these instances, no dislocation whatever will explain the anomaly. The difficulty appears to me to be real, unless we give up those views of stratification which would identify them with the parallel and consecutive layers of mechanical deposition.

331. It is an opinion gaining ground every day amongst geologists, that the seams of stratification are not always what they have been supposed,—the effect or sign of mechanical subsidence; and many other facts besides this, militate against the supposition we are considering. Were those layers really deposited from a fluid by the effect of gravity, how are we to explain the sudden changes which are often seen to take place in strata, not vertically, but horizontally, and this repeated often in a very limited space.? That what is called concretionary structure may sometimes produce parallel seams, we see in the case of those clay slates in which what are supposed to be the planes of stratification, are not parallel with the schistose planes. And that parallel seams, not to be distinguished from those of stratification, may originate in some other cause, is also obvious from the fact so often observed of two, and even three sets of these seams occurring

in the same rock; thus creating a difficulty of saying which is or which is *not* the set indicative of the strata. If we admit then with some of our most celebrated geologists, that in the older rocks the planes of structure have been erroneously attributed to stratification, the difficulty with which we are contending will vanish.* In this case there will be no necessity for inferring a continuation of the strata underneath, and therefore no violation of generally received notions as to the super-position of rocks. The newer formations will rest on the older, and as in this case, the configuration of the surface could not have had any effect in giving the present dip and direction to the upper strata, (for it would have been the reverse,) it is quite clear that neither in these rocks are the seams significative of mechanical depositions.

332. It is at all events very certain that, in all primary countries, the stratification presents various anomalies not easy to be explained on the hypothesis of the formations being mechanical deposits. It is likewise not impossible, that a more particular examination of our mountain strata may suggest some other explanation, or at all events lead us to view it as less contrary to geological observation than I have stated.† With these considerations in view we may for the present consider the order of superposition as determined by the succession of rocks found in proceeding southward, or at right angles to their direction. We will therefore suppose the schists to be deposited on the gneiss, and the sandstones on the schists, notwithstanding the dip being towards the crest of the chain. We have seen, that the two zones into which, on a large view, the rocks may be divided, are parallel with the direction of the mountain land, and with that of the elevated zone, though not with that of the chains, which, as we have before shewn, have no connection whatever with the geological structure.

* If we could follow their limits with the eye we should probably find the fact to be as now stated, a view of the subject which may tend to explain the apparent inflections and contortions of rocks in general, and perhaps the stratified structure, in all its varieties, may ultimately be considered as resulting from concretion on the large scale.—*Geol. Trans. vol.* 5, *part* 1, *p.* 176.

† See Mr. Weaver's Paper on the Geology of Ireland in the 5th vol. Geol. Trans. part 1. Dr. Macculloch and Professor Jameson appear also to be of this opinion. The latter, however, combines with it a less tenable doctrine, that the Earth may be a large polyhedral crystal, and the planes of stratification its cleavages.

333. In the separation of these two facts,* continuity of elevated ground and identity of geological structure, and which is everywhere so strongly marked in these mountains, we may perceive proof incontrovertible, that the present hydrographical arrangement of the surface has been posterior to the original formation of these mountains; in other words, that their vallies or hollows are effects of denudation, and not of original structure. This conclusion could not be more firmly established, even if we saw the corresponding but disjoined ends of the strata on opposite sides of the valley; such an appearance, however, is by no means rare, as may be seen in the details given in the preceding section. But the proofs need not stop here. For if there be a truth more firmly established than another, by many and various circumstances, it is this of the extensive waste which this surface has undergone, and evidently from causes far exceeding in power any that are now in operation.

334. It is sufficiently obvious, however, that though the system of vallies or drainage, generally speaking, be the effect of denudation, yet we are not to attribute all the irregularities of the surface to this cause. Some it is certain originally existed; some may have been caused by a sinking in of the strata. In the first way, we may account for much of the great depth assigned to vallies in Art. 41. The excavation of a valley of 15,000 feet in depth, and having a slope of nearly 30°, would indeed be incredible whatever force of water we employ, or however long the period we have at our disposal. Even with this abatement, enough remains to stagger our belief. Our incredulity may, however, be softened by recollecting the continually recurring difficulty of accounting for so many openings in the line of the strata, without any marks of displacement or dislocation.

335. There are some facts which, though they throw no light on the manner in which this great change of the surface has been effected, yet are sufficient to shew, that such a conclusion is not to be rejected, even though there may occur a difficulty in explaining all the details. The beds of some of the rivers are, for a part of their course, in the solid

* One of the first impressions made on the mind in examining the Tortworth district is, that the existing form of the surface appears to a certain extent to be unconnected with the nature of the rocky formations that compose its base, an observation indeed that may admit of almost universal application, and be deemed a maxim in Geology.—*Mr. Weaver Geol. Trans. vol.* 1, *p.* 319.

rock. In these cases, the depth is often considerable, while the appearance is such, as leaves not a doubt in the spectator's mind, but that the present channel was once filled up with solid rock. This is a conclusion we cannot escape from, however difficult it may be to understand the removal of so many thousand cubic feet of solid rock by the agency of water.

336. In all the river beds too we see that there are accumulations of gravel and boulder stones, all perfectly rounded, and consequently all of them such as have been subject to the action of water. These collections, it appears from the details I have given, are in many cases of very great extent, and frequently occur at a height of even 300 feet above the present bed of the river. That these collections should ever have been formed by such bodies of water as are found at present in their vicinity, is altogether inadmissible. Their extent, the size of the fragments, the distance from which they are derived; above all, their great depth, and the height at which they are found above the present bed of the river, all forbid so incredible a supposition.

337. Even if we could get over these difficulties, and really believe that rivers, which in their greatest power at the present day cannot move one of these fragments a few feet, did yet in former ages, transport for many miles, several thousands, nay millions of them, and accumulated them in heaps many times exceeding in height the greatest depth of the said rivers; even if we could get over the difficulties, yet others greater remain. The tract defined in Art. 71, called the Bhabur, we have seen equally consists to a vast depth of these water-worn fragments, evidently of the same era, derived from the same rocks, and transported by the same causes; so also the several plains or vallies described in Art. 57, *et seq.* contain immense beds, the same in every respect with those found in the river vallies. These it is evident, could never have owed their disposition to the power of rivers, whatever may be said of the former comparatively limited accumulations; because they are found where at present no rivers flow.

338. That there is some connection, however, between the disposition of these beds of gravel and formation of the river vallies, appears evident from the following fact:—In establishing a series of bores along the terrace, I found that the distance from the common boundary of plain and mountain land at which gravel was found, was greater in the beds

of rivers, or in their banks, than on the intermediate ground. Whatever therefore the cause which accumulated these beds of water-worn fragments, we see that it acted with greatest force in the direction of the river vallies.

339. There is another very striking fact which enables us to limit still more precisely the direction in which these fragments travelled. At Hurdwar, it terminates rather suddenly in the low range of hills, which bound the Dehra Doon to the southward. These hills, as I stated in Art. 61, form an uninterrupted chain or line of water-heads, on each side of which they are intersected with deep gorges now the beds of torrents. Those which open to the Doon, it appears, are strewed with fragments of the same kind as those which cover the valley itself; but those which open plainward, contain no fragments but of the rocks in situ, which it also appears are of an entirely different character, and not possible to be confounded. The deposit seems, however, to have continued along the foot of those hills, and even to have left fragments at the mouths of the gorges; but in no case do they extend to any distance upwards.

340. These deposits have been observed in every country in which as yet geological investigation has been carried on, lying at the foot of mountains, and often covering extensive plains, or scattered over the bottom of vallies. Perhaps in no country can they be seen on so large a scale as in these districts. The enormous extent of the bed comprising the Bhabur, and filling up the several vallies, is alone enough to excite all our wonder. They have everywhere been recognised as witnesses of the progressive nature of the changes that have affected the surface of the earth. They have established the fact of at least two eras, that of the original formation of these mountains, and the subsequent extensive denudation of the surface forming the present system of vallies. But from considering all the circumstances of the case a still greater discrimination may be made. It is almost certain, that they owe their present arrangement to some sudden and violent catastrophe. Now, it is not likely that their rounded form, being as they are amongst the hardest of stones, was given them by any other than a cause operating through a considerable period of time. Here then we have proof of a series of actions, which must have been posterior to the formation of the original strata, and which carries up the latter to a still higher antiquity.

341. Nor is this question affected by the doubt as to the origin of these boulders; that is, whether they have proceeded immediately from the debris of the primary strata, or immediately been formed into secondary conglomerates. It is remarkable, that the nature of the stones is the same in both deposits, the secondary rocks and the diluvium; the only difference being in arrangement, the former being distinctly stratified, and passing into well-defined micaceous sandstone, while the latter forms a confused heap of gravel, in which stones of all sizes and even angular fragments sometimes are found. That they have originated in the breaking up of secondary strata, is I think, the most probable, although we shall then be puzzled to account for the deposits in the beds of rivers where now no secondary rocks are to be seen. However this may be, it is still worthy of remark that the greatest accumulations are found where the secondary formations still exist.

342. Granting that some such catastrophe in these mountains as a mighty *debacle*, or rush of waters, must have given these beds of diluvium their present place, we shall see strong reasons for supposing, that for a time these waters have been pent up in the Doons or vallies, which extend along the frontier. Have they subsequently broke through this range by their own accumulated pressure, or has any other cause of change assisted in finding an outlet for this series of lakes? The reversal of the dip on the opposite sides of the river at Hurdwar, is a curious anomaly occurring in such a place, and must, I think, strike every one. Till all the circumstances be known, it is vain to speculate. Whether such fact or any disturbance of the strata is to be observed at the other *debouches*, will be interesting to determine.

343. The theory which has identified this rush of water, traces of which have been found in every part of the globe, with the deluge, as described to us in the Scripture, and which has derived its chief illustrations from the labors of Cuvier and Buckland, has been strongly opposed by the geologists of Scotland. In particular, Dr. Fleming has stated some difficulties with regard to the subject, not easily got rid of. He has shewn, that the silent and quiet rising of the waters, and their equally gradual subsidence, as deducible from the account of Moses, cannot be confounded with a cause which has evidently been sudden, vast, and overpowering. The former we see did not even abrade the surface, for vegetation, and trees even, still remained, whereas

the latter has torn up a vast mass of consolidated strata, scattering their ruins over an extent of many hundred square miles.

344. Granting, however, that these attempts to find a geological theory in the sacred records have been as hasty as ill-judged, we shall not find Dr. Fleming more successful than those whose labors he has overturned, in explaining the phenomena in these mountains. With him it is merely the bursting of a series of lakes, and the diluvium is in his nomenclature, lacustrine silt. The mere alteration of the name is of little signification, nor does it lead us a step further in our search after truth. But here is no series of lakes, no vallies that might conveniently be supposed beds of lakes. The only vallies in the several Doons are beyond the limits of many of the phenomena which their bursting is to explain. Were our geologists always satisfied with shewing what is *not* the cause, the science might make more progress than it has done, but one theory is no sooner laid than another rises to supply its place.

345. In reality, our chief object should be in the first instance to collect facts from every quarter. If the explanation is to be general the induction should be equally so, as well as the data on which it is founded. Our limited acquaintance with the surface of the earth will not allow of our generalising as yet with safety, and it will be constantly found, that the hypothesis invented to explain the phenomena in one country, will be overturned by facts observed in another. Dr. Fleming, in his hurry to establish his own view of the subject, has certainly confounded two distinct, and in many cases, easily recognised classes of appearances; and in truth, the whole of what Professor Buckland has advanced in his Reliquiæ Diluvianæ remains untouched, (because it is observation,) excepting his notion of the identity of the cause, the effect of which he has so ably traced to the deluge of Scripture. I need hardly add, that the phenomena in these mountains have a most striking analogy with those detailed in the above work.

346. The hasty generalisation which produced the Wernerian system of geognosy has long been acknowledged, and the fact established that few countries, even belonging to the same formation, present exactly the same arrangement and succession of rocks. The opinions of some geologists have even taken the other extreme, and it has been questioned whether there be any such thing as a general formation quite round

the globe; a continuous one there probably is not, but when we view amidst all the differences that undoubtedly do occur in the super-position and connections of rocks, the many and wonderful coincidences that still remain, not confined to a spot of limited extent, but *clearly* belonging to the whole *tract*, we shall be satisfied that the contemporaneous formation cannot be predicted of these masses in which such resemblances are found; at least they must be attributed to a common origin. When we read in Humboldt, that while in different countries, different plants and animals present themselves to the observation of the naturalist, the rocks are the same in every zone; in every climate we appear to be engaged * * * * * * * * known list of minerals might be formed, we have so small a catalogue of compound rocks, and these always the same wherever occurring, why should granite always contain quartz, mica, and felspar, and always nearly in the same proportions, however distant the localities? mica slate, mica and quartz, and so on of others. These are questions difficult to answer, but which none can avoid asking themselves who have ever reflected on the subject.

347. In all the grand features of geological character * * * * * * * * * * * Himmalaya does not [*coincide*] it is true with that [*of the*] Andes. But it bears a [*very*] close resemblance in general features to the description given us by Dr. Macculloch, of the Western Isles. As on those Islands, so here we recognise the great extent of gneiss occupying in each system the middle and highest tract. In the great deficiency of granite, we see another resemblance and a common difference from the dogmas of the schools, that the highest part of every system of mountain * * * * * * * * impossibility of discriminating in this point between the primary and secondary rocks. But the most interesting coincidence, at least to me, is in the arrangement of the schists, and their connections with the other rocks. In his chapter on the chlorite series, he has almost completely anticipated every thing I had to say on the chlorite schists of the Himmalaya.

* A quarter of a page, or more is wanting, where this and the following lacunæ occur, and there is no clue by which even to guess at the writer's views.—Ed.

348. The existence of coal all over the world, and always in t same geological situation, is another proof that even in *

* * * * * condition or state

things, which must have been common to every country of the glo Pursuing the analogy taught by the facts learned in the coal fields England, that valuable mineral has been brought to light in alm every part of the world, it may not therefore be uninteresting to enter ir some little explanation on this subject, in order to judge whether t deposit may be expected in this quarter, as in any way connect with the series of facts described.

349. The coal formation though, as has been observed, owing i origin most probably in every country to the action of some gene cause, may yet be considered, as far as appearances are concerned, be a local deposit, inasmuch as it is always of limited extent compare with the other strata. Its place in the system is well marked, n has any bed of coal worth mention ever been found out of that plac It is known to overlie a limestone, which from its relation to t coal, has been called carboniferous, and which itself lies upon the ro called the old red sandstone, the lowest of the secondary strata. Abc the coal measures is found the newer red or saliferous sandsto Between these two members of the series, it has always been obser to hold its place; subordinate strata occasionally intervening, occasi ally being wanting, but the coal never occurring, that is, in any qu tity above the latter, or below the former rock.

350. This would seem to be a sufficiently definite arrangement enable us always to pronounce on the greater or less probability finding this useful mineral in any tract in which the succession rocks has been accurately traced. Applying the principle to the pres survey, it will be found that limiting facts are wanting, although general presumption is strongly in favor of the existence of a c formation. Thus we have the saliferous or newer red sandstone the border of the mountain tract, dipping N. E., giving the prom of older or inferior deposits to the Southward; and again at Dehli, have the old red sandstone, leaving it a natural inference, that in intermediate space, intervening formations will be found.

351. The great coal field of Northumberland and Durham is situa in millstone grit and limestone shale (the upper anomalous beds of t

old red sandstone,) on the outside of which small patches occur of the newer red, and beyond that, a country of schistose formation. On one side it has the mountain or carboniferous limestone, and outside of it, a large band of the red sandstone, part of a mass which occupies the centre of England. The coal field of Wales is separated from the old red sandstone by a narrow strip of the carboniferous limestone. Those of Staffordshire are similarly situated with those of Northumberland. The coal field near Burdwan is covered by the newer red sandstone; all these facts, I think, give a strong probability to the opinion, that coal will be found in the Dooab. The facts that are wanting are such as would limit its position, and consequently give a well-grounded prospect of discovery, before commencing any thing like an expensive search. These facts will be furnished by the prosecution of the survey.

The concluding section of this Report is that upon the Mineral Productions of the Himalaya, which will be found in Vol. XVIII, Part I. p. 227 of the Trans. As. Society.—Ed.
