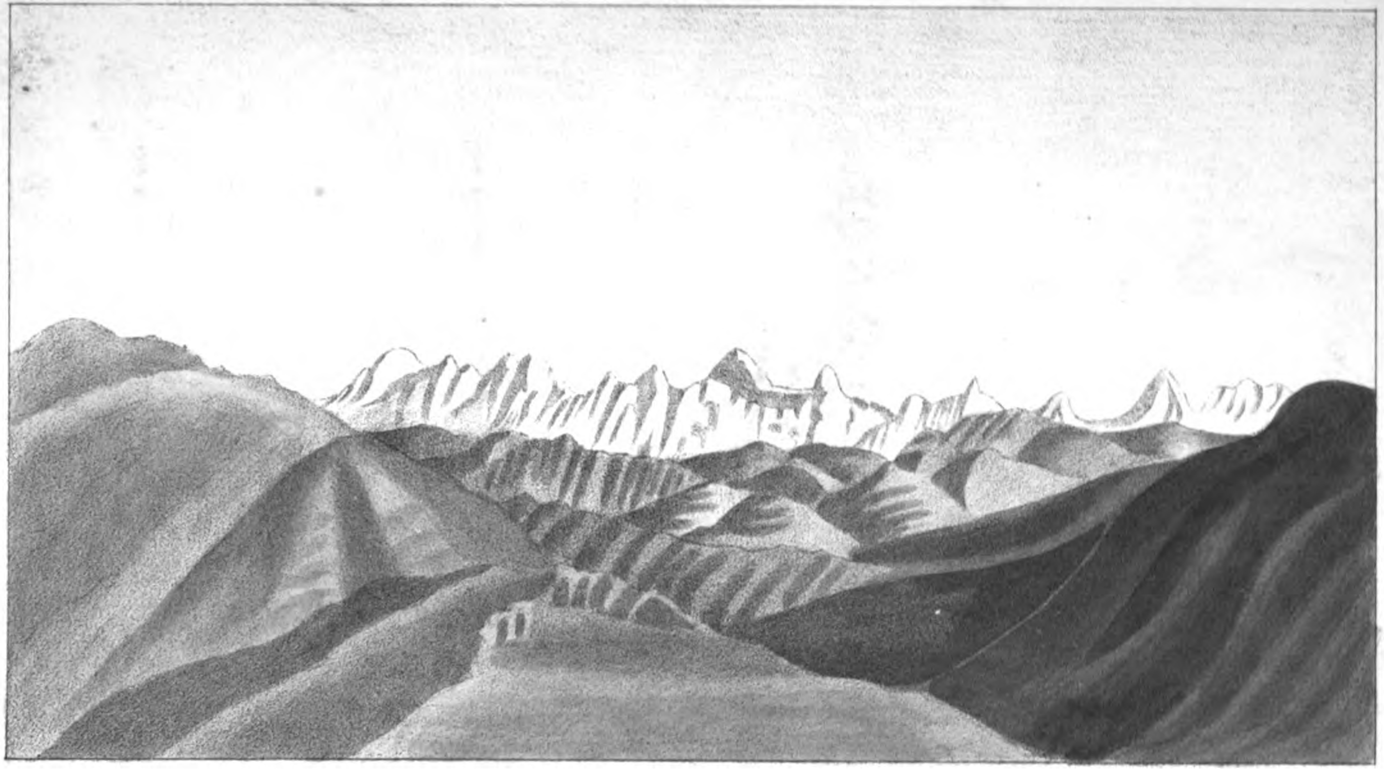

J. McClelland del.

Drawn on stone by J. Bennett.

A View of the Himalaya Mountains from the vicinity of Lohoogat on the Road to Fort Hastings

SOME INQUIRIES

IN

THE PROVINCE OF KEMAON,

RELATIVE TO

GEOLOGY,

AND OTHER BRANCHES

OF

NATURAL SCIENCE.

BY

ASSIST.-SURGEON JOHN McCLELLAND,

MEMBER OF THE ROYAL COLLEGE OF SURGEONS IN LONDON, AND OF THE MEDICAL AND PHYSICAL SOCIETY, CALCUTTA.

"While idle speculations about the structure of the earth lead to nothing better than wrangling and confusion; every new fact respecting the relative position of rocks, every accurate description of a district adds somewhat to our former knowledge, and contributes towards the completion of the science. Geognosy will be complete only when we are accurately acquainted with the structure of the whole surface of the globe, and when we understand completely the laws which regulate the changes which it is slowly undergoing."—THOMAS THOMSON, M. D.

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MDCCCXXXV.

TO

THE HONORABLE

SIR C. T. METCALFE, BART.

GOVERNOR GENERAL OF INDIA,

&c. &c. &c.

THIS HUMBLE EFFORT TO BE USEFUL,

IS,

WITH PERMISSION,

RESPECTFULLY AND GRATEFULLY INSCRIBED,

BY

HIS DEVOTED HUMBLE SERVANT,

THE AUTHOR.

PREFACE.

In submitting the following pages to the public, my object is to induce others more competent than myself, to enter into similar inquiries relative to the Geology of districts in India.

I do not flatter myself, that my humble efforts possess any intrinsic value. If they are found to have any interest; it is derived only from the importance of the subjects to which they refer.

Geology has, indeed, become a subject of popular interest in every country in the civilized world; so much so, that it may now almost be taken as the criterion of national intelligence and prosperity.

A noble effort has recently been made by a few eminent members of the Asiatic Society of Bengal, (with their distinguished President, the

Honorable Sir Edward Ryan, at their head,) to remove the reproach to which British institutions in India were liable, by adapting a department of the Asiatic Society exclusively to the cultivation of Natural Science.

A few months had hardly passed after this change, when a volume of Transactions issued from the Physical class, that would do honour to any Society in Europe. India, however, is not a country in which new publications are advertised in every village; and such are the disadvantages of private individuals in remote districts, that they often remain ignorant of the existence of the most important works, until some peculiar circumstance or accident presents them to notice. I mention this, as an apology for not having availed myself of some interesting papers that have recently appeared in India on Geological subjects, and which I had no opportunity of seeing, till my return to Calcutta.

There is one point that may require a word in explanation, namely, that of having departed from the practice of confining systematic descriptions, to what are called *simple* minerals; but in a country so remote from the observations of others, my object was rather to trust to descriptions than to names.

Should a mere name, unaccompanied with the description of the substance on which it is conferred, be misapplied, the error would lead to irremediable confusion. On the other hand, descriptions admit of comparison with each other, and with the things to which they relate; and by this means, correct not merely their own errors, but also the erroneous application of names: while they at the same time expose to our view the nature and peculiarity of whatever is submitted to them. It may therefore be supposed that I was anxious to avail myself, as much as possible, of systematic descriptions as the only sure basis of inquiry, and I could see no objection to their being applied, as well to mountain rocks, as to the rarer minerals.

The labours which I here take the liberty to submit to the public, are the result of a temporary residence in Kemaon, while on the regular tour of duty with my regiment in that province. Placed in Medical charge of two detachments, thirty miles apart in the mountains, with occasional liability to be called into head-quarters, fifty miles in another direction, I had frequent opportunities of collecting information, that it would have been difficult, if not, quite impossible, to resist, and I am only ashamed to have turned such advantages to so poor account.

There are, however, circumstances to be offered in palliation of the numerous faults that pervade this work. The first, is that of my unexpected removal from the province, with the troops to which I was attached, and the consequent interruption of my inquiries before they were completed. I still, however, hoped, that on my arrival at the station to which my corps was destined, I should there have sufficient repose to correct and arrange my MSS. and collections. A few days had hardly elapsed, after a harassing march, when I found myself under orders to join Dr. Wallich in Calcutta, (from which I was distant 1,100 miles,) with the view of proceeding, with that eminent man, on a Scientific Deputation to Upper Assam.

The multiplicity of objects, connected with my new appointment, appeared likely to engross the short time I had to remain in Calcutta; so that I at first abandoned all hope of being able to publish these labours. But the kind assurance of Dr. Wallich, that the world, though a severe, is yet a generous, arbiter in cases of this nature, as well as the kind offers I received from distinguished individuals, to correct such portion of the proof copy, as I might be compelled to leave unprinted on my departure from Calcutta, have encouraged me to submit the work, with all its defects, to the indulgence of the public.

Having once commenced printing, my object was to proceed with the greatest expedition; so as to accomplish as much as possible previous to my departure from Calcutta. I was therefore obliged to content myself with the inspection of a single proof—a circumstance, which, without great care on the part of the Printer, must have given rise to still more numerous errors than have occurred.

The indifference of Printers and Publishers in general to the appearance of works in which they have no property, is such as to deter authors from publishing, until they are enabled themselves to superintend the press at leisure; but the solicitude evinced by Mr. Pearce, for the works which pass through his hands, is a subject of gratulation to the Indian community, and is not the least of those new facilities that are now opened to the spread of literature.

CALCUTTA,
August, 1835.

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ERRATA.

The indulgent reader is requested to correct a number of errata which have occurred throughout this work, kindly bearing in mind the peculiar circumstances under which it went through the press, and which have been explained in the Preface. The most important ones are here pointed out.

Page 38, line 4, *for* 'slates,' *read* 'slaty.'
,, — ,, 5, *for* 'quartz gypsum,' *read* 'quartz and gypsum.'
,, 55, ,, 27, *for* 'vol. VI., *read* 'vol. VII.'
,, 115, ,, 2, from bottom, *for* 'Gorou,' *read* 'Goron.'
,, 130, ,, 16, *for* 'clay-slate,' *read* 'slate-clay.'
,, 139, ,, 12, *for* 'catastrophies,' *read* 'catastrophes.'
,, 172, ,, 14, *for* 'inertia,' *read* 'inertiæ.'
,, 178, ,, 13, *for* 'slates,' *read* 'slate.'
,, 216, *for* 'Murinus, Cristatus,' and generally all adjective specific names throughout the Zoological Catalogue,' *read* 'murinus, cristatus,' with small, and not capital, initials.
,, 264, ,, 16, *after* mineral, *insert* water.
,, 267, ,, 9, *for* 'two,' *read* 'three.'
,, 340, ,, 11, *for* '1.009,' *read* '1.0009.'
,, 341, ,, 7, *for* '1.001,' *read* '1.0001.'
,, 356, ,, 10, *for* '1.001,' *read* '1.0001.'
,, 369, ,, 3, from bottom, *for* 'Tarai,' *read* 'Taru.'

RESEARCHES

IN

THE PROVINCE OF KEMAON.

PART I.

GEOLOGY.

CHAPTER I.

INTRODUCTION.

It may be considered presumptuous to take this opportunity of offering a few remarks on the present state of Geology in India: but as I have in my humble sphere laboured unassisted in this interesting field, during the greater portion of my short residence in the country, I may be supposed to know something of the causes which here retard the cultivation of this science.

It is painful to reflect on the number of years the immense empire of Hindustan has been in our possession; and that to this day we should remain as ignorant of its physical structure as we are of that of China, or the interior of Africa. It is painful to turn over the leaves of mineral systems, and to find such accidental specimens as may have found their way from India to Europe alluded to, as regards the position from which they were derived, in as ambiguous terms as are usually adopted in explaining the source of those mysterious bodies called aërolites, which occasionally fall from the clouds.

The labours of geologists, within the last thirty years, have put us in possession of a vast fund of information respecting the physical structure of almost every part of Europe, and a great portion of America; but of the continents of Africa and Asia, we are still ignorant of a sufficient number of facts to enable us to conceive, even a general notion of their formation, with any tolerable degree of accuracy. The remedy for this defect lies with those who reside in foreign countries; for although such persons may not be so competent to convey information on difficult subjects, as those who live in enlightened nations, where a ready acquaintance may be formed with all that is known on any scientific question: yet it is to such sources we must chiefly look for the extension of geological science. Governments are not yet so liberal as to send philosophers to every portion of the earth, for purely scientific purposes; and philosophers themselves are seldom possessed of sufficient fortune to enable them, and disinterestedness to induce them, to incur the risk of losing both life and fortune even in such a cause.

In the few instances in which British governments have patronized the travels of scientific men, the motives have been rather the extension of commerce than the promotion of science; and often so exclusively so, as was calculated to defeat, rather than to serve even the mere object in view; for who can deny the impolicy of those frivolous instructions by which the traveller is generally embarrassed on entering upon his mission, as if the interests of science, and those of commerce were incompatible.

Thus for instance, when the natural and artificial productions of Mysore were required to be known, Dr. Buchanan was directed to make the following the *chief* objects of his researches in that country, viz. esculent vegetables, cattle, farms, cotton, pepper, sandal-wood, cardamums, mines, quarries, minerals, mineral springs, manufactures and manufacturers, climates, seasons, and inhabitants*. A few years afterwards, as if to shew the caprice with which such missions are devised, three gentlemen were selected to survey the then unexplored source of the Ganges, without any other instructions than merely to determine that geographical question†: so that it is easy to see, that under such a system, geology, and indeed, natural history in general, must be greatly or entirely neglected.

* Buch., Lond., 1807.

† Asiat. Res. 447-8, Lond. 1812.

Monuments of a people, or the external relations and mere connexions of rivers and kingdoms, force themselves on the antiquarian and the geographer; but the researches of the geologist do not belong alone to external nature: they must penetrate the surface of the earth, as well as scrupulously trace, from the deepest valley to the highest summit, the boundaries, extent, and relations of every rock*. Thus it is, that in geology, a greater effort, mental as well as physical, is required to produce a given effect, than perhaps in any other branch of natural science. Hence it is, that geology is so incapable of being advanced by studies in the closet; and so likely to be injured by careless or deficient observations in the mountain: and hence also, as well as from the practical utility

* M. J. C. Braun Neergaard, in his Memoir on the most Proper Means of accelerating the Progress of Mineralogy, read to the French Institute, 1812, observes: "In Mineralogy we have not the advantage, as in Zoology, of subjecting living beings to rules; nor as in Botany, plants, which, in dying, reproduce their genera and species."

it promises, the reason why it requires for its cultivation, in unfavourable climates, the encouragement of governments, by which the number of operators may be increased.

To the characters of a mineral must be added the extent to which it occurs in nature, as well as its connexion with, and transition into, other substances, before the description can be considered complete. To ascertain this, is generally beyond the means of individual exertion; but by a judicious division of labour, it might be rendered comparatively easy, were residents in different situations to describe the characters and relations of the rocks composing the vicinities in which they live.

The fact is, this interesting and important science is of too laborious a nature to be practised with the requisite zeal under ordinary circumstances, by foreigners, in tropical climates. The effects of exposure to the baneful influence of those climates are so fatal, that persons are little disposed to incur any risk of life, beyond what is necessary for the performance of their indispensable duties. Notwithstanding these nearly insurmountable obstacles to the successful cultivation of geology in India, much might be done were the requisite facilities afforded; and these, it might be supposed, would not be altogether withheld in a country which has been celebrated since the earliest times for the gold, diamonds, and other precious fossils which it affords.

The first great step in improvement would be, the organization of Geological Societies in different parts of India, on such footing as would render it a desirable object to the ambition of scientific men of all classes, to be enrolled on their lists. In order to give them practical effect, and to deprive them of the character of mere amateur societies, their expence should be borne by the state, and members thus freed from subscribing aught but their labours to their support. Libraries, consisting of all the standard works on natural history, should be furnished at the expence of government, as well as all kinds of philosophical instruments and chemical apparatus. Additional stores of this kind should be supplied either to the public at large, or only to the members of the societies, at such low prices, as would merely cover the expence of their importation.

The importance of this may be understood, when it is known, that the expence and difficulty of procuring philosophical instruments, books, &c. in the Upper Provinces of India, amount to an almost total prohibition of them, thus causing a perfect suppression of individual industry in the cause of national improvement, as well as of science. With respect to those philosophical instruments in particular, whose only value is their accurate adjustment, the submission of the purchaser to the most exorbitant charges for them seldom protects him from disappointment, such as is calculated to induce him, if not to force him, to relinquish all his efforts.

There is nothing utopian in the plan here recommended; the expence of books and instruments for the libraries and museums, as well as of the publication of Transactions, and other incidental charges would be little more than nominal, while the impulse which would be afforded to the science of geology, would be attended with practical and solid advantages to the state. A principal Society might be established in Calcutta, with branch institutions, at each of the other presidencies, including Ceylon, Singapore, and Canton.

In order that the more meritorious members might be rewarded for their services, as well as to secure the most deserving individuals, to fill public situations, the whole of the appointments in the departments of the Surveyors General of the different presidencies should be exclusively bestowed on such members of the Geological Societies as were not otherwise employed.

It may be said, that the Physical Class of the Asiatic Society of Calcutta is sufficient for all the purposes that are required; but the present state of geology in India is a proof, that however useful the Asiatic Society may have been in the promotion of other branches of science, it has really done nothing in this; and I very much doubt, if their Transactions up to a very late period, contain one mineral description that would be received by a systematic writer as correct*. The objects of the Asiatic Society are too comprehensive to be of much use in the cultivation of geology: this science itself requiring a greater variety of attainments in abstruse details, than could be well discussed in a Society devoted to general learning.

In support of this fact, it is only necessary to refer to the Transactions of the Geological Societies of Great Britain, and compare what has been done by those institutions within the last few years, with the few geological papers to be found in the whole series of Philosophical Transactions

* The period to which I refer is 1817: since which time, some late and much lamented authors, have evinced their zeal in behalf of geology, by communications of great interest. The more minute, and consequently the most important, portion of their labours have not yet been published, and it is feared, will be ultimately lost to the world from the defects in our institutions here referred to.

of London and Edinburgh. The Royal Irish Academy is perhaps an exception to the rule here implied; but if so, it is owing only to the influence of Richard Kirwan, the "the father of British mineralogy," whose writings on geological subjects attracted the attention of Europe, and gave a bias to the Society over which he presided, something like that which was occasioned by Newton in favour of mathematical philosophy. To the influence of Kirwan is ascribed, the honour possessed by the Dublin Society, of being the first institution in the British empire to endow a geological professorship. Yet, notwithstanding the interest evinced by already existing institutions in Ireland in behalf of geology, it has (I believe) been recently deemed expedient to increase their number, by the addition of a Royal Geological Society.

Before the world became acquainted with the labours of Werner, Bergman, Scheele, Klaproth, Kirwan, and Haüy, geology could not be called a science, and its imperfect rudiments were then safely confided to Societies celebrated for general learning. When however its objects became defined, its importance pointed out, and principles laid down and established for facilitating our knowledge of the Natural History of the globe—for extending our researches into the chemical nature of the mineral substances, of which the crust of the earth is composed, and their uses in the economy of life: then did geology present itself to enlightened nations, as a science entitled to peculiar attention; and Societies composed of the most eminent men were suddenly called into existence. Great Britain and Ireland alone can boast of four such institutions: while our Indian empire, although it occupies a portion of the earth's surface, about twenty times greater, excites no interest or attention.

It is agreed by all, that mineral topographies of districts, by competent persons, constitute the only way by which the science of geology is to be extended.

Up to the beginning of the present century, the English even at home were sadly behind other great nations in this department of science, and from 1724 to 1799, nineteen works only were published on the mineral topography of districts in the United Kingdom.

In France, from 1750 to 1799, sixty-two, and in Italy, thirty-six works on mineral topography were published; while Germany and the rest of Europe contributed to the world, two hundred treatises on the same subject.

During the time the science of geology was thus progressing in Europe, (as well as in America, where twelve descriptions of districts were published about the close of the eighteenth century,) it may be curious to learn what attempts were made in India, either to improve the resources of our new empire, or to extend the boundaries of science. The papers on the subject of mineral topography of countries in the East Indies, up to the end of the eighteenth century, are *four**.

The first of these is by Johannes Gerhardus König, and is published in the 4th volume of the Natural History Society of

* Dryander's *Bibliotheca Banksiana*, vol. iv. p. 72.

Upsal, entitled "Observationes Mineralogicæ, in India Orientali; e litteris ejus excerptæ à Joh. Jac. Ferber*."

The second is by James Anderson, and is, "An attempt to discover such Minerals, as correspond with the classification of Cronstedt, and thus lead to a more extensive knowledge of mineralogy in this country, the Coast of Coromandel, 1797*."

The third is by Carl Peter Thunberg; and was published in 1785, under the title of "Beschreibung der Mineralien und edlen steine, auf der insel Ceylon*."

The other is by Georgius Josephus Kamel, and is found in the early Philosophical Transactions, under the title of "De Mineralibus et Fossilibus Philippensibus*."

* Dryander's *Bibliotheca Banksiana*, vol. iv. p. 72. König was the pupil and correspondent of Linnæus, and the founder of Oriental Botany. "He was singularly qualified for the employment he had entered into;" says Dr. P. Russell, (pref. Roxb. Plants of Coromandel,) "more covetous of fame than of fortune, he persevered in his pursuits with an enthusiasm that set bodily fatigue, *spare meals*, and a scorching climate, at defiance." He appears to have been supported during

The question that now suggests itself is, whether any thing has been done since the period to which the history of the subject has been already traced, in order to retrieve the time that was lost in bestowing on India, the benefit of more enlightened views in regard to geology?

his labours by a pittance from the Nabob of Arcot; but three or four years before he fell a victim to science, we are told in the same work, that the "Madras Government, with the sanction of the Court of Directors, made an addition to his salary," i. e. an addition to the sum allowed him by the Nabob: he died suddenly before he had time to profit by his labours.

Of James Anderson, we know little more than that he was an eminent physician in the army.

C. P. Thunberg, afterwards knight and successor to Linnæus, in the University of Upsal; a fellow of the Royal Society, and of most of the learned Societies of Europe and America.

Kamel, or Camelli, was a Missionary; and probably a native of Portugal. He made many valuable communications to the Royal Society about the beginning of the last century, regarding the Natural History of the Philippine Islands. He was probably the first European who described the tea plant, and his name has been bestowed by Thunberg, on a genus of plants nearly related to tea.

In the Annals of Philosophy, for 1817, (vi. p. 164,) we find the following, under the head of "Mineralogical examination of India." "It must be rather mortifying to mineralogists, that the peninsula of India, which has supplied the world for so long a period with some of the finest productions of the mineral kingdom; and which now, in some measure, may be considered as belonging to the British empire; should, in a mineralogical point of view, be still almost unknown. There is every reason to expect, that this defect will now be remedied. Sir John Malcolm has taken with him to India Mr. Laidlaw, a gentleman educated as a civil engineer, and an excellent practical mineralogist and geologist, with the avowed intention of examining the country. We may anticipate from the labours of this gentleman; numerous discoveries which cannot but prove interesting to the scientific world, and of great importance to our Indian empire, from the new sources of wealth which they may disclose."

These were not the sentiments of a common mind, or of one that was likely to be swayed by any vulgar or idle motive; they were the expressions of a man whose long and laborious life has been devoted to the investigation of truth. They were the sentiments of the author of the most comprehensive system of chemistry that has hitherto appeared in the English language—it is only necessary to mention the name of Dr. Thompson.

There is, however, a third person, whose name is connected with these remarks, and whose sincerity in this or any other instance, God forbid I should attempt to impugn. It may be that the triumphant soldier, and successful politician, in the midst of the busy scenes into which he was hurried, forgot the humble, and perhaps eccentric, man of science; or abandoned him with all his faults and peculiarities to strangers, who may have expected to find him all perfection*. Whatever

* The position of parties in this case bears some analogy to that of Burke and his friend Barry; but, alas, how the great Indian statesman loses by following

they may have been, it would be improper in me to remark very closely, on the unfortunate causes which led to the failure of this talented, and once enterprising, man, in the noble design he had formed. I have said unfortunate causes; for such must be considered, whatever may have led to the frustration of a design, from which India might have derived so much benefit. Even this is not all that is, in this case, to be regretted; for in a country where any advancement in science depends on the enterprise, zeal, and assiduity of individuals, rather than upon a large community; the example of such a failure is calculated, justly or unjustly, to deter others from risking, not merely their lives and fortunes, but also their reputations,

up the comparison. To the forbearance of Burke with the foibles of genius, the British nation is no doubt indebted for those sublime achievements of the painter that now adorn the walls of the Society of Arts. Burke saw that he must either bear with his friend's peculiarities—that he must at least endeavour to improve them only by gentle means, or that his country must lose the benefit of his genius.

in a cause which has not hitherto been rightly estimated in India.

While allusion to this painful incident in the history of the science is, in itself, a powerful argument in favour of Geological Societies, as the only sure means of developing progressively the resources of our possessions; it may at the same time be the means of directing a case of individual hardship, to the attention of those who have the power, as well as the disposition, to award such redress as the case may require. That such a case should ever have occurred, that an individual who surrendered his fair prospect of fortune and fame in his native land; and at the expence of a small private fortune, perhaps, equipped himself for a task of vital importance to India, should be heard to complain of any want of liberality, calculated to induce him to relinquish his design, is more than can well be conceived: yet such would seem to have been the case. For some unfortunate reasons, it was deemed expedient to withdraw all pecuniary support from the gentleman who had entered so nobly upon the task above referred to, and thus abandoned in one of the most remote corners of India; a term of seventeen years have now passed over him, without the means of even transmitting his property to a place where he might dispose of it, and by this means return disappointed and ruined to that home which he left under the brightest auspices. A deep sense of the injury he conceives himself to have sustained has destroyed his confidence in man, and suppressed the utterance of any complaint. To those who think and feel, as become the sympathies of our nature, this tribute, to the living author of a great design, will neither appear indelicate, or absurd; although his own wrath may be partly anticipated, as the consequence of my good intentions*.

* I must here express my obligation to Mr. L. for the liberality with which he placed his valuable library at my disposal, which as far as books were concerned, left me little to complain of during the latter part of my residence at Lohooghat; but, unfortunately, I was too much employed in practical researches at the time to admit much reading.

It now only remains to refer to a few contributions regarding some of the minerals and mines in Southern India, by Dr. Benjamin Heyne; and our sketch of the melancholy condition of geology, and geologists, in British India, will be complete. The following extract from the preface of his work, which was published in 1814, will shew what he had to encounter; and is a true picture of the mortifying causes which still continue to thwart the best efforts of private individuals, in the cause of general improvement. "I could have wished," says Dr. Heyne, "to be more particular in mineralogical and geological descriptions, but found myself so often at a loss for want of specimens to refer to, that I have seldom attempted it; and in general, omitted all such as I conceived would not be found perfectly correct. I must here lament the loss of large collections, which I was obliged to leave behind me at different places, during the latter years of my residence in India, from want of means to carry them with me in the country, or of sending them to a place of safety."

Since the time of Dr. Heyne, twenty years of peace have nearly passed away, without any new facility having been opened to the cultivators of any one branch of science in India—a country in which all that is beneath the surface, all that requires the exercise of the higher faculties of the mind, in the practice of the arts, is neglected—a country, of whose riches we only avail ourselves, when she offers them to us, on the surface of her shores, or on the sands of her rivers. It must now, however, be gratifying to find, that the attention of Government is at length directed to the important object of public instruction; but still, let us be careful that we do not mistake the means by which this is to be effected—let us be careful that we do not confound the mere theory of science with its practice. Let us therefore attempt to remove those obvious causes which directly impede the performance of useful operations, rather than bestow exclusive attention on juvenile schools; in which, under existing circumstances, an education, without an object, can only be given.

Without pretending to be at all versed in political matters, it appears to me to be a maxim of common sense, that there is but one permanent source of national prosperity—that this consists in an industrious cultivation of natural resources. Where these are neglected, or deficient, (the latter is perhaps never the case,) the people are driven from time to time, as exigencies occur, to supply their wants and luxuries, by lawless aggression, against the property of neighbours; and in such a state of society, one province only flourishes on the ruins of another. This prædial spirit has prevailed from the earliest times in India; and on our success in ultimately replacing it, by habits of industry, in the practice of the useful arts, our future security must mainly depend.

When speaking of the mines, I shall again take the opportunity of making a few remarks on this important subject.

CHAPTER II.

GENERAL DESCRIPTION OF THE DISTRICT.

BURMDEO PASS—ROAD TO BELKET—CHOURA PANY—SNOWY PEAKS, THEIR PHYSIOGNOMY, THEIR ALTITUDES AND INCLINATIONS OF THEIR ACCLIVITIES—FORMULA FOR CALCULATING INACCESSIBLE HEIGHTS—VALLEYS OF THE GOGRA—PHYSIOGNOMY OF THE MOUNTAINS OF DIFFERENT ROCKS—GEOGRAPHICAL BOUNDARIES OF THE DISTRICT ABOUT TO BE DESCRIBED—MORE MINUTE OBSERVATIONS ON THE CHARACTER OF THE MOUNTAINS COMPOSING IT—SECTIONS INTO WHICH IT IS NATURALLY DIVIDED—SUPERSTITION OF THE NATIVES—HUMBOLDT.

BURMDEO pass is eight marches, or about ninety miles, from Bareilly, the capital of Rohilcund, in a northerly direction. It is an amphitheatre resembling a small bay, surrounded on all sides by the most delightful mountain scenery, except at a narrow outlet, where the great northern branch of the river Gogra emerges from its paternal mountains, to pursue a more placid course, through the plains of Rohilcund and Oude, until it joins the Ganges near Ghazeepore. From Burmdeo pass to Lohooghat is three marches; also in a northerly direction: during the first of which, the road lies across a rugged group of mountains, about 5,000 feet above the sea, and composed chiefly of calcareous grit stone, and slate-clay, and covered with dense forests of exotic plants. Having gained the summit of this group, a higher range still intercepts the view of the Himalaya chain, and the path descends rapidly to the encamping ground at Belket, which terminates the first day's journey. The whole of the intervening space, between Burmdeo and Belket, is uninhabited: a few huts, or what are here called villages, may be found on the higher elevations; but the valleys, like the Tarai*, which

* A Persian term which means *moist*; it is used in this instance by the natives of India, to designate the low belt of forest that extends along the base of the Himalaya for several hundred miles.

extends along the base of this group next the plains, are uninhabitable for at least six months during the year.

The second march is a continual ascent, from Belket to Choura Pany; a high ridge, which may be considered to form the brow of that elevated belt of alpine land which extends along the base of the great Himalaya chain, varying in breadth from sixty to ninety miles. It is here for the first time, since entering the mountains, that the snowy peaks burst upon the view, with a magnificence which it would be difficult indeed to describe.

From the encamping ground at Choura Pany, the view is rather circumscribed; but on ascending any of the neighbouring heights, an uninterrupted chain of slender summits are seen to extend, like a vast white curtain, from N. W. to E.; and considering the distance of the nearest to be sixty miles, the extent of the chain embraced at one view, cannot be less than four hundred miles. The lowest altitudes of this immense chain appear to be about six thousand feet above the line of perpetual congelation, which in this latitude is about twelve thousand feet; consequently, the lowest peaks in this portion of the Himalayas must be somewhere about eighteen thousand feet; while many of the higher summits approach an elevation of twenty-five thousand feet above the ocean.

Careful attention to the changes which the physiognomy of such mighty elevations undergo, is an object of the highest importance; and was, I believe, first suggested by Humboldt: but in order to afford much interest in a moderate space of time, constant observations of the most accurate and systematic nature would be necessary. Without pretending to any thing of this sort, I may refer to Plate I. fig. 1. which I sketched as a general outline of the chain, from one of the higher summits in the vicinity of Choura Pany. The relative altitudes of the different peaks were taken with a common Gunter's quadrant, furnished with two sight-vanes, and a plummet. On a subsequent occasion, I made a series of observations on a few of the most remarkable of the same peaks, from a situation about eighteen maritime miles nearer to them; and a mile N. W. of Petoragur, at an elevation of six thousand feet; the following result may be worth inserting.

1st peak (*a*), (Plate I. fig. 1.) the most remarkable of the eastern extremity of the range; height 2° 45′; western acclivity, 24°; eastern declivity, 60°. It has consequently an unsteady, or overhanging character, as if it were about to fall towards the east. Surrounding peaks; or those that are subordinate to it, are pointed and bristling.

2nd peak (*b*); height, 3°; western acclivity, 44°; eastern declivity, 55°; character, pyramidal and pointed.

3rd peak (*c*); height 3°; eastern acclivity, 29°; western declivity, 50°, near the summit; character, wedge-shaped.

4th peak (*d*); height, 2° 45′; eastern acclivity, 47°; western declivity, 51°; character, resembling a dome.

The lowest snow at the apparent base of the peak (*d*), 1°. 17′. The same at the apparent base of the peak (*a*). From these kind of observations also a formula may be derived for calculating inaccessible heights: the lower limit of perpetual congelation being determined. Here, as has been found by Webb and other travellers, that limit is about 12,000 feet; and its height at the base of (*b*), for instance, was 1°; deduct the height of the place of observation (6,000) from the height of the lowest snow (12,000), and the difference is the value of a degree of height; accordingly, the peak (*b*) must be somewhere about 24,000 feet high*.

The hours of the day, at which these awfully interesting altitudes are seen to

* Notwithstanding the confidence we are ever ready to repose in mathematical rules in the elucidation of the laws of nature, yet they are often as imperfect as the limited observations on which they are founded. Thus there is reason to believe, that the inferior limit of perpetual congelation is much more elevated on the S. W. acclivity of the Himalaya than has been assigned to it, by Captain Webb. There is reason to believe, that the inferior *annual* limit of snow varies so amazingly, according to peculiarity of seasons, that a series of years only would afford accurate calculations. See the Chapter on Climatology.

most advantage, is either before sun-rise, or after sun-set; when their soft crimson forms are barely relieved from the glowing tints of the sky, by the golden lights that play along their varied outlines.

From the position at which these observations are supposed to be made, the mountains which intervene between the snowy range and the eye, vary in their respective altitudes from six to twelve thousand feet. The different branches of the river Gogra are sometimes seen, but often only heard, in furious torrents, rushing down the river valleys, which divide the mountain groups from each other. The great valley of the Gogra is seen a few miles to the east: the river running from a north-easterly direction, and receiving a large branch that comes from the north-west. The north-eastern branch, continues to mark the boundary between the kingdom of Nepaul and the province of Kemaon. The western branch is soon discovered to be formed of two rivers: one of which comes from the north, and the other from the north-west, receiving its origin in the mountains, east and north-east of Almorah, in conjunction with the Pindur, or third branch of the Ganges.

The valleys of these rivers, sink to the depth of five or six thousand feet below many of the adjoining summits; but the general height of the mountains above the valleys throughout the district, is from two to five thousand feet.

The mountains are generally massive; and differ in their more minute outlines, according to the nature of the rocks of which they are composed. Hornblende-slate forms mountains, whose acclivities rise abruptly, at angles of from 65° to 35° with the horizon. Mica-slate and gneiss, as well as clay-slate, present acclivities that vary from 60° to 30°. The mountains composed of these rocks are usually wooded; and their summits are round-backed, undulating, or conical.

Limestone mountains are here characterised on the great scale; by abrupt rugged acclivities, mural precipices, lofty, varied, and picturesque summits, cascades, and subterraneous streams, deep ravines, and narrow inaccessible valleys, transition clay-slate forms barren, round-backed mountains; which are uniform in their appearance, and intersected by few ravines.

There is also a genus of rocks related to the Dolomite family, which deserves to be mentioned; as stamping a peculiar character, upon numerous mountains of the district: they form lofty caps, and shields; usually disposed in saddle-shaped strata, presenting smooth, and often inaccessible declivities; which are too abrupt to afford, even vegetable existence, except to grass and lichen: while ravines and low places, situated at the base of such mountains, are strewed with rounded masses, which have been precipitated from above.

The district which is to form the subject of the following pages, is embraced by the latitudes 29° and 29° 45′ N. Long. 79° 55′ and 80° 20′ E.; and lies on the western side, of the river district of the Gogra. Having thus defined the geographical limits, to which only it is intended, that the following pages shall refer; it may be proper to recapitulate such of the foregoing remarks as apply only to this limited space, and to add such further observations, on the general characters of the district, as may lead the way to the more minute details respecting the rocks and minerals of which it is composed, and of the relative connexion of these to each other.

It has been said, that the mountains of certain rocks, as gneiss, hornblende-slate, &c. derive peculiar outlines from the nature of their composition. These distinctive characters may even be traced to more minute particulars. Hornblende-slate, for instance, appears to have much more effect, in resisting the destroying power of the atmosphere, than either gneiss or mica-slate: the latter rocks may therefore be distinguished from the former one, by the numerous white patches of naked surface, whose active state of decomposition prevents the growth of vegetable matter. The mountains of gneiss may again be distinguished from those of mica-slate, by the overlying masses of granite; which have been denuded by the decay of the softer rock, in which they once existed as beds, or central nuclei: enormous masses of this kind are found throughout the gneiss district, which extends from the ruins of the ancient city of Chompawut, in a north-westerly direction, probably for a hundred miles: I have traced them myself for forty miles.

The valleys, formed by the different tributary branches of the Gogra, divide the district into sections. The first is that deserted tract that lies between Burmdeo pass and Belket. The second is a more important section; and extends from the river Ludhoo, at Belket, to the Ramessa, and is chiefly composed of primitive rocks. A ridge of granite, composes the centre of this section; and forms occasional elevations of nearly eight thousand feet. Gneiss, hornblende-slate, mica-slate, and clay-slate, are the other principal formations, which occur in this section.

The third natural division is that which lies on the north of the Ramessa river, and between the rivers called Mahi Kali and Surjee; embracing some fine, though small valleys, the principal one of which is the valley of Shore; and to avoid the confusion of names, it may be proper to use this term to distinguish the adjoining portion of the district.

Of the mountain rocks that occur in the Shore section, primitive clay-slate is the oldest, and forms the basis of this part of the district, and ascends to elevations which are occasionally above 8,000 feet: primitive, transition, and floetz limestone also occur in succession, and bestow their peculiar stamp on the aspect of the neighbourhood. The mountains are here more majestic than in either of the other sections; each individual, standing almost detached from the group to which it belongs, and bearing some well-marked character, which leaves on the mind, an impression not easily effaced. Thus we find, in the Shore district, every mountain distinguished by

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some traditional name, derived from a sacred rock, or ancient temple, which usually caps the summit. At certain festivals, crowds of the superstitious population resort to these romantic caves and temples; and on more private occasions, the solitary devotee often ends his life, in the attempt to gain an almost inaccessible summit, in order to invoke the protection of some grotesque representation of the deity, to which the mountain is dedicated. How forcibly the selection of such localities, for religious purposes, attests the influence of what is awful in nature, over the mind of man, even in his rude and nearly savage state.

"In the infancy of civilization" (says Humboldt) "high places were chosen by the people, to offer sacrifices to their gods: the first altars, the first temples, were erected on mountains." This remark was suggested by his intercourse with the aboriginal inhabitants of the Andes; its accuracy is confirmed by the customs that prevail among the Hindoos of the Himalayas!

The following table exhibits the mountain rocks of the district, in the order in which they occur, as well as could be determined in so small a tract of country; which, however well adapted for the purpose, could enable no talent on the part of the geologist, to construct a table of the geognostic succession of rocks, that would be found on more extensive enquiry to be correct. On the contrary, I expect to find reason, as we become more acquainted with the description of other districts in India, to bring into a much more natural and scientific connexion with each other, many rocks that are set down here as distinct formations; such as those siliceo-magnesian deposites, described under the heads Common, and Compact Dolomites, and Siliceous Oolite. I must beg, however, not to be here understood, as expressing a preference to such general descriptions, as are not based on the most intimate and minute acquaintance with the nature and peculiarities of the districts of which they profess to treat.

TABULAR VIEW OF THE MOUNTAIN ROCKS THAT OCCUR IN KEMAON.

Primitive Rocks.

1. Granite, containing beds of ferruginous slate.
2. Gneiss, containing central nuclei of granite, and nodules of hornblende.
3. Hornblende-slate,
   - var. a, granular, containing beds of gypsum and chlorit slate and porphyritic green stone.
   - ,, b, coarse slates.

   Mica slate, containing beds of gypsum.
4. Clay-slate, containing beds of quartz gypsum.
5. Limestone, containing splintry hornstone and beds of green stone.

Transition Rocks.

1. First formation suite, containing traces of fossil remains of zoophytes.
   - oldest transition limestone,
   - slate and limestone,
   - coarse magnesian limestone,
2. Common dolomite or steatitic sandstone, var. weathered, containing traces of zoophytes.
3. Transition slate.
4. Transition limestone, stratified, containing beds of overlying,
   - Granatine.
   - Fibrous limestone.
   - Talc.
   - Common Serpentine.
5. Compact dolomite, granular, passing into calcareous oolite splintry,
6. Siliceous oolite.

Floetz Rocks.

1. First floetz formation,
   - a, Copper slate.
   - b, Alpine limestone.
   - c, Tabular limestone, containing distinct concretions resembling small fishes.
   - Slaty magnesian limestone.
2.
   - Argillaceous sandstone.
   - Slate-clay.
3.
   - Calcareous grit stone.
   - Vesicular limestone.

Alluvial Rocks.

1. Mechanical alluvial deposites,
   - Nagelflugh.
   - Siliceous earth and gravel.
   - Aluminous earth.
2. Chemical alluvial deposites,
   - Calc Luff, lowermost layers, containing leaves of unknown plants, succeeded by beds of osteocolla, and the leaves of known species.
   - Calc sinter.

CHAPTER III.

PRIMITIVE FORMATIONS—GRANITE, GNEISS, HORNBLENDE-SLATE.

ON THE ARRANGEMENT OF MOUNTAIN ROCKS—OBSERVATIONS OF WERNER AND RAUMER ON THIS SUBJECT AT VARIANCE—GRANITE—THE DIRECTION OF THE PRINCIPAL MOUNTAIN CHAIN INDICATED BY THE GRANITE—CONCENTRIC DISINTEGRATION OF GRANITE—DESCRIPTION OF THE GRANITE OF KEMAON—GNEISS—ITS DISINTEGRATION AND CENTRAL NUCLEI—THE DECAY OF GNEISS MOUNTAINS, AND THE DESTRUCTION OF THE CITY OF CHOMPAWUT FROM THIS CAUSE—THE RUINS OF CHOMPAWUT—DESCRIPTION OF GNEISS RESUMED—SUBORDINATE BEDS IN GRANITE AND GNEISS—HORNBLENDE-SLATE, ITS GEOGNOSTIC POSITION, ITS STRATIFICATION, ITS DESCRIPTION, ITS VARIETIES, ITS FOREIGN BEDS—CHLORIT SLATE—PORPHYRITIC GREEN STONE.

In describing a district, the geologist has little to do with the observance of any particular system, in the arrangement of his subject. It is, perhaps, best to follow no artificial method, such being, in general, foreign to the purpose of practical geognosy; however proper and essential when applied to cabinets of minerals. Werner, for instance, found in the mountains of Saxony, that hornblende-slate chiefly occurs in subordinate beds in clay-slate; seldom in gneiss, or in mica-slate: he therefore placed it in his system along with primitive trap, and assigned to it a position between primitive limestone and the oldest porphyry.

In the Riesengebirge, Raumer found the same rock to prevail to a much greater extent than it had been found by Werner in the Erzgeberg; and its geognostic position was found, by Raumer, to be between a kind of granite and gneiss: and this circumstance induced him to propose a new arrangement of mountain rocks. This was perhaps unnecessary, as Werner did not consider hornblende-slate as peculiar to any fixed position with respect to other rocks. Be this as it may, it is found in Kemaon resting on gneiss, into which it passes on the one hand, and into mica-slate and clay-slate on the other; and from the extent to which it occurs, as well as from its position, hornblende-slate appears to rank next to gneiss among the mountain rocks that compose the eastern frontier of the province; a fact which is sufficient to shew how inexpedient it is, to enter upon inquiries of this kind, with preconceived notions derived from arbitrary systems.

I shall for convenience begin with granite, giving a history of this and each of the superincumbent formations in their order of superposition; and although the plan will occasion some repetition, yet it is hoped, that this will be of a less objectionable nature than such as necessarily arise out of the form of a journal, in which travellers usually convey scientific information of this kind.

1.—GRANITE.

This rock is found at Choura Pany, penetrating through gneiss, and forming a succession of elongated elevations, which if not the loftiest, at least constitute the basis of the highest district in

Kemaon. Some little explanation is here necessary to the right understanding of the disposition of the strata generally, which will be progressively developed in the course of the descriptions of the different rocks. The ridge alluded to extends in a north-westerly direction, for forty or fifty miles, but terminates, or is obstructed, a few miles east of Choura Pany, by the great valley of the river Gogra. This range appears to be an elongation of the Leti, Tirsal, and Dhanapur mountains, which form the eastern boundary of the valleys in which the Alacananda river arises; and may with great propriety be named, in the language of geographers, the *principal mountain chain:* while the great chain to which the snowy peaks immediately belong, may, in like manner, be called the *high mountain chain.* A better idea of the relative connexion of these chains may be formed, by the reader conceiving himself placed on Choura Pany. On the south, he sees the plains of Hindustan below him like a mist, and distant about twenty miles; on the north, the high mountain chain, or snowy peaks already described; and on the north-west, a succession of elevated mountains are observed, extending from Choura Pany, obliquely, towards the high mountain chain to which they are attached: these constitute the principal mountain chain, and this chain gives off subordinate groups, which, on the one side, pass in close succession to the plains, where they terminate in a line of steep declivities; and on the other, these lateral groups intermix with similar groups, given off by the high mountain chain, and forming between them the valleys of the Gogra.

This somewhat complex description would not have been required, were the chain of mountains to which it refers, as distinctly marked by their altitudes, as by their strata; but as this is not the case, and as the whole province appears, if superficially viewed, a mere chaos of mountains, we are not to lose sight of any indications presented by their inter-

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nal structure, and particularly by the strata of granite.

The granite, as has been stated, makes its appearance only in the centre of this mountain chain, in the loftiest places, such as Choura Pany. It is stratified, and extends in the direction of N. W.; the strata are nearly vertical, and appear to be composed of nodula, around which concentric layers are wrapped, in the form of newer and newer deposite. This appearance may however be referred to the effects of weathering, as it is only observed on surfaces that have been long exposed. A similar appearance has been long since observed by Dolomieu, in blocks of granite, in ancient Rome; and also by De Luc, in the granite mountains of Silesia.

The colour of our granite is grey, sometimes of a reddish hue, derived from the felspar; but the usual colour is bluish grey. The mass is fine-grained, and resembles specimens I have seen of Aberdeen granite: the quartz is crystalline, but the felspar is dull and earthy. The latter appearance may be the effect of exposure to the weather, as I cannot depend on the perfection of the specimens examined; and from the great hardness of the rock, I was unable to detach fresher pieces. Its specific gravity is 2.71375.

2.—GNEISS.

Gneiss reposes on the granite, in conformable strata, and the transition between the two rocks is by imperceptible degrees, so that it cannot be determined where the one begins, or the other ends.

In the newer granite, the quartz becomes less crystalline, and of smaller quantity, in proportion to the other ingredients, until at length it disappears, so as to leave chiefly felspar and mica, with a very small portion of amorphous quartz. The change renders the rock less compact; and in this state it occurs at the base, and on the acclivities of Choura Pany; and from thence it extends in a north-westerly direction, forming the principal portion of the most elevated district in Kemaon.

Its course is marked by immense denuded masses of granite, or more compact and durable gneiss, as well as green stone. Sometimes these masses are grouped together with remarkable order; at others, the most awful confusion prevails. In one place, a number of loose, unconnected masses, are heaped one above another, in the form of a cone: an instance of this kind occurs near Dole, on the road between Lohoogat and Almorah. On other occasions, mountain masses of enormous size and globular shape are accumulated on the verge of a frightful precipice; and so nicely balanced in their critical situation, that the slightest application of force would be supposed sufficient to precipitate them to a fearful depth, with an effect that could scarcely be contemplated. It may easily be presumed, that such scenes would be ascribed, by ignorant and superstitious people, to preternatural causes, connected with the exploits of their deities; and a celebrated temple at Dhee, also on the road between Lohoogat and Almorah, is naturally formed between two masses of this kind.

As to the origin of these stupendous rocks, there can be but one explanation; namely, that they were originally contained as central nuclei in gneiss; which from a peculiar tendency to decay, mouldered into friable earth, and was removed by the torrents, leaving the present masses exposed upon the surface. Nor is this a mere speculation; for the fact is established by numerous masses of a similar nature, progressively undergoing the same changes; and so rapidly do they take place, that even human institutions are sufficient records of the sinking and decay of mountains. A most instructive and humiliating instance of the changes that are taking place in the physical, as well as in the moral, world, is presented by the ruins of Chompawut*, the ancient capital of Kemaon.

The catastrophe by which Herculaneum was destroyed, was but the excessive operation of causes, to the effects of which, certain countries were ever liable: such also is the destruction of a city by an

* Now called Kalee Kemaon.

earthquake. Visitations of this kind are indeed terrible to contemplate, but they are generally sudden, and of brief duration. Not so is the silent and slow destruction of a city, by the decay of the rock on which it is erected: here the horrors of desolation must necessarily be protracted, and in the case of a people who must have been more ready to ascribe the catastrophe to a slow and vengeful destiny, from which it were useless to attempt escape, rather than to a law of physics, that a better informed people would have understood, the effects must have been awful. Yet such appears to have been the fate of Chompawut.

This city was erected on gneiss at the northern side of Choura Pany, and was totally destroyed by the decomposition of the eminence on which it stood. A few vestiges only remain, owing to the accidental circumstance of their having been erected on the more durable beds of the rock; but in other respects, although built of granite, and probably intended to endure for ever, scarcely one stone remains on another.

Whether or not there be any records regarding this city extant, I am unable to say; but probably there are none. The severe conflicts that formerly took place between the Goorkah princes, can have left few historical remains of fallen dynasties. All I could learn on the spot was that the last Raja, who resided at Chompawut, fled with his court to Almorah, in consequence of a *dream*. As many of his subjects as could, followed him, and the remainder settled in various parts of the province. The fort, having been erected on granite, still remains, and is at present occupied by a Tesildar, or native collector of revenue; but of the Raja's palace scarcely a trace is to be found.

There is, however, the base and doorway of a Chubootra, or balcony, remaining, and it is supposed, the palace must have been situated in the vicinity of this; a belief that is confirmed by the numerous blocks of laboriously sculptured granite, which are strewed on the surface. The balcony is also of granite, ornamented in the richest style of bass-

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relief. At the lower extremity of the ruins, a fountain, and three or four temples, remain in good preservation. The temples are erected in a level area, about a hundred feet square, which appears to have been excavated into the solid rock. They are polygonal on their bases, and about twenty feet in diameter, and enclosed above by arched domes. The fountain is a small apartment, about ten feet square, and erected outside of the quadrangles, in which the temples are placed: these structures are of exquisite proportions and beauty, and are entirely composed of granite, ornamented in a style of elegance and minute profusion, that must have taken great labour and taste to accomplish*.

* Since the above was written, I had the honour of an interview with His Highness Raja Gomaun Singh, lineal descendant from the Rajas of Kemaon; and I took the liberty, through the medium of a friend, as an interpreter, to inquire of His Highness, what information he possessed regarding the antiquities of the ancient seat of his ancestors. He was delighted to find that any one beside himself felt interested in the subject, and took a letter from his breast that he had

Had I been permitted to finish my researches in Kemaon, it was a part of my intention to have made a full description of these antiquities. They are probably of a very early date: the present inhabitants can give no account of them; and I found some remains of domestic architecture, (also of granite,) situated on the face of the mountain at the upper extremity of the principal ruins. They were quite overgrown with forests of aged oak, that could scarcely have existed at the time these edifices were inhabited.

While this brief sketch illustrates the change that gneiss undergoes, from exposure to the atmosphere, it may also direct

that day received from the Bramins, whom he employs to protect the ruins of the temples, although the country has long since passed from the hands of his family. He said, if I wished it, he would send me a history of his ancestors, in which I might find something respecting Chompawut, but nothing whatever regarding the origin of the temples, which surpass all antiquity. The history of his family, he observed, was so long, that an elephant would be required to carry it. He confirmed the tradition of the dream, and supposed it to be about 500 years since the city of Chompawut was deserted.

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to the notice of others, the subject of these interesting ruins, with a view to their further elucidation.

The strata of gneiss run in the direction of N. W. and dip 80° to N. E.; they vary in thickness from five to eight feet, and contain foreign beds of granite, green stone, iron mica, and micaceous iron ore; also cotemporaneous veins of quartz and felspar.

Specific gravity of fresh specimens 2·635. The mountains which are formed of this rock are usually rugged, and covered with dense forests of oak.

(A) FERRUGINOUS SLATE.

The rock to which this name is given occurs in subordinate beds in each of the foregoing rocks.

At Choura Pany, it is found in granite, in beds of a hundred feet thick. At Dole, about forty miles north-west of Choura Pany, a similar rock occurs, resting on gneiss. Its colour is blackish grey, with lighter and darker stripes on the surface of the cross fracture.

It occurs massive. External lustre glimmering; lustre of the principal fracture, shining, and of the cross fracture, earthy, or glimmering. Fracture, slaty, with a single cleavage. Fragments, tabular. It is semi-hard, inclining to soft. It soils. Specific gravity, 2·384.

Physical Characters.

It has no effect on the magnet, either before or after exposure to the blow-pipe.

Chemical Characters.

On exposure to the blue flame of the blow-pipe, it slowly assumes a reddish yellow surface. It gives to borax a greyish green colour, inclining to greyish-white on the edges.

This rock might be named a mica-slate, containing a small portion of micaceous iron ore, finely disseminated with very fine granular quartz, common mica, and fine earthy felspar.

3.—HORNBLENDE-SLATE.

It has been shewn, that the two rocks, (gneiss and granite,) already described, form the principal mountain ridge, in nearly, but not quite, vertical strata: for a dip of 80° is invariably observed, bending to the north-east. This fact, together with others which are yet to be observed, renders it nearly certain, that a great basin or trough, of considerable depth, is formed by the substratum, or fundamental rock; descending from the centre of the high mountain chain, and ascending again to form the basis of the principal mountain chain. This basin, it would appear, is filled up partly by a number of successive layers, of newer and newer rocks, and these layers or strata are not uniformly spread over every portion of the cavity of the basin; but they are accumulated in particular places, and thus form subordinate troughs, or valleys; which have again been transformed by succeeding deposites of newer rocks.

Hornblende-slate appears to have been deposited chiefly in the bottom of this basin; and to ascend only in small quantity, or to disappear entirely on its higher margins*. In these latter situations, it

* On the S. W. acclivity of the principal mountain chain; or, in other words, the ascent from Belket to Choura Pany, hornblende-slate is found, at the altitude

either assumes a coarse granular structure, and passes into gneiss, as on the southern acclivity of Choura Pany, and into mica-slate, as below Durgura; or it changes into a very fine granular description of clay-slate, as in the bed of the Lohoo river, on the northern foot of Choura Pany.

It may be more consistent with the nature and connexions of this rock, to imitate Werner and Professor Jameson, in considering hornblende-slate, not as a distinct formation, as described by Raumer*, but as occurring only in beds; but there can be no doubt that those beds are of much greater extent than either of those eminent geologists contemplated;

of 6,000 feet, to change into the character of gneiss; and in the course of this mountain acclivity, conical peaks rise one above another. The centre of each peak is composed of granular hornblende-slate, closely resembling gneiss, from which it only differs by containing hornblende sufficient to give it a greenish hue; while the strata surrounding these centres retain the character of hornblende-slate, until we ascend to the altitude already mentioned, which appears to be that at which hornblende-slate disappears.

* Annal. Phil. vol. vi. p. 478.

and as the term *bed* affords too contracted an idea of a rock, which composes an extensive portion of a district, the inconvenience might perhaps be avoided by substituting the terms *partial formation**.

The direction of the strata of hornblende-slate is ruled, rather by the direction of mountain groups, than by that of principal mountain chains; or, in other words, its direction is subject to variation, arising from local irregularities of the surface of the basin, in which it is deposited. The dip is seldom less than 60°, and often as much as 80°.

The acclivities of mountains composed of this rock are usually rugged and

* To Raumer, green-slate occurred resting on gneiss and granite in the Riesengeberge; to Werner it occurred in clay-slate. In Kemaon, it is found resting on gneiss. To these we might perhaps apply the terms of first, second, and third trap (or partial trap) formations; but it is highly probable, that in a more advanced state of Geological Science, these seeming irregularities may be reconciled to some general law, which has hitherto eluded our observations. This is the more probable, as our geognostic acquaintance with the structure of the earth is as yet confined to a comparatively small proportion of the whole surface.

inaccessible; and tabular masses of nearly perpendicular strata stand several feet erect above the surface. From this peculiarity, soil sufficient for the growth of the most luxuriant vegetation is retained on the steepest acclivities.

Oak being in this latitude the inhabitant of loftier altitudes than are formed by this rock, the forests that prevail on it are chiefly composed of pines of the largest growth.

The tract of district composed of hornblende-slate, although of considerable extent, is almost totally deserted; and the few villages that are found on it, are miserably poor, and, in general, uninhabitable for several months during the year; as well from the miasmata and heat that prevail in its dense forests, and deep valleys, as from the rapacity of the wild beasts by which these are infested: as the tiger, leopard, and the bear.

Hornblende-slate having been found in so many different positions, with respect to other rocks, a minute description of it, as it occurs in Kemaon, resting on gneiss, may be useful in assisting to form its separation into species, depending on the rocks with which it is associated in nature.

Its colours are seladon, pistachio, and olive-green.

It occurs massive, and contains cotemporaneous laminæ of quartz, in thin alternate layers, and flattish grains, from small, to very small; and even finely disseminated. External lustre, dull, inclining to resinous. Fracture foliated, and slaty, with a single cleavage. Lustre of the principal fracture glistening, or shining, and of the cross fracture, glimmering. Shape of the fragments, tabular. Distinct concretions, lamellar. It affords a greenish grey streak. It is opaque. It is semihard. It is somewhat sectile. It affords an earthy smell when breathed on, and feels rather meagre. Specific gravity, 2·920.

Chemical characters. It is not fusible before the blow-pipe; probably from its intermixture with common clay, a large proportion of mica, and other impurities, as its lightness indicates.

Variat. a.—Coarse Granular.

Its colours are greenish grey, seladon, and pistachio green; with a pearly and glimmering lustre. Fracture, coarse granular; but somewhat inclining to slaty. Lustre of the fracture, resinous and slightly shining. Distinct concretions are lenticular, inclining on the one hand to lamellar, and on the other, to granular. Specific gravity, 2·708.

It appears to contain felspar, as well as quartz, and may be considered as the transition between hornblende-slate and gneiss.

Variat. b.

Colour, dark greenish grey. Fracture, slaty in the large, but compact, even, and inclining to earthy in the small. Lustre, glimmering. It is opaque. It is similar in the streak. It is semi-hard, inclining to soft, and affords a strong bituminous smell when breathed on. Specific gravity, 2·728.

This rock is a transition between hornblende-slate and clay-slate; and appears to be composed of minute grains of quartz, imbedded in a basis of clay and hornblende.

The foreign beds, which are contained in hornblende-slate, are gypsum, micaceous iron glance, common iron glance, chlorit-slate, and primitive green-stone.

The first is common to this rock, and mica-slate, and will be noticed in the next chapter; and the description of the iron ores may be consulted in the account of the mines.

The chlorit-slate and porphyritic green-stone appear to be peculiar to this formation.

(B) CHLORIT-SLATE.

Its colours are emerald and grass green. It occurs massive. Internal lustre, pearly.

Fracture scaly foliated. Distinct concretions, thin lamellar. Lustre of the distinct concretions, shining. It is opaque, and it affords a light-coloured streak.

It is soft, and perfectly sectile. It is meagre to the feel. Specific gravity, 3.

It occurs in large quantity in the lower strata of hornblende-slate, and is found at Chimtouly, in the vicinity of the iron mines. It also occurs at the southern foot of Choura Pany, near Belket, where its scaly laminæ alternate with thin laminæ of quartz. It is the substance that gives the slaty structure to hornblende-slate.

(C) PORPHYRITIC GREEN-STONE.

This rock is found at the southern foot of the principal mountain chain, where it forms at Belket, a portion of the bed of the river Ludhoo. I have not been able fully to ascertain its extent and geognostic relations; and as this is a point of first-rate importance, it would be improper to hazard an opinion upon it.

It will be seen on inspection of the map, as well as from what is said in the description of Belket, that if the porphyritic green-stone passes under the elevated mass of strata composing the southern declivity of Choura Pany, that then those philosophers, who contend that the strata of mountains have been elevated to their present position, by the expansive operation of heat, confined in the centre of the earth, would find in the peculiar position of this green-stone, a strong argument in favour of their doctrine; but if, on the other hand, it should appear on further inquiry, that this formation, like the others we have described, presents the character of a deposite from above; then, of course, the first argument would come to nothing. This rock is composed apparently of equal parts of hornblende and felspar, in minute crystals, mechanically mixed, so as at first sight to look somewhat like a fine granite. It is not stratified, but divided in all directions by adventitious rifts, which give it a brecciated structure in large masses. The fragmented pieces are usually trapezoidal. It is hard, and not particularly heavy.

CHAPTER IV.

PRIMITIVE FORMATIONS — MICA-SLATE, CLAY-SLATE, PRIMITIVE LIMESTONE.

NATURE AND GEOGNOSTIC POSITION OF MICA-SLATE—OLDEST GYPSUM, ITS DESCRIPTION—CLAY-SLATE—NATURE OF THIS FORMATION AND PECULIARITY OF THE PRINCIPAL MOUNTAIN CHAIN IN REGARD TO IT—MOUNTAINS OF CLAY-SLATE CONTRASTED WITH THOSE OF HORNBLENDE-SLATE, AND AN ATTEMPT TO EXPLAIN THE CAUSE OF DIFFERENCE BETWEEN THEM—PROVIDENTIAL ASSOCIATION OF CLAY-SLATE WITH LIMESTONE, MORE ESPECIALLY IN ALPINE COUNTRIES—VARIETIES OF CLAY-SLATE, WITH THEIR DESCRIPTIONS AND DISTINCTIONS—DISTINCTION BETWEEN THE FINE CURVED CLAY-SLATE AND TRANSITION SLATE—QUARTZ, AND THE SINGULAR SEPTARIUM OCCURRING WITH IT—DESCRIPTION OF DRAWING SLATE—PRIMITIVE LIMESTONE—DESCRIPTION OF ITS VARIETIES—SPLINTERY HORNSTONE.

4.—MICA-SLATE.

THIS rock occurs in small quantity in proportion to either of those formations described in the last chapter. It is found at Durgura, alternating with gypsum, and a micaceous kind of clay-slate, which, but for the absence of quartz, might also be named mica-slate, for it is a scaly compound of primitive clay and mica. From its nature, however, as well as from the geognostic situation in which it is found, it may be considered to be a transition between mica-slate and clay-slate.

Mica-slate also occurs associated with similar rocks at Choura Pany, and in various parts of the district, always occupying the same geognostic place. It generally rests on hornblende-slate; but in the higher altitudes, where that rock is wanting, it rests on gneiss. It is composed of small grains of quartz, some felspar, and a considerable proportion of grey or white silvery mica. Mean direction of the strata W. N. W.; mean dip, 50°.

(A) OLDEST GYPSUM.

Gypsum is found, as has been stated, alternating with mica-slate, at Durgura, and on the southern declivity of Choura Pany, in beds of from fifty to three hundred feet thick. The strata are subdivided by numerous slaty rifts, which run parallel to the strata seams, and divide the rock into tables that vary from two to six inches thick. It also occurs at Chimtouly, in beds, in hornblende-slate.

Its colour in some beds is reddish white, and in others, greenish-white. Lustre glimmering; but sometimes glistening, especially in the principal fracture, while that of the cross fracture is pearly. Fracture, slaty in the large; large fragments are consequently tabular, but small pieces are wedge-shaped. Distinct concretions, straight lamellar. It is faintly translucent on the edges. It is semi-hard. It is rather easily frangible.

Specific gravity of the reddish coloured variety, from Durgura, 2·612, and of the greenish white kind, from the same place, 2·574 and 2·669; while a variety of the same from beds in hornblende-slate at Chimtouly, is, 2·3.

Chemical characters. It is infusible before the greatest heat of the blow-pipe, either when placed on charcoal or held in the forceps. Even with the addition of borax, and the flame directed to the edges of the laminæ, it evinced little signs of fusibility; nor is it soluble in any proportion of water.

These experiments were not made on the specimen from Chimtouly, which appears to be a purer gypsum than the others, from its more compact and sparry character, as well as from its containing less mica.

5.—CLAY-SLATE.

This great formation composes, at least, a sixth part of the whole province, and is stretched in conformable strata over the mica-slate and trap rocks described under the head of hornblende-slate. It commences on the N. E. acclivity of the principal mountain chain* under the

* This formation is quite deficient on the south-western acclivity of the principal mountain chain, as far as I have been able to observe, or learn from the observations of others. Should this deficiency prove to be general, the fact will be very interesting, as the succession of primitive rocks will in that case be unequal on the two sides; a circumstance which, however common in regard to single mountains, can only be accounted for in the case of high and principal moun-

out-going of the substratum, at the elevation of about 7,000 feet, and from thence stretches into the lower districts forming mountain groups, in conjunction with newer rocks, through which it often pierces, forming peaks and ridges seven and eight thousand feet high.

These elevated and massive groups, whose bases are surrounded with mantle-shaped strata of limestone, traverse, obliquely, the centre of the Alpine land, situated between Choura Pany and the snowy range. The mountains often appear isolated from each other, or only to join by slender mountain-arms; and thus they form numerous small elevated valleys, which present the most striking contrast to the inhospitable aspect of those tracts of country which are composed of hornblende-slate. The cause of this difference of character, so remarkable between the

tain chains, by supposing the strata composing them to have been disturbed and uplifted subsequent to their original deposite—a doctrine long since rendered plausible by M. de Saussure and others.

districts composed of these formations, may be easily explained.

Hornblende-slate, if left undisturbed, is one of the most indestructible of all rocks by mere atmospheric causes*; we, accordingly, find the mountains composed of it in the same state in which they were originally formed by nature, as is indicated by their rugged acclivities, and the absence of debris at their bases. Clay-slate, on the contrary, is soft and friable, or its hardness depends on ferruginous ingredients, which are decomposed by the heat and moisture of the atmosphere: these causes keep up a constant process of decay; in consequence of which, the valleys, if not gradually filled up, are at least prevented from sinking deeper; while the mountains, freed from original asperities, look worn and rounded in their outlines, and their surface in time becomes converted into alluvial soil, which either remains in situ, or is carried down

* This I suspect is contrary to the general impression, probably derived from observing the rock in the vicinity of torrents, roads, quarries, &c.

to fertilize the valleys situated at their base; and here an interesting observation presents itself.

Ferruginous clay would form a barren and unproductive soil, unfit to supply the wants of man: so we find by the direction of a bounteous Providence, that this clay, in its progress from the mountain acclivities to the valleys, is carried by the torrents over beds of limestone and marl; and by the calcareous admixture thus acquired, the ferruginous oxides are decomposed, and a soil is afforded, which is capable of yielding with little labour, no less than three crops of grain annually*.

This extraordinary fertility is only observed in the floetz districts, in which the admixture of slate and limestone is so adjusted on the mountain acclivities, as to render the small proportion of arable land that occurs in such places,

* "Are any of the salts of iron present? They may be decomposed by lime."—What the philosopher recommended to be done by art, is here spontaneously performed in the great laboratory of nature before our eyes.—Vide Sir H. Davy's Agricult. Chem. p. 5.

capable of supporting a population that could not exist, but for the beneficent law of nature, which thus increases the fertility of one portion of a district, in proportion to the sterility of another.

The four varieties of clay-slate that have been noticed in Europe, may be detected here.

1. Variat. Bluish grey; with a faint tinge of greenish yellow, and a slight glimmering lustre. Specific gravity, 2·3.

This is a common rock, and is the oldest member of the series, if we may judge from its geognostic situation. It is very distinctly stratified; but the strata are intersected at irregular distances by seams, which pass at right angles to the seams of stratification, giving the whole somewhat of a columnar structure.

2. Variat. Old blue-slate. The colour of this rock is bluish black, rendered reddish grey on the edges by long exposure. It has generally a fine slaty structure, but it is sometimes also compact. It is this variety that forms, occasionally, the lofty altitudes in floetz districts al-

ready alluded to. It forms the basis of Takill, the highest mountain in Kemaon that I have had an opportunity of examining; and which, according to measurements taken by order of Government, proved to be 8·221 feet.

The acclivities of this mountain are covered by the different formations of limestone, from under which the slate is rarely seen protruding, except on the highest summits. Specific gravity of a specimen from the cap of Takill, 2·643.

3. Variat. This is scarcely entitled to a separate consideration from the first, as it is only distinguished from it by the total absence of particles of mica, and by the distinct concretions in this inclining somewhat to a granular shape; while in the first they are lamellar, and the two kinds pass into each other, the present variety always maintaining a superincumbent position with regard to the first, of which it may be considered as merely the newest extreme*.

* It might be more correct to describe this as the second variety, as it seems to be an older rock than the old blue slate.

4. Variat. This is distinguished by its crystalline and curved slaty laminæ, and is a very important variety, from its liability to be confounded with transition slate. It has a more earthy lustre than transition slate, which is pearly, and it is generally stained on its external surface with red oxide of iron, an appearance rarely observed on transition slate. It is also occasionally mixed with mica, and, indeed, passes into mica-slate. It sometimes occurs of a bluish black colour, while the transition slate that is likely to be confounded with this variety of primitive clay-slate, is always light grey; and, lastly, primitive slate is somewhat lighter: the specimens of this that I examined, differed from 2·567, to 2·4, while several specimens of transition slate were each found to exceed 2·6.

This rock forms sharp elevated ridges, with conical peaks; and it occurs chiefly in high primitive districts, unaccompanied by limestone.

Clay-slate contains some unimportant beds of gypsum. It contains likewise beds of graphite, and is the only repository of massive quartz.

(A) QUARTZ.

In the district laid down in the map, quartz is found in cotemporaneous veins in clay-slate: these are generally small, seldom exceeding twelve inches in diameter; and do not usually run more than ten or twenty yards in length: but they are often much smaller than this, branching off in different directions, and terminating in wedge-shaped points.

Beds of quartz are also frequent: they sometimes measure eight or ten feet in diameter, and run for miles in the direction of the strata; several of them usually occurring in the same vicinity. They terminate by the approximation of their walls below, and wedge themselves out at their extremities like cotemporaneous veins. Quartz also occurs in overlying masses, along the lofty ridges and peaks of clay-slate; where its presence might be accounted for, by supposing it to have been yielded from former beds in the slate, which being more subject to decay than the quartz, gave up its contents to the surface, by a similar process to that which has been observed to produce the masses of granite in gneiss districts. It occurs, however, in this situation along with a peculiar septarium, which is of a sufficiently curious nature to raise doubts in the minds of some, I should think, as to the origin of this deposite of quartz. The subject shall be again reverted to, when treating of the septarium here alluded to. Quartz is also found in the same situation, in the form of small and minute hexagonal prisms, or suppositious crystals. The colour of the quartz is white.

(B) DRAWING SLATE.

This rock occurs in beds which are situated between clay-slate, and transition and floetz limestone: and often contains copper pyrites. It has frequently a brecciated structure, the fragments of which are cemented with calcspar.

Its colour is iron black. It occurs massive. Surface smooth. Lustre resinous, and sometimes glistening. Fracture diverging fibrous, inclining to scaly foliated. Fragments cunieform. Distinct concretions, very thin, lamellar. It is opaque. It affords a lead-grey streak. It soils slightly, and writes. It is soft, meagre to the feel, and sometimes affords a strong bituminous smell when breathed on. Specific gravity, 2·787 and 2·78.

Chemical characters. It is infusible.

6.—PRIMITIVE LIMESTONE.

Primitive limestone composes the northern acclivity of Takill; and from thence it extends in a north-westerly direction, probably for many miles. I have myself traced it twenty or thirty.

It occasionally gives way to the newer limestones, and again appears constituting the peculiar feature of some rugged precipice. I have never observed it to form a mountain summit, or to occur in any altitude above five or six thousand feet at the utmost.

In a small river valley, which partly separates Takill from the Oudepore group, this rock forms the most frightful precipices on both sides that can well be imagined. These precipices compose broken, and seemingly tottering mountain acclivities, that ascend in places for three or four thousand feet, at various angles between 45° and 75°; and as the only road between Lohooghat and Petoragur lies along the verge of these precipices for several miles, it is impossible that the most indifferent traveller could pass, insensible either to the danger of his situation, or the beauties of the scene. This limestone is distinguished in the large scale, by its thick slaty appearance, owing apparently to occasional laminæ of argillaceous matter which pass an uncertain length through each stratum, parallel to the strata seams. The strata are mantle-shaped, rather than conformable; or they may be said to partake of the nature of both. This variety of the rock is of a bluish grey colour, with a dull lustre.

On the mountain acclivity composing the southern boundary of Goron valley, there is also a bed of primitive limestone, distinguished from the former in being conformable, and in the colour being snow-white, reddish-white, and peach-blossom red, without lustre.

The fracture of the first variety is compact, and coarse splintery; of the second, large conchoidal, inclining to foliated. Distinct concretions, very fine granular; but they are coarser, in the second, than in the first variety, and the former is slightly translucent on the edges; the latter nearly opaque. They are semi-hard. The second variety is brittle; the first not particularly so. Neither, is very difficultly frangible; but the second variety is the most fragile. When the second variety is moved loosely in the hand, it affords a slightly grating sound. Specific gravity of the bluish grey variety, 2·6477; of the snow-white, 2·6; and of the peach-blossom red, 2·7.

Chemical characters. They dissolve rapidly, and with effervescence, in muriatic acid.

The snow-white strata are lowest in the bed, and lie directly on the old blue slate. The peach-blossom kind next occurs. It is probable from its external characters, as well as from its stratification, that the bluish grey variety is the newest; but the total absence of any detritus or organic remains in it; and particularly its giving support to a deposite of transition limestone, are sufficient reasons for placing it in the primitive class of rocks.

The snow-white and peach-blossom varieties contain subordinate beds of the following rock.

(D) SPLINTERY HORNSTONE.

There are three varieties of hornstone in the Shore district, each of which appears to be peculiar to the class of rocks with which it is associated in nature. The first variety is that which occurs in primitive limestone, and its description naturally belongs to this place.

It occurs massive, either long and cylindrical, or flat, approaching to the character of strata.

Colours, faint greenish, yellowish, or bluish white. Surface smooth. External lustre dull. Fracture compact, splintery, and large conchoidal, inclining to concealed foliated, with a double cleavage. Cross fracture, small conchoidal, and uneven. Fragments, irregular, indeterminately angular and sharp-edged. Lustre, pearly, or in places glistening from minute particles of calcspar.

It is semi-transparent in thin fragments. It is semi-hard, approaching to hard. It is not very difficultly frangible. Specific gravity, 2·816.

Chemical characters. It is infusible before the blow-pipe.

It is found along with the primitive limestone of Goron valley. I have also found it in amorphous masses, in floetz limestone; at the north-western extremity of the Oudepore mountains, near Petoragur.

CHAPTER V.

TRANSITION ROCKS, OLDEST TRANSITION LIMESTONE, SLATE AND LIMESTONE, MAGNESIAN LIMESTONE, COMMON DOLOMITE.

GENERAL REMARKS—TRANSITION OBSERVED BETWEEN PRIMITIVE AND SECONDARY STRATA—PROOFS AND CONCLUSIONS—OLDEST TRANSITION LIMESTONE, ITS DESCRIPTION—SLATE AND LIMESTONE, ITS DESCRIPTION AND NATURE—COARSE MAGNESIAN LIMESTONE, ITS DESCRIPTION—COMMON DOMOLITE, OR STEATITIC SAND-STONE, ITS DESCRIPTION, ITS VARIETY AND NATURE—FURTHER DESCRIPTION AND REMARKS—TRANSITION SLATE.

THE rocks belonging to this class are distinguished from primitive rocks by their position; by greater irregularities in regard to stratification; and by containing obscure traces of organised beings, as well as by certain characters presented by the structure of the rocks themselves.

In Shore valley, we find a black, fine grained limestone, resting in unconformable strata, on clay-slate. These masses are sometimes overlying, and of various external shapes; as long, round, flat, cavernous, and entangled. The flat approach to tabular shapes, and are piled upon each other, so that in places they form ridges, which rise to the height of two or three hundred feet above the valley, when they end in tabular summits. The highest tables which compose these summits are quite horizontal: while the lower ones approximate more to the dip of the clay-slate, on which they rest. It is difficult, when viewing these appearances, to resist the belief that this limestone belongs to a newer period in the history of the world, than the clay-slate; for in the primitive rocks, we have seen one series succeed another, in regular and unbroken order, without any marks of violence or confusion from local causes.

In another part of the district, an impure, fine-grained limestone, is found mechanically mixed with newest clay-slate, in thin, slaty lamillæ*. In succeeding strata, the quantity of calcareous matter increases, until the argillaceous ingredient disappears, and the limestone either assumes the usual character of the transition rock, or it approaches that of an impure magnesian limestone. The impurities of the magnesian limestone are of two kinds: one distinguished by containing minute grains of quartz or silex, and the other, by containing argillaceous clay. The first, when fresh, presents some of the characters of the soapstone family; but when weathered, it looks like a fine siliceous sandstone: while the second has a dirty scaly texture, internally, somewhat like clay-slate; but carelessly examined, it would be mistaken for granular limestone.

These three rocks rest on the third variety of clay-slate, and they appeared to me to occupy nearly the same geognostic situation; but I am unable accurately

* It presents the same external characters as the "flint-slate" in the German collection of minerals in the Asiatic Society's museum.

to describe their relative situation to each other, further than that the limestone seemed to be the substratum, and that above it, beds of curved pearly slate occurred, of greater or lesser thickness, from five hundred, or more, to only a few feet. The superincumbent strata of this slate soon begin to display occasional laminæ of magnesian limestone. This appearance becomes more extensive in each succeeding stratum, until the slaty laminæ disappear from the magnesian rock, which either changes again into slate by a similar gradation, or constitutes of itself the superincumbent structure of mountains.

From these observations it appears evident, that a change has here taken place, from the primitive to the transition rocks of Werner; in support of which, the following reasons are presented to our notice:

1st. The clay-slate on which the lowest bed of limestone reposes is, indubitably, a primitive slate.

2nd. The limestone bears the characters of a transition, rather than of a primitive rock.

3rd. The magnesian limestone, and the slate that lies over the common limestone, contain traces of organised fossils, which are referrible to the earliest transition period.

4th. Mountains of crystalline, fine-curved, and pearly slate, containing cotemporaneous veins of quartz, rest on the magnesian limestone, in conformable strata; and as it is clear that this slate cannot be a floetz rock, it follows, as a natural consequence, that the substratum cannot be considered as belonging to that class.

Thus it appears, that transition rocks are clearly indicated in the mountains of Kemaon; that grey wacke, and grey wacke-slate are both absent, and that their place is supplied by a rock composed of a mixture of magnesian limestone and argillaceous clay: and lastly, that however adverse to our former notions, we shall be obliged to admit magnesian limestone into the class of transition rocks.

Without attempting to speculate on this subject, I shall proceed at once to the description of the rocks themselves, as the only way in which information either useful or satisfactory can possibly be afforded on a subject of this nature.

1.—OLDEST TRANSITION LIMESTONE.

This is the oldest member of the transition class, and in every country, that has been hitherto examined, it marks the commencement of secondary strata.

It is found on the western acclivity of a lofty mountain near Lohooghat, which is called the *Soee*, (which signifies *needle,)* where it runs for a short distance in a line with the Petoragur road, at an elevation of about six thousand feet. The bed of rock then crosses the road, and descends into deep valleys: in these I have traced it extending in a north-westerly direction, as far as Ryegong. It is scarcely stratified, but rather disposed in an unconnected succession of tabular masses, which extend in the direction of the general strata, forming a bed that varies in breadth, from ten to fifty feet, and upwards. The *lying* side of the bed is formed by either the third or the fourth variety of primitive slate; while the *hanging** side is formed of a mixture of slate and limestone, either magnesian or common; but neither side is at all well defined. The course of the bed is marked by occasional small caves, or rather holes and interstices, as well as by overlying tables, and rounded masses of limestone, the surface of which is often converted into a brown dusty matter, and is divided by cellular reticulations of fine veins of calcspar—an appearance which is here peculiar to this rock. The following are its characters:

Colour, Berlin blue. Lustre glistening. Fracture compact, large conchoidal. Distinct concretions, fine, or very fine

* These terms have been long ago introduced from the technical language of miners; they are very expressive, especially to those who are practically acquainted with the appearance of beds and veins. The lying side means the inclined floor, on which the contents of the bed reposes, while the hanging side is the roof or lower surface of superincumbent rock.

granular; the fine granular concretions are somewhat angular, and have a dull dark-blue colour: while they are surrounded on the fractured surface by minute splinters, which appear to the naked eye like very fine white specks.

It is opaque. It is semi-hard.

It is entirely dissolved with brisk effervescence in acids.

2.—ALUMINOUS SLATE AND LIMESTONE.

This rock next occurs in the succession of the transition series, and is formed of alternate layers of limestone and slate. The limestone ingredient is generally magnesian, but sometimes common; especially in the vicinity of the last described rock. The slaty portion has mostly a bituminous appearance, but it is little altered by exposure to the blowpipe. The thickness of the layers which constitute the mass, varies from a line to seven or eight; and the different layers wedge each other out, by a curved slaty sort of structure. The argillaceous part comprises usually two-thirds of the mass, and the colour of this portion is sometimes bluish black; at others, blackish green, with a resinous lustre.

The limestone layers are grey, seldom without a tinge of green; and in all cases, present a very fine granular structure: are semi-hard, afford a coarse splintery fracture, with wedge-shaped fragments, and are quite opaque.

The greenish variety of this rock crosses the bed of the Ponar river, in a very low situation, about a mile due north from Ryegong. It here contains fossil appearances, consisting of rings grouped two or three together, and placed each in the corresponding axis of the other, so as to convey the impression, that they belong to some extinct form of organization; although on breaking the rock, there is no appearance of its containing an extraneous substance.

The same bed makes its appearance at an altitude of fifteen hundred, or two thousand feet higher than the previous locality. This new situation is on the road between Ryegong and the Soee, and a few miles east of the village of Boida, where it forms a steep declivity, giving support to magnesian limestone and transition slate, and is not distinguished by the appearance of the extraneous fossil above alluded to. In both situations the rock is conformable; and it appears by its colour and weight to contain probably both chlorite, and hornblende, which minerals constitute whole mountains in the form of hornblende-slate in this vicinity, and give a tinge of green to the older transition deposites that repose upon them.

This rock is also found in mantle-shaped strata, resting on hornblende-slate, at the south-western extremity of Takill, where it constitutes the corresponding declivity of the Ramessa valley. Here the argillaceous portion of the rock corresponds with the colour and nature of the old blue clay-slate, which constitutes the principal structure of that mountain, and which we may infer was the original repository that afforded the material of the slaty portion of this rock. A third

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variety occurs at the Sooee, where the limestone portion is combined in a mechanical alternation of layers, with ordinary transition slate.

Specific gravity of the greenish coloured variety, 2·75, and of the bluish kind from Takill, 2·647.

3.—COARSE MAGNESIAN LIMESTONE.

This rock may occasionally be found alternating with, and passing into the foregoing; but it occurs chiefly in a newer or incumbent position, and such is the case at the Sooee. From thence it has been traced into the Ponar valley, preserving the same geognostic position. In the latter situation, rolled masses are found of great size in the bed of the Ponar river; and on the surface of these the same singular traces of organic fossils, already observed in the former rock, are delineated; but the figure is in this better developed, the rings constituting each figure are more numerous, and conform to an awl-shaped outline. They are uniform in size, and quite independent of any peculiarity of structure, or colour of the rock, for they occur in all varieties of it, and may, although only superficial, be considered the vestige of some organised substance. See plate ii. Fig. 11.

The following are the characters of the rock. Colours dark bluish grey, pearl grey, and reddish white. Lustre dull or inclining to resinous, and of some to pearly, rarely glimmering.

Fracture compact, even, inclining to earthy in the blue, but to coarse splintery, passing into large conchoidal in the pearl grey variety.

Distinct concretions, small or fine granular; lustre of the distinct concretions in the blue kind, resinous. Pearl grey kind, is translucent on the edges; the blue is perfectly opaque.

It is semi-hard, and rather difficultly frangible; specific gravity of the dark coloured variety, 2·65, and of the pearl grey, 2·687.

Chemical characters: dissolve very slowly, and with very feeble effervescence in

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nitric acid, leaving about 40 per cent. of insoluble matter. With the addition of twice or thrice its weight of borax, it becomes, after continued exposure to the blow-pipe, imperfectly converted into a white enamel on the edges.

This rock passes into the following variety, which rests upon it in conformable strata.

It agrees in most of its characters, with the magnesian limestones of England, and may assist in determining the geognostic rank of those rocks, should the point be still uncertain.

(A) COMMON DOLOMITE; OR STEATITIC SANDSTONE.

The artificial arrangement of this species is one of those difficulties, which even M. Neergaard acknowledged must occasionally be expected by the best practical mineralogist; and a new name (says he) given to a substance, often induces people to believe that the substance is new.

Although I have distinguished this rock by the name of steatitic sandstone, I have done so, chiefly to express the uncertainty of my own opinion, as to its true nature: I however, strongly suspect, that it will be found to be a magnesian limestone, differing from most of the species with which we are acquainted. In the mean time, I feel assured, that an accurate description will answer the purposes of science, better than any speculations I can offer on the subject.

Its colours are greenish, bluish, and yellowish grey; often tarnished with reddish brown delineations on the surface. It rarely occurs cream yellow.

External lustre, dull; but internally it is vitreous. Fracture rather coarse splintery, in the small; but slaty, or concealed foliated, in the great. The splinters become white and mealy, on exposure to the air for a few months; and on longer exposure, the whole surface assumes an earthy aspect, presenting for a time, occasional blue spots, of irregular shape and earthy lustre.

The small fragments are indeterminately angular, or inclined to wedge-shaped, with sharp edges.

Distinct concretions are very fine granular, and scarcely perceptible in fresh specimens.

It is translucent on the edges. It scratches glass, and is with difficulty scratched with the knife. It is rather brittle. It feels meagre. Specific gravity, 2·6134 to 2·7725.

Chemical characters. It is very partially soluble in nitric acid, and even when previously reduced to impalpable powder, 70 per cent. at least remains insoluble. After exposure for several minutes to the blue flame of the blowpipe, it loses a portion of its colour and weight, and becomes easily frangible; and by the addition of borax, its edges, with much difficulty, are converted into a white enamel*.

* From these characters it would seem, that this rock contains a large proportion of very minute quartzose grains, imbedded in a magnesian basis.

(E) WEATHERED STEATITIC SANDSTONE.

Weathered specimens of the above-described rock are so different from it, in their external characters, that they would not be recognised as belonging to the same species, were they not seen in sitû, presenting all their different stages of mutation, between the fresh and the disintegrated rock.

It may not here be improper to refer to Dr. Berger's remarks on the identity of soap-stone and serpentine, which he believed to be of common origin; in proof of which he adduced the analysis of serpentine by Kirwan, and of soap rock (seifenstein) by Klaproth, and then observed: "We see that with the exception of silica and water, which are most abundant in soap-rock, there is in the last substance a diminution of about 0·03 or 0·04 of all the other component parts of serpentine, as if they had been destroyed in consequence of the disintegration of the rock, and carried off by the waters."

The principle which these observations of Dr. Berger render so probable, is exemplified in this instance by the transformation of the foregoing into the present rock; apparently by the removal of the talcose parts by weathering.

Its colour is grey, with a tinge of green, more or less faded, according to the freshness of the specimens; and it contains numerous curved and ring-shaped stripes of reddish brown and ochre yellow, chiefly the latter*.

External surface, rather corroded and granulated. Lustre, dull. Fracture, earthy.

Distinct concretions, very fine granular. It is semi-hard, inclining to soft. It is very easily frangible. It is perfectly opaque. Specific gravity; 2·607, after emersion, 2·674.

* Derived from the oxidizement of common clay-iron stone, which mineral is very generally distributed through the rifts and seams of both varieties of the rock, and occasionally contains impressions of zoophites, one of which I found on the highest point of the Sooee.

Chemical characters. It is insoluble in acids, and before the blow-pipe, affords with borax, a milk-white enamel.

These two varieties, so different in their characters, may be esteemed as having been originally but one substance. The first variety rests on, and passes into the coarse magnesian limestone; but sometimes a bed of transition slate intervenes. It composes the loftiest altitudes of the Sooee, where it assumes, occasionally, the character of a fine siliceous sandstone. From this situation it extends into the low district of the Ponar valley, forming in its course, bold, rugged, and often inaccessible mountains, which are distinguished by their sharp ridges and narrow deep valleys. It crosses the Ponar valley, and continues the same direction, probably without interruption, to Almorah, where it rests on a low ridge of slate, probably transition slate. Here it answers the purposes of architecture, and is, we may suppose, from this circumstance, less disposed to decay than the specimens subjected to examination.

This rock is intimately connected with compact dolomite on the one hand, and magnesian oolite on the other; both of which occur to an important extent in Kemaon, as will be seen in the next chapter.

4.—TRANSITION SLATE.

This rock may be said to consist of two varieties, distinguished rather by their position, than by any peculiarity of character.

The first is that which rests immediately on the bed of oldest transition limestone, and the second is that which rests on the common dolomite or steatitic sandstone.

The lowest strata are dark and earthy, and emit a strong bituminous smell—properties which diminish in the newer strata, which assume a clear pearly lustre, with, or without a fine curved structure. These characters however, disappear in low valleys, where the rock is more exposed to moisture: in these situations too, it is important to observe, that it is always more or less impregnated with detritus from surrounding substances. Thus, for instance, when the valley in which it is situated is subordinate to mountains of hornblende-slate, the transition slate is found to present a greenish tinge; in other cases, it contains calcareous matter. Nor are these the effect of alluvial changes alone, but appear, especially in the former case, to be inherent in the constitution of the rock.

The oldest stratum, or that which lies in contact with the first bed of limestone, is found broken, crushed, and indented, as if it were by the mechanical pressure of the superincumbent strata, indicating that these were deposited; while the former was in a state of emolescence, and the limestone hard and unyielding*.

Transition slate contains few contemporaneous veins of quartz, and when these

* As limestone hardens not by the evaporation of its moisture, but by the absorption of carbonic acid, we can have no difficulty in conceiving how it may have become very quickly hard and unyielding in a situation where carbon still abounds.

do occur, their walls are bituminous, loose, and friable; while in clay slate, they are compact and intimately united to their contents.

Transition slate forms the mountain on which the village of Barakote is erected; and at the southern extremity of that mountain, the slate is seen resting on the common dolomite*.

* I have been thus particular in pointing out a spot on the high road between Lohooghat and Petora, where the important fact of transition slate resting on this sandstone may be observed by every traveller who passes, without the trouble of dismounting from his horse.

This singular fact is the more important, as I find the same peculiar sandstone is a very generally distributed rock throughout India.

CHAPTER VI.

TRANSITION ROCKS, TRANSITION LIMESTONE, COMMON DOLOMITE.

THE VARIETIES OF TRANSITION LIMESTONE—REMARKS ON ITS STRATIFICATION, ITS DESCRIPTION—OVERLYING VARIETY DESCRIBED—COMPACT AND COMMON DOLOMITES COMPARED—MOUNTAINS OF COMPACT DOLOMITE DESCRIBED, ITS GEOGNOSTIC RELATIONS, STRATIFICATION, AND LOCALITIES—NATURE AND CAUSE OF ITS TRANSITIONS INTO SUBSTANCES APPARENTLY DIFFERENT FROM EACH OTHER—DESCRIPTION OF GRANULAR COMPACT DOLOMITE, ITS CHEMICAL CHARACTERS AND LOCALITIES—SPLINTERY COMPACT DOLOMITE DESCRIBED—OOLITE OR GRIT-STONE, CHARACTER OF ITS MOUNTAINS, ITS DESCRIPTION—GENERAL REMARKS ON THE ROCKS HERE DESCRIBED AS DOLOMITES, AND THE REASON FOR SUPPOSING THEM TO BE OF A DIFFERENT NATURE.

5.—TRANSITION LIMESTONE.

It is difficult to say whether this rock, or that siliceo-magnesian deposite, described in the last chapter, be entitled to priority of rank in a chronological arrangement; for as they do not occur together within the limit of the district examined, we have no data on which to form any decisive observations, and in this, as in all similar cases, mere argument would be a poor substitute for facts.

The present rocks are, however, well known and described in almost every geological work; but as we cannot be too well acquainted with the natural appearances of every formation in every country, I cannot forego the opportunity of offering a few remarks on these strata, as they appear in Kemaon.

This limestone presents two varieties, which are well distinguished from each other, by the manner in which they occur in nature, as well as by their specific gravity. The most important, because the most extensive of these, is somewhat stratified and conformable, and in conjunction with clay-slate, forms whole mountains and even mountain groups. Beds of graphite sometimes intervene between the slate and limestone; at others, the two rocks change gradually into each other, by what may be named a *chemical* mixture, in order to distinguish it from the more mechanical alternation of parts, which constitute the transition between similar rocks described in the last chapter.

This transition takes place by means of a rock that consists of carbonate of lime and alumina; one or other of these ingredients preponderating at a particular place, according to the proximity of clay-slate, or of limestone; and this coarse earthy substance affords, like swine-stone, which it resembles in its nature, an unpleasant odour when rubbed.

Unless limestone contains impurities, either constitutionally disseminated in its structure, or externally applied in the form of a coating on its surface, or constituting strata seams, it undoubtedly acquires a homogeneous and unconformable character, from the corrosive effects to which it is subject from various chemical agents. Hence it is, that those limestones which are the purest carbonates, and which are most exposed to the influence of external causes, display the smallest signs of regular stratification, such as the alpine limestone. Why, it may be asked, is stratification usually most indistinct in those limestones that present fused-like and corroded precipices? The answer is, that the continuity of strata on the surface of mountains of pure carbonate of lime, and the original features of the precipices of such mountains, have been destroyed and effaced by the same causes, namely, the chemical action of waters.

The blue primitive limestone described in the fourth chapter, is as distinctly stratified as any other formation in the district; but it owes the preservation of its integrity in this respect, to the layers of compact argillaceous matter that adhere to the surfaces of the strata, and which thus protect them from the corrosive effects of the waters. The opinion of some respectable geologists, that stratification is incompatible with the nature of limestone, as a chemical deposite, may have arisen from observing the appearances which alpine limestone is liable to assume, without considering the causes to which those appearances are here referred*. Chemical compounds only assume crystalline forms under certain circumstances; and we may safely venture to conclude, from the appearance presented by calcareous rocks, that the circumstances under which they were deposited were unfavourable to any other law than that which still governs the gravitation of matter.

The specimen of limestone which led to these remarks, is found in large quantity in the Shore district, and is probably among the oldest transition rocks that are found there. It composes the small mountain ridge in the centre of Shore valley, whose tabular structure was alluded to in the beginning of the last chapter.

It might, from what was there said, be supposed to be a floetz limestone; but

* Mr. Bakwell, if I recollect right, in his very interesting and popular introduction to geology, asserts, that it is a physical impossibility that limestone can, from its nature, be stratified.—See Edition 1816.

this is not the case, as the nature of the transition that has been described to exist between it and clay-slate, is sufficient to shew; and it does not always, nor even generally occur in tabular masses. It forms most of the mountain acclivities that encircle Shore valley. Most of these when viewed from a distance, present very distinct marks of stratification; but on approaching them, they appear like loose unconnected mountain masses, divided certainly into tables; but these are again cleft and comminuted sometimes into slaty fragments, cemented with tufa and calcspar. Other fragments are cubical, and various massive shapes of enormous size, presenting fissures which are either open, and lined with calcspar, or filled with tufa. Although thus wrecked and broken, evidently by the action of alluvial waters, this rock may still be said to be stratified in the great scale, as indicated by the distant view, and also by the minute inspection of detached masses, in which traces of obliterated strata-seams are often to be found.

The colour of this limestone is bluish black, sometimes Berlin-blue, and rarely streaked with tile-red.

It is often brecciated, the distinct parts being cubical and rhomboidal, but so closely united, that its brecciated character is only detected by attempting to break it.

The fracture is small conchoidal, fragments rather inclined to sharp-edged.

Lustre, dull. It is opaque. It is semi-hard. Specific gravity, 2·61 to 2·671.

Chemical characters. It dissolves entirely with brisk effervescence in acid, and affords a snow-white quick-lime, without falling to powder.

(A) OVERLYING VARIETY.

This variety of transition limestone occurs in distinct masses, of various shapes and sizes; the former frequently irregular, but often rhomboidal, cubical, columnar, seldom round. They occur singly, or in large numbers, piled loosely together in the form of bold rugged knolls, mountain shields, and caps: more rarely, two or three enormous isolated blocks are so nicely balanced upon each other, as to convey the idea of their having been so placed, by some artificial power beyond our conception. Their external surface is granulated and uneven, often also streaked by projecting lines.

Its colour is velvet black, with numerous spots and veins of white calcspar.

Fracture, large conchoidal, inclining to granular foliated. Fragments, indeterminately angular, and rather blunt-edged. Lustre of the fracture, glimmering, sometimes glistening.

It is opaque. It affords a white streak. It is semi-hard. Specific gravity, 2·8435 and 2·8668.

Chemical characters. The same as the foregoing.

It sometimes rests on the foregoing variety, with which it usually occurs; it also rests on clay-slate, and is extensively distributed on mountain ridges and acclivities in the vicinity of Shore, between the altitudes of five and seven thousand feet. The spotted variety in particular is a beautiful marble, and would be highly esteemed, if within the reach of a people whose knowledge of the arts enabled them to appreciate its value.

Along with these limestones, beds of green-stone, slaty talc, and graphite are very common. The transition green-stone and the graphite are peculiar to this formation, but the talc also occurs in floetz limestone. The stratified variety is also the repository of copper pyrites.

6.—COMPACT DOLOMITE.

The description of the rock now about to be entered upon might have followed that of the common dolomite, or steatitic sand-stone, with which it appears, in many respects, to be connected. There are however differences both in regard to physical and external characters between them, that ought not to be confounded, the more so as they appear but to constitute varieties of a series of rocks, which, as far as I am capable of judging, are as yet imperfectly known.

Under such circumstances, every character that appears to constitute a well founded distinction ought to be adhered to, until something satisfactory be ascertained respecting their chemical, as well-as physical history. While the former rock was found to rest beneath transition slate, the present one is found to repose upon that slate, and never as far as I have seen, gives support to any superincumbent formation.

Having entered the mountains from the plains, viâ Burmdeo pass, and crossed the ridge of grit-stone; mountains of compact dolomite are seen rearing themselves abruptly out of the narrow valley of Belket. The beautiful green and blue colours of their naked precipices; the picturesque forms of their lofty summits, as well as the uniform arrangement of their massive, and nearly perpendicular strata, convey, upon the whole, a most sublime effect.

In this locality, the geognostic relations of the rock are not capable of being very satisfactorily ascertained. It is separated from hornblende-slate on the one side, by a curved slaty rock composed of chlorite and quartz, which, from observations made on the spot, I was led to believe, passed into a granular variety of the rock now under consideration.

On the opposite side of the mountain, it forms a close local connexion with the grit-stone; but I had no opportunity of determining whether or not any physical assimilation exists between these two apparently distinct mountain rocks.

The strata are distinct and nearly vertical; the dip being seldom less than 75°, alternately changing from N. N. E. to S. S. W. The direction is consequently W. N. W. The strata are divided by numerous rifts and fractures, passing at right angles to the seams of stratification, which give the rock a columnar appearance. It would however seem, that these divisions of the strata are the effect of causes which are still in operation: such as the encroachment of the periodical torrents on the bases of the mountains; the percolation of water from above, as well as the concussion of earth-quakes.

At the bridge which crosses the Răm-gungah river, on the road leading between Almorah and Petoragur, and above forty miles to the north of the first-mentioned locality, the same rock again occurs. The granular variety here constitutes the bed of the river in nearly horizontal strata, resting on green transition slate. It ascends in the deep ravines, on the Petoragur side of the river, and is found in the lower parts of the Gorou valley, two thousand feet at least above the situation it occupies at the bridge.

On the opposite, or Gungowly side of the river, the rock changes its character into siliceous oolite, by giving up its colouring matter, and assuming a porous nature; and in this state it ascends on mountain shields, occasionally forming bold rugged knolls on the rising acclivities, till at length it forms one of the loftiest ridges in Kemaon, and is terminated by Rye Peak, a conical summit, scarcely less elevated than Takill.

In these various situations, the rock makes numerous transitions into substances apparently different; but as they all agree in their chemical characters, and change progressively into each other, it was necessary for the development of their history to embrace them under one general view, although it may now be necessary to describe the extremes as distinct species. The changes of this siliceo-magnesian deposite, seem rather to depend upon altitude, than upon any other circumstance that I have been able to detect. Thus at Belket, at an altitude of about 1,300 feet, it is the same as it occurs in the valley of the Ramgungah, at about 1,500 feet. At Pokrè, on the acclivity of the Deary mountains, near Gungowly, at an elevation of about 6,000 feet; it is nearly identical with the common dolomite of Jeerconie, which is described in the last chapter; and at the altitude of 7,000 on the Deary mountains, it assumes the character of an oolite, which bears the same relation to *compact dolomite*, as the weathered steatitic sandstone of the *same altitude* on the Sooee bears to common dolomite of that place.

(A) VAR. GRANULAR.

Although this is only a sub-species, I shall describe it first, as it appears to be the oldest variety.

Its colours are peach-blossom red, Columbine red, passing into pearl-grey; sky-blue, and emerald green. External lustre inclines to resinous.

Fracture, compact, inclining in some cases to diverging fibrous, and in others, to imperfect small foliated. Principal fracture, coarse splintery ; cross fracture, granular. Lustre of the fracture, pearly.

Fragments, wedge-shaped, and blunt-edged.

Distinct concretions, small, round granular, and egg-shaped, with smooth surface. Lustre of the distinct concretions, vitreous.

It is not easily scratched by the knife. It is translucent on the edges. It is brittle.

It is easily frangible ; rarely however it is moderately tough, and if cut into thin strips, would probably prove flexible. Specific gravity, from 2·657 to 2·505.

Chemical characters. It is very partially and slowly dissolved in nitric acid, with a most feeble effervescence. After exposure for five minutes to the blue flame of the blow-pipe, it displays a conglomerated texture, consisting of small white grains, imbedded in an imperfect slag; with the addition of borax, the granular portion is converted into a bluish white enamel on the surface, but the other parts undergo no further alteration.

This rock occurs at Belket, where it is surrounded by lofty mountains, primitive as well as floetz, and transition. It rests on hornblende-slate and a mixture of quartz and chlorite, and passes into compact dolomite. It is also found in the deep valley of the Ramgungah river, near Petoragur, where it rests on transition slate, and passes into oolite. In the latter situation, the strata are between mantle-shaped, and conformable. It is found in the lower parts of Gorou valley, along with transition limestone, and in this situation, it is dull and earthy, and in every respect resembles in appearance, a coarse calcareous grit-stone. The snow-white variety I have never found in sitû, but abundant rolled masses of it occur in the rivers and valleys in the vicinity of the other kinds of the rock.

(B) VAR. SPLINTERY.

Colours greenish-white, passing on the one hand into emerald green, and on the other, into azure blue. Lustre, between vitreous and resinous.

Fracture compact, fine splintery, even. Fragments, indeterminately angular, and rather sharp-edged. It is translucent on the edges. It is similar in the streak. It scratches glass, but yields easily to the file. It is rather brittle. It is rather fragile, and somewhat meagre to the feel. Specific gravity, 2·659.

Chemical characters. It is very partially soluble in nitric acid. Before the blow-pipe it looses its colour, and becomes fragile; and with the addition of borax, it melts on the edges into an opaque white enamel.

It forms whole mountains at Belket, which is the principal locality in which it is found The peculiarity of its stratification has been already described.

It contains nests of earthy and slaty chlorite, and blue felspar.

(c) SILICEOUS OOLITE.

The next member of this series of rocks is an oolite or grit-stone, that composes a lofty range of mountains on the north of Gungowly; the name of which is *Deàry*. The highest point of it is a conical peak, that ascends about 300 feet above the general height of the ridge, and is named in the new map of the province, lately published by the Government, *Rye Peak*. It is however very difficult to derive the real name of a mountain from the natives. Indeed, it is only after repeated inquiries, that the true name may be guessed at with any tolerable degree of success.

On traversing this range, I was enabled, with the assistance of Gunter's quadrant, to form a pretty near estimate of its height, by making comparative observations between it and other altitudes that have been determined, and I should conceive the Rye Peak to be about 8,100 feet. This ridge extends in a north-westerly direction, between the Ramgungah and the Surjee rivers. It is entirely composed of oolite, resting in saddle-shaped strata, on transition slate. It is narrow at the summit, and extremely steep, but rarely inaccessible: and its outline is diversified by numerous very bold conical peaks. The acclivity which rises out of the valley of the Ramgungah, is distinguished by remarkably prominent and insulated dome-like shields; and the surface of the whole ridge, as well as of the acclivities of the peaks, are strewed with overlying masses of the rock, and clothed with forests of oak.

Colour of the rock is yellowish white; surface rough; external lustre, none. Internal lustre, inclining to vitreous.

Fracture compact, uneven, inclining to coarse splintery on the one hand, and to large conchoidal on the other.

Fragments, irregular, blunt-edged.

Distinct concretions, fine granular. Surface of the distinct concretions, smooth. Lustre of the distinct concretions, vitreous.

It is translucent on the edges. It is similar in the streak, and semi-hard. It is not particularly brittle; is easily frangible, adheres slightly to the tongue, and often affords a grating sound when handled. Specific gravity, from 2·6 to 2·5975.

Chemical characters. It dissolves very partially and with feeble effervescence in nitric acid.

It becomes enamelled on the surface after exposure to the blue flame of the blow-pipe, with the addition of borax.

It is distinguished from granular foliated limestone, by its slightly vitreous aspect, and by its comparative insolubility in acids. It passes occasionally into all the different varieties of rocks, which have been here described, under the common head of dolomite; but which, I suspect, will be either found to constitute a distinct family, or at least a new species of magnesian limestone, containing a larger and more uniform proportion of silex than has hitherto been discovered in any of the numerous varieties of that rock.

CHAPTER VII.

ROCKS, SUBORDINATE TO THE TRANSITION CLASS, OCCURRING IN BEDS.

PECULIARITY OF THE OLDER STRATA, AND AN ATTEMPT TO EXPLAIN THE CAUSE—MISCELLANEOUS ROCKS—GRANATINE—FIBROUS LIMESTONE—COMMON TALC—VARIETY OF DITTO—MINERALS ASSOCIATED WITH TALC—VARIEGATED CLAY-SLATE—BRECCIATED SERPENTINE—NOBLE SERPENTINE.

THE rocks described in the foregoing pages, include, with one or two exceptions, all the great formations that compose the solid mass of the principal mountain chain. They rest on granite, which penetrates through them, not in vertical strata, but with a dip of 75° to the north-east. There is reason to believe that this is not a true dip, but rather a superficial bending of the strata (of a similar nature to what may be seen in plate III), that does not extend to the lower granite.

The immense accumulation of primitive rocks, which composes the alpine land, extending to the high mountain chain, must occasion a pressure on the side of the Himalayas calculated to force the vertical strata of granite towards the plains, the side on which it is least supported*. What strengthens this view is, that clay-slate, a rock that constitutes two-thirds of the acclivity on the side of the Himalayas, is quite absent on the opposite side next the plains.

Were it not for this explanation, the granite would be taken for a newer formation than the gneiss and hornblende-slate on which it seems to rest, a transposition of rocks which is contrary to all established principles of geognosy,

* "As the waters which formerly assisted in supporting the mass of mountain began to lower their level, those masses then lost their former support, yielded to the action of their weight, and began to separate and be detached from the rest of the mountain, falling to the free side as that where least resistance was opposed." Werner.—Vid. New Theory of Veins.

and which we could not receive unless confirmed by the most extensive and careful observations, such as would embrace the Himalaya range from Tartary to Hindustan. In the mean time, the above explanation may be sufficient to account for the local appearance on the south-western acclivity of Choura Pany, the only locality in which I have had an opportunity of examining this apparent inversion of the superposition of strata.

Before proceeding to the notice of the great floetz formations, it is necessary to describe some less extensive deposites, which appear to be of older date. They are found in beds in primitive and transition rocks, and newer varieties of them occur also along with floetz limestone. An interesting locality, in which all of these minerals are found, is represented in plate IV. and is situated about two miles north of the cantonments of Petoragur.

1st, Granatine. A rock of this nature is derived from primitive limestone, along with which it is found in rather extensive beds in clay-slate. The oldest variety of the rock is stratified, and the newer kinds are strewed over extensive tracts of the district in overlying masses.

It is composed of dolomite spar and calcspar, imbedded in an earthy basis, which in the oldest variety is calcareous, and in the newer it approaches to a talcose nature. In the oldest variety the crystals of dolomite spar are very small, but in the newer sorts they are often middle sized. This rock is often associated with copper and iron pyrites; in such cases, the ores when they occur in sufficient quantity, appear to have displaced the other ingredients of the rock, and to constitute the matrix in which the dolomite spar is imbedded. Its specific gravity is 2·990.

I have never found it on high ridges, but chiefly forming rugged mountain shields and belts, extending along the abrupt declivities of limestone mountains. In this way it is found in the vicinity of Petoragur, on the rugged path to Kuttygong, at Gungowly, and at the Rye copper mine, as well as at that of Ager in the valley of Barabice. It has a strong resemblance to sienite, with which formation it is probably connected.

2nd, Fibrous Limestone. This substance occurs, along with common talc and the last described rock, at the north-eastern extremity of the Oudepore mountains in conformable strata. It is found in the valley of Barabice in the same way. It occurs also on a low ridge, which forms the western boundary of the valley, in mantle-shaped strata, resting on transition limestone and clay-slate. The strata are usually thin, and the whole bed seldom occupies more than a few feet in thickness. It sometimes occurs in overlying masses, of great length in proportion to their thickness and breadth. Its colours are lead grey, greenish and bluish grey, clouded and striped with smalt blue. External lustre dull, and spotted with a reddish tarnish. Internal lustre somewhat pearly. The remaining external characters agree with the description given by Professor Jameson to this substance. Specific gravity, 2·768.

Chemical characters. It burns to quicklime without falling to powder, and dissolves with brisk effervescence in nitric acid.

3rd, Common talc. This rock is found along with that last described, and with the granatine; in both of which it is disseminated. It also occurs, though rarely, as an extraneous fossil in transition and floetz limestones.

Its colours are bluish, and greenish grey, and bluish black; sometimes these colours alternate together, in spots and streaks, in the same specimen. Its lustre is between pearly and metallic.

Fracture, curved slaty. It is translucent on the edges. It is soft. It is sectile. It is not difficultly frangible. It feels greasy. Specific gravity, 2·8.

Chemical characters. When exposed for five minutes to the flame of the blowpipe, it loses a small portion of its weight, and becomes snow-white, hard, and brittle, and with the addition of borax, it is changed on the edges into a greyish-white enamel.

Variet. b. It occurs massive, and also in the state of a fine loose powder, which with moisture is converted into pipe-clay.

Its colours are bluish and greenish-white, clouded with bluish-black. External lustre, pearly, with a greasy kind of gloss. Fracture, slaty, inclined to fibrous. It is transparent on the edges, and in thin folia. It writes, but does not soil. It is very easily frangible. It is very soft, and perfectly sectile. It feels very greasy. Specific gravity, 2·6082.

Chemical characters. Its weight, tenacity, and hardness are unchanged by the action of the blow-pipe, nor is it fluxed by the addition of borax. During the application of heat, the colour of the white sort assumes a permanent bluish grey.

The chemical characters of this variety are different from those that have been usually found to belong to talc, and as

I have found this mineral to accompany the repositories of copper ore, its peculiarities are the more deserving of attention.

The varieties of talc and soap-stone examined by Kirwan, Klaproth, and Bergman, were found to become hard and brittle after the application of heat, and to melt with the addition of borax. We are therefore led to conclude, that the variety here noticed, partakes more of the nature of pot-stone, or the soap-stone of Cornwall, than of common talc; but it is probable that its peculiarity merely depends on the absence of argill, to which in these cases the phenomenon of hardening before the blow-pipe is usually to be ascribed. Indurated talc, amianthus, and rhomb-spar, as well as common felspar and hornstone, occur along with common talc.

4. Variegated Slate. This rock is found in the district of Shore, resting on clay-slate, in mantle-shaped strata; and sometimes it is also found conformable, on considerably elevated ridges and moun-

tain shields. Fracture, slaty in the large, like ordinary clay-slate; but in the small, it presents a second cleavage, parallel to the edge of the strata; and the fragments derived from the latter fracture, are tabular, and ornamented on their surface, with alternate layers of indigo-blue and greenish and yellowish-grey, blended together with various degrees of intensity, like the coloured stripes of a ribbon. It is soft, and without lustre.

The strata usually dip about 30° more or less, according to the acclivity on which they lie. They are intersected by vertical rifts, which divide them into rhomboidal masses of various sizes; these rifts are always parallel to each other, they consequently intersect the strata seams at about angles of 30° and 60°. Though not universal, this kind of structure is rather prevalent in the newer clay-slates.

Variet. a. This is a still newer slate, and is found often resting on transition limestone. It generally occurs along with calcareous rocks, and is consequently very common in the Shore district, where it composes low shields and knolls. Its structure is brecciated, but fine slaty in very small fragments. The distinct brecciated masses are tabular, and cemented by calcareous matter, with which the external surface of the rock is almost always coated. It contains numerous fissures, which are lined with calcspar. Its colour is very light, yellowish grey. It is soft, and contains no scales of mica; but is distinguished by a slight crystalline lustre, which, together with the absence of vegetable impressions, is sufficient to prevent its being confounded with clay-slate, which seldom or never is found to compose knolls, or mountain shields; but rather occurs as upfilling in cavities and hollows at the bases of mountains.

5. Brecciated Serpentine. Of the geognostic importance of this rock, I am unable to give any precise information. It appears to be of considerable extent; and from the circumstance of its giving support to transition limestone, as well

as from the massive and conformable nature of its strata, it may be ranked amongst the early transition, if not among the newer primitive rocks.

It is found at Julaghat, about twelve miles from Petoragur, in a north-east direction, where it forms the bed of the Mahi-Kali river. Lofty inaccessible acclivities ascend abruptly on both sides of the river, to the height of several thousand feet above its bed; in these, transition and floetz limestones are the principal rocks, and both rest occasionally on the serpentine; but I have been unable to discover the substratum on which this rock reposes*, as well from want of time, and the inaccessible nature of the neighbourhood, as from the vicinity of a foreign state: the Mahi-Kali river forming here the boundary between the British territory, and the kingdom of Nepal.

It is stratified and conformable. Direction W. N. W. dip 40° E. N. E. Its

* I believe it to be clay-slate.

colour is greyish black. Fracture, compact, large conchoidal, more or less perfect.

Lustre, dull; but externally it is slightly metallic. Fragments, indeterminate and rather sharp-edged. It is opaque. It affords a light-grey streak. It yields with some difficulty to the knife. It is rather difficultly frangible. It affords a soft powder, and is in its massive state, soft and warm to the touch. Specific gravity, 2·68.

Chemical characters. In nitric acid, it is partially dissolved, with very feeble and slow effervescence, and the residue forms a jelly. After exposure to a white heat before the blow-pipe, it assumes a reddish colour on the edges, and with the addition of borax, it is converted with difficulty into a greenish black enamel.

The indestructible character of this rock is well demonstrated by a few prominent strata on either side of the river, projecting in such a manner as to contract the breadth of the stream, from sixty or eighty yards, to about forty feet;

although the quantity of water transmitted by this rapid torrent is probably equal to that of the Thames at Putney, or Kew. An old tottering bridge, composed of beams of timber extended across this contraction of the stream, forms the only communication between Nepal and the Company's dominions in Kemaon during the rains; but at other seasons, the river is fordable in some places, and in others, may be crossed in boats.

The structure of the rock is brecciated, and in attempting to break it with the hammer, it separates into rhomboidal pieces, which were bound together with carbonate of lime. Those surfaces which have been exposed to the occasional friction of the current, are uneven; but perfectly smooth and polished with an oily gloss, similar in appearance to a highly polished surface of wood by unctuous applications.

Another variety of common serpentine, differing from the above in its specific gravity, is found on the mountain which separates Shore, from the valley of Deodara, at an elevation of 6,000 feet. It is also of black colour, but it is not brecciated. Its fracture is large conchoidal. It is easily scratched with the knife, and is quite opaque. Specific gravity, 2·81.

Variet. a. Noble Serpentine. It is found on the eastern acclivity of Durge, on descending into the valley of the Mahi-Kali, in amorphous masses. It first occurs in the form of a soft brecciated slate, having a large conchoidal cross fracture, with a lustre between earthy and pearly on the principal fracture. It soon assumes the compact structure of serpentine, and presents the following characters.

Colour sea-green, with occasional fine streaks of talc, which are light grey and shining.

External lustre dull; lustre of the fracture between resinous and pearly, with occasional glimmering specks.

Fracture compact, large and small conchoidal. The large conchoidal is often very fine splintery.

Fragments rather sharp-edged, and

feebly translucent on the edges. It is difficultly scratched with the knife, and affords a pearl grey streak. It is not very fragile. It feels rather meagre. Specific gravity, 3·174.

Chemical characters. In the trials made by the blow-pipe, it proved infusible without addition, but with borax it melts with considerable difficulty into a greenish grey enamel.

It occurs chiefly overlying, in long and rolled masses, and often assumes a brecciated structure, and in such cases the fragments are cemented with calcspar, steatite, &c. It is often also penetrated with veins of these substances, and often with corbonate of lime. It is found near the village of Goorat, on the path leading from Petoragur to Julaghat.

CHAPTER VIII.

FLOETZ ROCKS, FIRST FLOETZ LIMESTONE, MAGNESIAN FLOETZ LIMESTONE, VESICULAR LIMESTONE, SUPPLEMENTARY OBSERVATIONS ON ADDITIONAL FLOETZ ROCKS.

FIRST FLOETZ LIMESTONE DIVIDED INTO THREE BEDS, VIZ. COPPER-SLATE, ALPINE LIMESTONE, AND TABULAR LIMESTONE—THEIR GENERAL DESCRIPTION—MAGNESIAN FLOETZ LIMESTONE, SUBDIVIDED INTO CRYSTALLINE AND EARTHY—DESCRIPTION OF CRYSTALLINE VARIETY—DITTO OF EARTHY DITTO—VESICULAR LIMESTONE, ITS PROBABLE IDENTITY WITH THE RAUCH-WACKE OF THE GERMANS, AND THE NAGELFLUGH OF THE SWISS—SINGULAR PORPHYRETIC SEPTARIUM, ITS DOUBTFUL ORIGIN AND NATURE, ITS RESEMBLANCE TO THE IRONSTONE SEPTARIUM OF ABERLADY, DESCRIBED BY THE LATE DR. HUTTON—HORNSTONE—ARRAGONITE—SUPPLEMENTARY OBSERVATIONS—ROAD FROM BELKET TO BURMDEO PASS—BITUMINOUS MARLSLATE—CALCAREOUS GRITSTONE AND ARGILLACEOUS SANDSTONE—DESCENT TO BURMDEO—SLATE-CLAY ORGANISED FOSSILS—CONGLOMERATE—PHYSICAL REMARKS.

THE rocks usually described as belonging to the floetz class, do not here occur in that regular order of succession which has been observed by geologists in less alpine parts of the world; but the peculiar deposites, so generally observed in mountainous countries, and described under the head of first floetz, or alpine limestone, is well marked in Kemaon as the commencement of the series of floetz deposites.

If we admit distinctions founded on the peculiar nature of extraneous fossils in each bed, or on their absence, such principles will suggest the following division of this formation.

1st. Copper-slate, distinguished by the presence of copper ore, and by containing beds of graphite.

2nd. Alpine limestone, reposing on copper slate, and forming lofty, irregular, and often inaccessible heights, containing no extraneous fossils.

3rd. Beds of tabular strata, mantle-shaped, and often nearly horizontal, but differing in this respect according to the inclination of the surface on which they repose, and farther distinguished by the presence of distinct concretions resembling small fishes.

(A) COPPER-SLATE.

This rock composes a large proportion of the Shore district. It extends along the bases and acclivities of the primitive and transition mountains, forming in these situations, a succession of small subordinate basins, occasioned by the circuitous contortions described in the direction of the strata. The strata are usually made up of layers which are separated by rifts, and transversely broken, so as to give the whole a comminuted, thick slaty appearance.

Between the fractured parts in the lower strata, nests of bituminous fossils, talc, copper, and iron pyrites occur.

(B) ALPINE LIMESTONE.

Mountain, or alpine limestone, occurs in lofty irregular accumulations, which rise abruptly in the form of rugged, often isolated pyramidal mountains, whose acclivities are formed by the almost perpendicular rearing of tabular masses, while their declivities are composed of unconformable, brecciated, homogeneous mountain-masses, presenting few external traces of the tabular, or stratified structure, but merely cemented together, and perforated by caverns, fissures, and subterraneous waters. The bases of the mountains of alpine limestone, are overspread with masses precipitated from above by some natural convulsions, and again agglutinated by the same or succeeding catastrophies, and transformed into subordinate knolls, mechanically as well as chemically, grouped together in the most sublime and picturesque forms.

(C) TABULAR AND MANTLE-SHAPED VARIETY.

This rock occurs in patches, pretty extensively distributed on low shields and valleys, throughout the Shore district. The strata are subdivided by slaty rifts like the copper-slate, but unlike the latter, they are almost always flat, and seldom or never form basins, or contain bituminous talcose, or metallic fossils; but are distinguished by containing concretions resembling small fishes, one of which is represented in plate V. figs. 1, 2, 3.

These several varieties of limestone, are scarcely to be distinguished from each other, by their external or chemical characters; which may be set down as follows:

Colours bluish-grey and ash-grey. Externally tarnished with dirty greyish white. Sometimes the internal and external colours alternate on the surface, giving the rock a variegated flinty appearance.

External surface smooth, and without lustre. Lustre of the fracture dull. Fracture compact, large conchoidal, inclining to fine splintery. Fragments irregular, somewhat sharp-edged. It is feebly translucent on the edges. It affords a light-coloured streak, and is capable of being scratched by the knife, but not without difficulty. Specific gravity, 2·732.

Chemical characters. It dissolves completely, with brisk effervescence, in nitric acid, and burns to a fine white quicklime without falling to powder.

MAGNESIAN LIMESTONE (SLATY).

This rock is much more allied to the magnesian limestones of England, than any of the previous deposites of a magnesian nature that have been described, and from which it is perfectly distinct in all but its chemical characters.

It occurs as a partial deposite, along the course of the small river that drains the valley of Shore. The strata are nearly horizontal, or they seldom dip more than 15°, tending to the same general centre, so as to form an irregular shallow basin.

The course of the strata is singularly waved, forming a constant succession of undulations, which have often the regularity of artificial arches of masonry; an appearance which is well exposed by the section of the rocks formed by the bed of the river, and represented in plate V. fig. 4. This deposite rests occasionally on transition limestone, whose irregular surface appears to have given rise to the waved disposition of the superincumbent rock; and although I found it to contain no organic fossils, its geognostic position, and form of stratification, induced me to consider it to be cotemporaneous with those beds of tabular limestone described in the preceding article; which would bring it to something near the epoch of similar deposites in England. Like the English rock too, the lower beds are blue, while the upper ones are yellow and earthy; and although it will be shewn, that this difference is chiefly referrible to the chemical changes to which the rock is liable under certain circumstances of exposure, it will nevertheless be necessary to give a separate description of each variety.

(A) CRYSTALLINE, OR COMPACT VARIETY.

Colour, bluish-grey. External lustre dull. Lustre of the fracture very faintly glimmering.

Fracture, slaty foliated in the large, owing to very thin argillaceous layers, which give it often a thin lamellated structure, but compact in the small, and fine splintery, inclining to even.

Fragments, tabular in the large, but wedge-shaped and indeterminate in the small, with blunt edges. Distinct concretions, very fine granular. It is opaque. It affords a bluish-white streak. It is semi-hard, inclining to soft. It affords an earthy smell when breathed on. Specific gravity, 2·7, 2·71.

Chemical characters. It affords a feeble effervescence in nitric acid, and a very small quantity dissolves. Before the blow-pipe it loses its colour, and becomes somewhat friable; and with borax it melts, with some difficulty, into an opaque porcelaneous mass.

(B) EARTHY VARIETY.

This, although an apparently different substance, is derived from the elongation of the strata of the foregoing rock, and the transition between them is so abrupt as to be seen on a single hand specimen.

The slaty laminæ of the first variety, run alternately into the earthy structure of the other; while the same strata seams, the same fine layers of argillaceous substance, and large slaty rifts, are continuous between both, proving them to have been originally the same, and subsequently changed by an inherent tendency to decay; for it is difficult to conceive how these appearances could exist, if the strata seams were the result of crystallization, and the elementary constitution of the rocks themselves, originally different from each other.

To the chemical action of external agents, may therefore be ascribed, a portion, at least, of the changes to which this rock is subject; for those beds which are most changed from what we may suppose to have been their original nature, are also most superficial, and consequently, most exposed to the influence of those agents. Nay, even the elevated edge of a single stratum, presents the character of a fine earthy, yellow sandstone; while the lower portion, which dips under other strata, is a blue crystalline limestone. The characters of this variety are as follows:

Colour, ochre yellow. Lustre, none.

Fracture, earthy*. Fragments indeterminate and blunt-edged. Distinct concretions, very fine granular. It soils slightly. It is soft, and adheres to the tongue. It affords a ringing or creaking sound when tossed loosely in the hand. Specific gravity, 2·1. Increases after absorption.

Chemical characters. It does not effervesce or dissolve in acid. Without addition it undergoes no change before the blow-pipe; but with borax, it forms a white porcelaneous mass.

VESICULAR LIMESTONE.

This is a coarse breccia, composed of fragments of transition and floetz limestones, loosely aggregated and cemented with calctuff, containing round empty vesicles of various sizes, and presenting the general appearance of what an inex-

* Fine argillaceous streaks of a blue colour pass through the substance of the rock, parallel to the strata seams, causing rifts, which give the rock a thick slaty structure; but as these are natural separations, it would be incorrect to describe the fracture as "thick slaty."

perienced person might conceive to be, volcanic slag. Nor would the closest inspection remove the impression, without an examination of a newly fractured surface, when the fresh looking fragments of limestone, and the glistening specks of calcspar and tuff, present the ordinary characters of their respective natures; which could scarcely be the case, had they been exposed to the action of fire.

It occurs in overlying mountain masses, in the neighbourhood of transition and floetz limestones, generally resting on low ridges, but also on the verge, as well as at the base of precipices composed of these rocks. Also in valleys and ravines at the foot of limestone mountains; but in the latter situations, it degenerates into conglomerate*, still however bearing the character of a single formation. On higher altitudes, the fragments of which it is composed are small, seldom larger than

* The difference between a brecciated and a conglomerated rock is, that the first is composed of angular, and the latter of rounded, or more or less worn masses cemented together.

hand specimens, and they vary from that, to the size of very small distinct concretions. These fragmented parts are sharp-edged, and form about half the mass; the remainder being partly composed of calc-tuff, and partly of compact red marl, containing minute cavities, lined with calcspar; but the size of these cavities increase as you descend, and in proportion as the rock becomes coarser. On the higher altitudes, where the fragmented particles are small and even minute, the cavities disappear, and the rock assumes a compact porphyritic structure, becomes stratified, and somewhat conformable, as is the case on the summits of Durge mountains, which form the north-eastern boundary of Shore valley, at an elevation of seven thousand feet. From thence it may be traced along the mountain acclivities, and into the deep valleys that skirt the limestone of Takill, Oude-pore, and the surrounding country.

This rock is probably the rauch-wacke of the Germans, which was formerly supposed to be connected with the first floetz formation; it is also analogous to, if not identical with, the nagelflugh of Switzerland, which is nothing more than the various fragments of other rocks, agglutinated by calcareous cement.

PORPHYRITIC SEPTARIUM.

The rock to which this name is given occurs in overlying masses near the highest ridges and summits of Takill, at an elevation of upwards of eight thousand feet. It is composed of common felspar, as a matrix to fragments of transition limestone. The felspar is also found separate, in small detached masses, whose structure is angulo-cellular. The cells are large enough to contain middle-sized crystals, and the septæ between them vary in thickness from an eighth, to a twentieth part of an inch; but the larger cells are generally subdivided by still more delicate septæ, the whole presenting the character of magnified cancelli of the bones of animals.

Close to these cavernous fragments, we find columnar and cubical masses of the compact rock: these present rough, dull, surfaces; but on closer examination, we find the roughness in some places to depend on the remains of broken cells, and in others, to be caused by minute suppositious crystals of felspar, aggregated in manipular and rose-shaped groups, which are superimposed on the surface of the rock*.

On breaking a fragment from the sound rock, we find the fracture compact, and numerous white lines of felspar running in various directions, forming cells which are filled with fine granular limestone of a blue colour, corresponding in every respect with the characters of massive transition limestone.

Some of the more superficial cells were

* An interesting fact is, that the crystals are sometimes found superimposed in the cavities of the broken cells, as well as on other parts of the surface. Thus it is proved that the crystallization took place subsequent to the formation of the cellular structure; and as no crystals are found in those cells which contain limestone, this latter substance must have been deposited previous to the formation of the crystals.

filled with floetz limestone, and partly with red marl and calcspar.

As the cells of this septarium have no communication with each other, we must conclude that the limestone imbedded in them, must have had a prior existence. From whence then was the matrix derived, and to what cause are we to ascribe the singular structure of the whole? The structure, it will be observed, is similar to that of the ironstone septarium of Aberlady, on which Dr. Hutton of Edinburgh chiefly rested the demonstration of his celebrated theory of the igneous origin of the earth. The mountain on which it occurs is composed of primitive clay-slate, penetrating through the different formations of transition and floetz limestones, and forming conical peaks, the highest in the district; but they are composed of solid undisturbed strata. The above question therefore can hardly admit of any explanation founded on the volcanic nature of this mountain.

It might, notwithstanding, have been more consistent with the nature of this rock, to have inserted it under the head of volcanic or pseudo-volcanic minerals; but as I have met with no other instance of such substances, I considered it unnecessary to refer it to a distinct chapter, especially as there appears to be as much reason for assigning it to one class, as to another. I have found common felspar in one instance near Petorah, containing rhomboidal empty cavities; but both the nature of this specimen, and the locality in which it was found, is too nearly allied to the rock here described to allow it to be considered a distinct substance.

Among the remaining earthy minerals found to occur along with floetz rocks, I may mention a peculiar description of hornstone. Arragonite is also found in the form of a biniary compound with talc. The following are the further particulars of these substances.

HORNSTONE.

Colour, oil green, and greenish grey, faintly clouded with siskin green. It occurs massive. External surface, smooth, and tarnished reddish. Lustre of the fracture dull, inclined to resinous.

Fracture between compact and splintery. Fragments wedge-shaped. It is translucent on the edges, and affords a white streak. It yields easily to the knife, but not to the nail. Specific gravity, 2·655.

Chemical characters. It is infusible before the blow-pipe.

It is found in floetz limestone, along with talc, to which it appears to be allied.

ARRAGONITE.

This mineral is found near the village of Gooseragong, in Shore valley, along with masses of floetz conglomerate, at the base of lofty precipices of alpine limestone. It occurs in round masses, which are composed of minute rhombic and hexagonal prisms, imbedded in a talcose matrix. The crystals are very refractory on exposure to heat, and emit a slight odour of gun-powder.

SUPPLEMENTARY OBSERVATIONS ON ADDITIONAL FLOETZ ROCKS.

We have now enumerated the different mountain rocks, and earthy minerals which compose that part of the province, that extends from Belket to the valley of Barabice—a distance of six marches in a northerly direction; and the only rocks which remain to be described, are those composing a massive group of mountains that run between the principal mountain chain, and the plains, and which, there is reason to believe, must be referred to the class of floetz rocks. This mountain group is the first that is crossed on entering Kemaon by Burmdeo pass, and has been alluded to in the beginning of the second chapter.

My knowledge of the rocks that compose this group is but limited, from not having had the opportunity of tracing their history: I have, however, endeavoured to avail myself of one or two opportunities, in which I crossed this way in the performance of my professional duty, and have thus been enabled to extend the map to the foot of the mountains, as well as to acquire a tolerable idea of the physical constitution of this group; but as it forms the link of connexion between the plains of India, and the Himalaya mountains, the absence of a definite geological history of it is much to be regretted.

Belket, as has been stated in a former chapter, is situated in the valley of the river Ludhoo, and lies about six maritime miles from Burmdeo; but from the circuitous windings of the mountain path, it is probably fifteen miles to travellers.

From Belket to Burmdeo pass, the path at first lies for some distance along the bed of the Ludhoo; and wherever the substratum makes its appearance amidst the huge rolled masses of quartz, dolomite, and trap, it is found to be the coarse porphyritic greenstone, which has been described in the third chapter.

1. Bituminous marl slate. Next to the greenstone just mentioned, we find a blue coloured fine earthy limestone, corresponding with the characters of bitumin-

ous marl slate. It is opaque, and has a coarse splintery fracture, approaching to earthy, with a slight glimmering lustre, and it effervesces briskly in acids. The strata are conformable, and dip to the north-east. One of the specimens examined was found to contain either copper or iron pyrites, probably the former.

2. Calcareous grit-stone. This rock is met with on ascending the mountain, and it appears to be derived from the bituminous marl slate. It composes almost the whole upper surface of the mountain, from the elevation of a thousand, to that of four thousand feet, and seems to be composed of fine sandy particles, imbedded in a calcareous basis. Its colour is greenish-grey: the green hue depending on the presence of chlorite, the peculiar colouring detritus of the primitive mountains to which this group is subordinate. It also contains particles of hornblende and mica, derived no doubt from the same source. It has an earthy lustre, is rather soft, and effervesces briskly in acids, and about a third part of

the mass is dissolved. Its specific gravity is 2·6.

It contains detached nodules of compact splintery hornstone, clay iron stone, and some other rocks.

3. Argillaceous sandstone. Leaving the path, and ascending one of the highest peaks of the group, the calcareous gritstone is found to disappear, and to perform a transition into a substance having somewhat similar external characters; but containing no calcareous matter, the arenaceous grains being imbedded in an argillaceous basis. This rock is detached into conical caps, in distinct patches. Sometimes it is found extending along the highest ridges, in small-sized masses, broken and strewed thinly over the surface, or collected into irregular heaps. It presents a large slaty fracture; but a compact and earthy one in the small, with fine granular distinct concretions, closely impacted. Lustre, earthy, except on the surface of the large slaty fracture, which glimmers with mica. I have not observed it to contain any fossil remains.

On descending from this ridge, the path to Burmdeo pass lay for the most part in deep ravines: these were composed of calcareous grit-stone, in conformable strata, presenting a dip of 30° to the north-east. Numerous brooks descend through these ravines, depositing calcareous incrusta-tions on the rocks over which they pass, and thus indicating the calcareous nature of the upper structure of the mountains from which they issue—a testimony which is partly confirmed, by the mighty pre-cipices and rugged outlines, which these mountains present to the plains. As we descend, the grit-stone still continues, and the extraneous substances which it contains increase in quantity as we ap-proach the base of the mountain. Along the base of this group, rounded hills occur from 50 to 300 feet high, composed of water-worn masses of every variety of size, imbedded in slate-clay. These hills ascend abruptly, leaving water-courses and ravines between them and the moun-tains, while the opposite declivity slopes gently down to the plains. The slate-clay is composed of fine sandy and dusty particles, mixed mechanically with mica, and abounding with impressions of reeds and stems, and leaves of aquatic plants, and doubtless many other organic remains, which are yet to be explored, and to which no nation but our own, would have been so long indifferent. But there are difficulties in the way of such researches, in this particular locality, which neither national zeal, nor individual enterprise could fully overcome. Nature, as if to suit the structure and disposition of particular creatures to the tract they are destined to inhabit, has bestowed on the gigantic elephant and savage tiger, the perpetual inheritance of this most awful landscape; and in order to render more secure from the tyranny of man, at least one spot on the surface of the earth, she has bestowed on this part of the Tarai —a climate which the human constitution could not endure, even for a day at certain seasons. Yet how adapted to our sympathies is this appropriation of a locality that marks such contrasts in its physical structure! On the one hand, we have plains extending almost to the African continent, and to the Indian ocean, with hardly an undulation to relieve the monotony of space. On the other, an almost interminable succession of mountains, ascend one above another, until they penetrate beyond the regions of animal existence, and conceal themselves in clouds. Nor is there here, as in most other countries, any softening of parts—any blending of extremes—a foot of earth—a single line, marks the awful contrast.

CHAPTER IX.

ALLUVIAL ROCKS.

MOUNTAINS ARE THE SOURCE OF ALLUVIAL DEPOSITES —THE NATURE OF THESE DEPOSITES—HOW PRODUCED—SILICEOUS ALLUVIAL DEPOSITES—ALUMINOUS CLAY—NAGELFLUGH—CALCTUFF—CALC SINTER —VOLCANIC ROCKS.

In Kemaon, as in all other mountainous countries, we can have no such uniformity in alluvial deposites as in low countries; but the phenomena connected with their production can be here studied with more advantage, as mountains are the great natural laboratories in which alluvial rocks are prepared, and from which they are transmitted to fertilize the earth.

Alluvial deposites are derived from the disintegration of the older rocks, by the destroying agencies of heat, light, moisture, and we may perhaps be allowed to add, of earthquakes, and the attrition of winds. It may indeed be improper to designate as *destroying* those effects that keep up the never-ceasing supply of alluvial soil, so essential to the existence of the inhabitants of this globe, vegetable as well as animal. In Kemaon, the varieties of these deposites are few, and differ from each other according to the source from which they were derived. In arranging them, we cannot follow any rule founded on priority of formation, the changes that produce the different varieties being simultaneous.

Some of the older rocks are disintegrated more slowly than others; accordingly we find in alluvial deposites, a preponderance of rocks that are in the large scale easily frangible and hard; so that when once detached from the original masses to which they belonged, they are incapable of further reduction of size, except by their own friction: these are all of a siliceous nature, and our sands and gravel are familiar instances of them.

Next in proportion to these we have the finer earthy particles, which formerly existed in a state of mechanical combination in the older strata, and which became detached from their original repository, either by the decomposition of some of the matters that held them together in their former state, or by the absorption of moisture, their particles lose their affinity for each other; the mass softens, separates, and is removed by the waters, in order to fill up and level the original irregularities of the surface of the solid rocks, and render them fit habitations for the various tribes of terrestial beings, by which the earth is peopled.

This order of alluvial deposites, comprises the various aluminous clays, which derive distinctive characters from the proportion in which they are mixed with silex, lime, magnesia, and iron.

1. Siliceous alluvial deposites. The original source of these rocks are the oldest primitive formations. They are derived from the most elevated ridges of granite

and gneiss. The quartz contained in those rocks is pure siliceous earth, and the same substance is contained in the felspar and mica, with which the quartz is here associated. The felspar is decomposed by the causes already adverted to, and the siliceous earth is carried down from its original repository by the torrents, and is deposited on the level table lands, or in lower valleys. In the former situation, it is seldom mixed sufficiently with other ingredients to form a productive soil: its great defect is the want of absorbent properties, and it is therefore a dry barren earth; but in these elevated places, it seldom remains long, but is carried into deeper valleys, and finally to the plains, where it enters in due proportion into the constitution of arable lands; while its excess either changes the direction and the course of the rivers, or is carried by their waters to the sea, causing, as some philosophers have detected, a slow but gradual recession even of the waters of the ocean itself. So that every stratum of gneiss, that moulders into decay in the mountains of Kemaon, contributes its share with the rest of the Himalaya, to the formation of new provinces at the mouths of the Ganges, an effect to the completion of which, those moveable wastes of sand that slowly accompany the current of the river, are silently, but progressively advancing.

2. Aluminous clay. This substance, which presents so many varieties, according to the ingredient that preponderates in its constitution, is derived in Kemaon from the disintegration of clay-slate. Its repositories are consequently lower than those of siliceous earth. The whole of the exposed surfaces of the strata of clay-slate yield it. The iron pyrites, to which in a great degree most of the clay-slates owe their strength and hardness, is converted into an oxide, by the action of the atmosphere. The rock now becomes soft and friable, and assumes a reddish brown colour. In this state, it either crumbles to powder, and is carried away as soon as it is formed; or it remains for a time in situ, ready to be washed down

into the ravines, and from thence into the valleys, where it is mixed with siliceous and calcareous earths, and is thus converted into one of the most fruitful soils. But we find, that these alluvial accumulations are not destined to fertilize the mountain valleys alone; for as these are little more than water courses, subject to violent periodical inundations, which carry all accumulations before them to the plains where the beds of the rivers are low, and too contracted for the floods, the waters loaded with mud spread over the low countries, depositing the matters they carried with them from the mountains.

The foregoing alluvial rocks never occur separately, but are always more or less mechanically mixed together; and it is partly for this reason, that they are classed under the head of mechanical alluvial deposites. In Switzerland, and some other countries, there is a third deposite of the nature here mentioned, called Nagelflugh, by the Swiss. It occurs also in Kemaon, but not to such extent as to entitle it to be ranked with either of the preceding mechanical alluvial rocks. It contains fragments of limestone, and other rocks, imbedded in a basis of calctuff. The vesicular limestone, described in the last chapter, is probably only the oldest variety of what we here allude to.

The difference between them is, that the vesicular limestone is more extensively distributed, and that it is found on lofty, isolated places, where it is difficult to conceive that it could have been formed, except by some general cause not now in operation; while the conglomerate we here allude to, is on the contrary, only found in low places, and still continues to be formed by such local as well as general causes, as occasion the falling of fragments from the upper structure of mountains, and the re-union of these by calctuff: so that the one appears to be a diluvial, and the other an alluvial, deposite. The subject is further elucidated in the Essay on Goitre—section v.

CHEMICAL ALLUVIAL DEPOSITES.

1. Calctuff. In districts where limestone prevails, as in the neighbourhood of Shore valley, numerous detached beds of this deposite are found. One bed of this substance, I found to consist of a succession of layers, formed by the successive changes to which the extinct brook from which it was formed, must have been subject at different periods.

The lowest layers contain numerous univalve shells belonging to the genus helix; along with the shells, fragments of rocks sometimes occur, and the leaf of an unknown plant is also found in them; unfortunately the layers, in which these last were contained, were too friable to allow of the preservation of a perfect specimen. Along with the impressions extensive accumulations of the figures called osteocolla, from their resemblance to the bones of animals, were found.

The uppermost layers contained none of the appearances above-mentioned, but abounded with the leaves of those species of plants that now grow on the spot.

Plates VI. VII. and VIII. represent a few of these impressions of leaves.

2. Calcsinter. This substance occurs lining the inner surface of caverns in limestone: it also lines the surface of fissures of this as well as other rocks which are situated beneath precipices of limestone, and in all these situations it assumes the various external shapes that have been observed to belong to it in other parts of the world.

VOLCANIC ROCKS.

Of the class of rocks, which are referred by geologists to an igneous origin, I have not had an opportunity of seeing any in Kemaon, except the septarium described in a former chapter be considered to belong to this class.

CHAPTER X.

MINES OF THE NORTH-EASTERN FRONTIER OF KEMAON.

MINING, HOW IT OUGHT TO BE CONSIDERED—THE NECESSITY OF MINES BEING MORE ATTENDED TO IN INDIA—CONDITION OF THE MINES IN KEMAON—CONDITION OF THE PERSONS EMPLOYED IN THEM—THE DEFORMITIES OF THESE PERSONS—HOW THE MINES MIGHT BE IMPROVED—COPPER GLANCE—REMARKS UPON THE SAME—COPPER PYRITES—DESCRIPTION OF A MINE OF THIS ORE—DESCRIPTION OF THE ORE—NATIVE MODE OF REDUCING THESE ORES—YELLOW SULPHURET OF COPPER—ORES OF IRON—MICACEOUS IRON GLANCE—COMMON IRON GLANCE—CONCLUDING OBSERVATIONS.

"Would it not be an obligation, a duty, for us to collect and leave to future generations as much instruction and knowledge as possible, on the labours carried on in our mines, whether it be in those that are still worked, or in those that have been given up?"—WERNER.

THE subject of mining is commonly considered under two distinct heads; the first, as an important department of the political economy of almost every nation;

and the second, as a branch of natural history. With respect to this division of the subject, it is scarcely necessary to observe, that any inquiry into the mineral value of a newly acquired district should be preceded, by a comprehensive investigation of the character and relations of the rocks of which it is composed; and that inattention to this important precaution, must render all attempts to ascertain the value of territory empirical and uncertain; and on the manner in which this task is executed must depend, the waste of capital on the one hand, and the neglect of valuable resources on the other.

My researches having been confined to a comparatively small portion of Kemaon, I cannot from such limited experience pretend to give an opinion, as to whether or not the mines of that province are ever likely to become, under the most skilful management, of any great national importance.

The district I examined, contains two mines of copper, and one of iron. The former have been the scene of barbarous efforts to extract ore for many centuries. Besides these mines, I have found the remains of others, in the neighbourhood of Shore valley, which have been long since abandoned.

One encouragement we have in conducting scientific researches into the value of our mines is, if they disappoint us in the prospect of riches, they reward us with a greater variety of new and important information, commercial, scientific, and political, than we could expect to derive from any other pursuit.

The indifference that prevails in India, with regard to this interesting and highly important subject, is only to be accounted for by some peculiar trait in our national character. The same apathy existed in England in regard to the importance of working our mines at home, on scientific principles, until roused from her lethargy, by the example of continental nations: Geological and Wernerian Societies sprung up, and the natural history of our mines, as well as the economy of working them, began of late to receive that attention to which such subjects are entitled. If an improved system in the conduct of these important operations were at any time required in England, how much more so is it called for in India, where the arts are so utterly unknown.

The moral improvement of the people of India, is already receiving the earnest attention of the highest authorities in the state. In the plans that have been devised, it cannot have been overlooked, that to effect this noble regeneration, the *vis inertia*, so characteristic of the inhabitants of eastern nations, is first to be overcome.

This we might try to remove, by instructing them in the use of the mechanical arts; in their use in increasing the supply of the necessaries of life; in preparing raw materials for their social wants; and in rescuing increased resources from the bowels of the earth, at a diminished price of human labour.

These would, at least, be auxiliary means of effecting a reform in the native character, no less worthy of the age, than of a British Government; and with such practical illustrations of the benefit of science before their eyes, the natives of India, naturally a shrewd mercantile race, would not be backward in taking advantage of the lesson.

These reflections have been suggested by a visit to the copper mines at Gungowly, and Barabice, which from want of the attention usually paid to such works in Europe, appear to be only a source of misery to those who are engaged in working them; while the revenue they afford to the state is merely nominal.

These mines are farmed, or let at a trifling rent, to mercenary contractors or Teekedars, whose only object is to procure the greatest quantity of metal, at the smallest possible expence. These Teekedars again contract (as well as I could understand) with the owners of slaves, for the labour of extracting and smelting the ores; and between both parties the unfortunate workmen are ground down to such a degree, that if their squalid looks did not bear testimony to the truth of their complaints, I could not have believed them.

The origin of these mines must be referred to a very early period, yet no improvement in the mode of operations adopted, appears to have marked their progress; so that it is probable, the art of mining was as perfect in Kemaon a thousand years ago, as it is at the present day; a fact which illustrates the baneful influence of tyranny and oppression, rather than a condition of the human mind that is incapable of profiting by experience.

The drifts or passages of the copper mines are so contracted, as only to allow children to creep into them with any degree of facility; and it is this imperfection that occasions much of the cruelty already adverted to. About a hundred persons are employed at the mines of Gungowly, and Barabice. They are nearly all frightfully deformed; and although this has been in another part of my researches, referred to cretinism, yet it is by no means incompatible with what is there stated, to suppose that their evils are caused in some measure, or at least aggravated, by the practice of sending them into the earth, while they are mere children, for the purpose of dragging out the ores; a labour which they are forced to commence at the age of nine or ten years, and to continue during the remainder of their lives. For this, their only reward is a small quantity of earth, and stones containing particles of copper ore; from which, with much additional labour, they extract about eight annas worth of copper a month. At these two mines there are from thirty to fifty children, under the age of twelve, thus employed, without the hope of release during the period of their natural lives; and if disqualified by age or infirmities for this duty, they are then employed, as long as they are fit for labour, either in the workings of the mines, or in the smelting houses; but if quite incapable of farther employment, they are left perfectly destitute, or at best only dependant on their miserable offspring, who are brought up to the same bondage*.

On mentioning the cruelty of the practice to the Teekedar, he informed me that it has existed since the earliest times, and that it prevails generally in all copper mines throughout every part of the neighbouring provinces.

In the Company's territories, however, I am sure the evil of employing children

* Since these remarks were written, I find on reference to the Asiatic Researches for 1829, that the late Captain Herbert, (whose excellent talents were employed by the Government, to investigate the value of the mines in our mountain provinces,) has favoured the world with some valuable observations on the mines of Kemaon.

The greatest portion of the labours of this talented and much esteemed author, relative to Kemaon, remain unpublished; and in the paper here adverted to, he recommends various methods of improving the mines, without making any remark upon the condition of the persons employed in them. This is only to be accounted for, by the fact of our being so much accustomed to witness the oppression of the natives of India towards each other, that we are almost in daily habit of passing, unobserved, very culpable cruelties, so long as they are merely confined to native society.

in the mines, only requires to be pointed out in order to be soon suppressed, when it is to be hoped that Nepal and other mountain states will follow the example.

The next step towards the improvement of our mines, would be the introduction of machinery, which might be easily furnished from the great military arsenals; and a few European mechanics, and practical miners, might be placed over the natives, with a view to instruct them in the European principles of working mines. A new establishment of this kind, would at first be attended with some little expense; but if conducted with the requisite skill, it would ultimately prove no less important to the commerce and welfare of the nation, than to the advancement of the native character.

Under the present policy, the province of Kemaon, though abounding in ores of copper and iron, with inexhaustible forests for the supply of fuel, barely affords sufficient revenue to support its own establishments.

The repositories of metallic minerals

which have occurred to my observation, are only of two kinds, and they belong to that class which is of cotemporaneous origin with the rocks in which they exist.

The first is where the ores are disseminated in the strata seams, and in the substance of rocks in nests and kidneys; and the second, is where they occur in lying masses. Examples of the first are presented by the repositories of copper, and of the second by those of iron.

The copper is found only in the slate of yellow sulphuret; but of this there are three varieties, which differ much in value from the quantity of metal they afford, as well as from the labour required to reduce them: the following is a description of each.

1.—COPPER GLANCE.

Colour, passing from sulphur yellow to siskin green, sometimes spotted and clouded on the surface, with the pavonine tarnish.

It occurs massive coarsely disseminated. Fracture compact, large conchoidal. Lustre, shining and metallic. Fragments blunt-edged. Distinct concretions, thin lamellar. It is soft in the greener, but inclining to semi-hard in the yellower varieties. It is not very difficultly frangible. Specific gravity from 4·06 to 4·093, but the specimens tried were not quite free from stony matter, otherwise it would be somewhat heavier, probably 4·2.

Chemical characters. Before the blowpipe it melts readily into a greyish black globule, which when broken, displays the cupreous lustre. During torrifaction, a sulphureous odour is excited, and about 15 per cent. of the weight is lost. It does not effervesce in nitric acid.

Notwithstanding the yellow colour of this ore, it is probable from its chemical characters, that it is the copper glance of Professor Jameson, the vitreous copper ore of Kirwan, and the grey sulphuret of copper of Dr. Kidd. It contains a large proportion of copper, and very little iron, and is found in repositories along with copper pyrites, semi-indurated talc, and rhomb spar. These repositories are formed by transition limestone, and granatine: mines of this ore have been wrought in the neighbourhood of Gungowly for many hundred years. The ore is also found in Shore valley in the vicinity of Goseragong, in similar repositories*.

2. Copper Pyrites. This ore is found in the valley of Barabice, where a small mine of it is worked. The ore is here accompanied by nearly the same rocks as at Gungowly, and Shore valley; but

* From occasional nodules of slag, and glassy scoriæ, found on the low ridge that divides the valleys of Shore and Goron from each other, as well as from the mineral constitution of this ridge, I suspected that metallic minerals must have been found here, which on inquiry proved to be the case. The only ore I could find was copper pyrites; although the natives of the place say silver and lead have been also extracted somewhere in this locality. They pointed out to me an old mine from which these metals were said to have been afforded, but I could find no trace of any but copper. The mine was given up about a hundred years ago, it is said, in consequence of part of the roof falling in, by which several lives were lost.

besides talc, graphite also forms the matrix in which the ore is disseminated.

From the imperfect state of mining, as of all other arts among these people, it is probable that the workmen are contented with pursuing the softer rocks in the workings of the mine, whether these contain the greatest quantity of ore or not.

I endeavoured to ascertain this point, as well as their general mode of working, and for this purpose entered the mine.

It is a horizontal excavation, which varies in height from two, to four feet, and in width from eighteen inches, to about three feet, so that the whole is what English miners would call a *creep*. About twenty-five yards from the entrance there are two counter openings, which descend obliquely from above into the mine; through one of these a stream of water enters, and the other serves as a ventilator: but as the passage to the workings penetrates twenty or thirty yards beyond these openings, the principal portion of the mine derives no benefit from them.

Having penetrated about forty yards, I was reluctantly compelled to return, in consequence of the very contracted nature of the remainder of the passage.

This mine is excavated at right angles to the direction of the strata; and as the dip of the latter is at an angle of 45, the drift is consequently penetrated through successive layers of rock. This is compact slaty limestone, of bluish grey colour, alternating with lying masses of talc. Comparing the external, with the internal appearances, it would seem, that the repositories of the ore which the miners are at present extracting, must be situated between the limestone and clay-slate, which latter composes the substratum upon which the limestone reposes. Beds of graphite however, intervene between the two rocks, and it would appear to be in these beds that the present workings of the mine are situated; but it is not to be supposed, that the original miners penetrated so far through solid rocks, without meeting with a sufficient quantity of ore during their progress, to reward them for their labour; and it is therefore probable that new workings might be advantageously formed, at a more convenient distance from the entrance of the mine. The native miners appear to be quite unacquainted with the use of gun-powder, as a means of facilitating their operations; their only implements being hammers and large iron chisels. As the fragments of ore and stones containing it are detached from the rock, they are placed in small leathern bags, to each of which a strap is attached, which is passed over the shoulder of a boy, who with a lighted torch in the one hand, supporting his body on the other, assisted with the knees, he drags his unweildy burden along the floor of the drift—a task which is rendered the more practicable, by the load being half suspended in a greasy mud, which is formed by talcose earth and water. About twenty young lads (who, from their deformities, as well as from the peculiar nature of their employment, look more like young alligators than human beings), perform this part of the duty; while about six or seven men are employed in the workings.

The ore is of a bright orange, or golden yellow colour. It seldom occurs massive; generally coarsely and finely disseminated. Fracture, compact, and fine grained. It is semi-hard, inclining to soft. It is rather difficultly frangible.

I could not procure a mass free from stones, and large enough to enable me to take its specific gravity.

Chemical characters. When heated to redness, it gives out an hepatic odour, and is reduced to a black globule with some difficulty. It does not effervesce with nitric acid.

The process of reducing copper pyrites, as practised by the natives of Kemaon, is worthy of description, although it does not differ much from the method that prevails in the mining districts of Southern India*. The ore being disseminated in solid stony matter, the whole is pounded and washed. The lighter parts being thus carried off, the metallic particles and

* As recorded by Buchanan and by Dr. Heyne.

adherent sand is placed, when dried, in a blast furnace, which resembles the hearth of a blacksmith's forge. The furnace is previously prepared with a coating of pounded and moistened charcoal. Charcoal is also placed over the ore, and heat is applied, and kept up for an hour, when the whole appears in the state of black slag. This is again reduced to powder, and mixed with cow-dung, and then rolled out to a broad flat layer, about two lines in thickness, and placed on a pile of wood so constructed as to burn for several hours with an uniform intensity of heat.

The art of constructing the pile is in selecting the wood of equal size and density, and in igniting the whole pile, so that it may burn simultaneously. After this process, the regulum is found in a loose, friable mass, of a reddish and blackish brown colour. It is again powdered, and placed a second time into the blast furnace: on this occasion, a few small fragments of quartz are added as a flux*;

* I am here only speaking of the method adopted at the Ager copper mine, where I witnessed the whole

and when the compound is reduced to the fluid state, the blast is stopped, and the coals removed from the surface of the melted mass ; the iron and lighter impurities float on the surface in contact with the air, and become oxidised. The oxide of iron thus formed, and all adhering impurities are now removed from the surface, in a succession of layers of dross, and the pure copper remains in the bottom of the furnace.

In the first fusion, the ore is freed from most of the earthy substances with which it was mechanically combined, and also from a portion of the sulphur. To get rid of the remainder of the latter substance, the roasting on the pile is an effectual and economical mode, especially where fuel is expensive or scarce. This

process. Captain Herbert, in his interesting observations on this subject, says, that no flux is used, from which it would seem that the practice of reducing the ores at different mines varies a little. This is so far right, for the nature and utility of fluxes should depend on the nature of the ores.

ore yields from 25 to 30 per cent. of copper.

3. Yellow Sulphuret of Copper. Colour, pale straw yellow. It occurs massive, tuberose, and coarsely disseminated. External lustre glimmering. Lustre of the fracture, splendent. Fracture coarse grained, uneven.

Distinct concretions, fine angulo-granular. Lustre of the distinct concretions, specular splendent. It is semi-hard. It is brittle. It is very easily frangible. Specific gravity of specimens not quite freed from stones, 4·280. If freed from extraneous matter, it would probably be 4·4.

Chemical characters. Before the blowpipe it gives out sulphurous fumes, which burn with a pale blue flame. It loses about 20 per cent. of its weight, and is reduced to a black slag, which is attracted slightly by the magnet. By continuing the flame, patches of copper are at length reduced, and found to constitute about a sixth part of the mass.

From the phenomena it presents before

the blow-pipe, it is probable that this ore is composed of about 40 per cent. of iron, and the remainder of copper and sulphur. It is extracted from the Rye mine, near Gungowly, along with copper glance; but from the small quantity of copper it contains, and the difficulty of reducing it, it is rejected by the miners.

Under an improved system of management, it might be advantageous to inquire, if the large proportion of sulphur contained in this ore, would not render it deserving of attention*.

ORES OF IRON.

1. Micaceous Iron Glance. This ore occurs in hornblende slate, in lying masses. Mines of it are worked in the Ponar

* Dr. Thomson describes a very simple method employed by Assessor Gahn at Fahlun, for distilling sulphur from pyrites. It consists merely of a long wooden box, which is made to serve as a flue to a furnace in which the pyrites is roasted. The sulphur is deposited in the wooden box, and may be swept out at pleasure. It is then melted and cast into rolls. See Travels in Sweden, p. 219.

valley, at an elevation of about four thousand feet above the level of the sea. It is extracted with little labour ; and the repositories are sufficiently extensive to afford a perpetual supply of iron to the whole of the upper provinces of India.

Its colours are iron and greyish black. It occurs massive. Internal lustre, splendent. Fracture perfect, undulating curved foliated, with a single cleavage. Distinct concretions, curved lamellar. It is perfectly opaque. It affords a blackish brown streak. It is easily frangible. Specific gravity, 5·1375. It is scarcely attracted by the magnet.

Chemical characters. I found it infusible before the blow-pipe, with or without addition; but it gave to the glass of borax, a tinge of yellow.

2. Common Iron Glance. Colours, steel grey, greyish black, and blackish brown. It occurs massive. Fracture in the large, passing from perfect to imperfect foliated, with a single cleavage: but in the small, it is compact and fine grained. Lustre of the fracture, passing from shining to

glistening. It is hard. Specific gravity, 4·64.

It has more magnetic energy than the foregoing species, but it does not attract iron filings.

Chemical characters. The yellow tinge caused to the glass of borax is more obscure in this, than in the last species.

Both of these ores are found in the same repository, and in the same mine; but the common iron glance is also found in various other parts of the province, in repositories in clay-slate.

The second species differs from the first, in containing a more considerable quantity of earthy matter, which may account for its lighter specific gravity, and greater hardness. Probably too, it contains less oxygen; a circumstance that will explain its more active magnetic properties, and which is indicated according to Kirwan, by its slight effect in discolouring the glass of borax*.

The fine granular variety contains a small quantity of calcareous earth, and it

* 2 Kirw. 134.

is to this important accident, that the success of the natives in smelting these ores must be referred. The ores are broken into small fragments and mixed carefully together, previous to placing them in the blast furnace, in which they require to remain for two hours before they acquire the state of imperfect scoriæ, and become magnetic. I suspect, however, that the same effect would be produced in a shorter time, and with a great saving of fuel, were the proper proportion of calcareous matter added, in order to develope the most fusible condition of the other extraneous ingredients.

CONCLUDING OBSERVATIONS.

It is not to be understood that the foregoing notice of mines embraces all the varieties of metallic minerals which are contained in Kemaon. On the contrary, these remarks have been confined to the productions of a comparatively limited space, which is considered to contain nothing like the valuable mines that are found in various other parts of the province.

As a guide to others who may engage in the prosecution of these inquiries, (which so far from being exhausted, are yet only in their infancy), it may be useful to remark generally, that the ores of copper appear to follow the course of the transition and floetz limestones, beginning in our territories, at the valley of the Mahi Kali river, about the situation of Julaghat, and extending through the valleys of Shore, Goron, Barabice, Gungowly, and extending in the same tract in a northwesterly direction. The repositories are all composed, as far as I have seen, of the same rocks, and are all *disseminated;* nor have I in Kemaon seen an instance of a metallic vein*.

* Captain Herbert, in the paper already adverted to, makes frequent mention of the term *vein*, when describing the repositories of copper ore. Probably he did not intend to imply the technical meaning of the word. Nothing can be of more consequence in an economical, as well as geological point of view, than to distinguish the true nature of mineral repositories.

Iron ores are peculiar to primitive rocks, and pursue the course of their strata.

In Girwal, which is now considered as a great section of Kemaon, various mines of copper and lead are said to occur. Some of these have been mentioned by Lieut. Webb, (xi. Asiat. Res. 1808,) whose visit to them took place at a time when the whole was in the possession of the Nepalese; and he expressed his surprise that such mines should be neglected. Twenty years have now elapsed since these provinces fell into our own hands, without any improvement having been attempted in the mode of operations carried on in the mines. It has been shewn by the lamented Captain Herbert, that improvement to a certain extent might be made with safety, and advantage to our resources; but I would urge, with the same views, a reason that is likely to have much more weight with the Government of India—namely, the melioration of the condition of the operative miners.

CHAPTER XI.

CLIMATOLOGY AND EARTHQUAKES.

EFFECTS OF CHANGES IN THE CONDITION OF THE ATMOSPHERE ON OUR SENSATIONS ILLUSTRATED—RADIATION OF HEAT AT THE AZORES, AND CANARY ISLANDS, WHERE OCEAN IS THE RADIATING SURFACE—DITTO FROM THE LAND IN EUROPE AND AMERICA, COMPARED WITH THE SAME FROM HINDUSTAN—PECULIAR ATMOSPHERIC PHENOMENA—MEAN DIURNAL VARIATIONS OF HEAT AT LOHOOGHAT—DIFFICULTY OF PROCURING PHILOSOPHICAL INSTRUMENTS IN THE INTERIOR OF INDIA—EXTRAORDINARY FALL OF RAIN—EARTHQUAKES IN KEMAON—CONNEXION BETWEEN THEM AND THE ERUPTION OF VOLCANOES—PHYSIOGNOMY OF THE HIGH PEAKS OF THE HIMALAYA.

THERE is no branch of science that affords a more interesting or extensive field for inquiry than Climatology: every change of place impresses us with new sensations, which are commonly, but erroneously, imputed to the mere change of scene, without reference to the influence of the different density, temperature, and moisture of the atmosphere, from that to which we have been accustomed.

This is illustrated by the effect produced on our sensations when ascending the acclivity of a lofty mountain—all our feelings then undergo changes not to be accounted for by the proportional development of new scenery, or of that to which we have been familiar under a new point of sight; for the effects are the same in the ascent of mountains to which we are accustomed, and which disclose no new or even generally interesting scenery.

The importance of the subject, and the difficulty of procuring instruments in India, for making accurate observations, are reasons which have deterred me from attempting more than a few common remarks on the climate of Kemaon.

Taking the mean annual temperature at the equator to be 84°, then deducting one degree of heat for every degree of latitude as we approach the pole, the mean temperature in the 30° Lat. would be 54°; but at Grand Cairo, which is in the 30° Lat., the mean annual temperature is 73°.

Kirwan, who took into consideration all the causes (known in his day), that contribute to modify the distribution of heat on the surface of the earth, computed the mean annual heat of the 30° Lat. to be 70·7.

Dr. Heberden, from observations made at the Azores, and on the Peak of Teneriffe, found, that at the former, the diminution of temperature is 1° for every 145 feet, and at the latter, 1° for every 190 feet of ascent. General Roy found that 1° of diminution of heat is equal to 280 feet. Saussure found from experiments on the Alps, that a degree of heat is equal to 287 feet; and these last observations agree nearly with those of M. Bouguer and the French Academicians on the Andes, who, at an elevation of 15,560 feet above the sea, found the thermometer stand at 30°: while another at the base of the mountains stood at 84. If we adopt either of these last estimates (as most favourable to any application of the principle in the present case), and deduct the diminution of heat from 70·7, then the mean annual temperature at Lohooghat would be 50°, nearly 10 degrees below what it really is according to the annexed table :

Altitude of the place, 5,562 feet above the Sea—Lat. 29° 22′ N. Long. 85 East.*

	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Mean Annual Temp.
1830-31†	59.32	66.59	68.41	69.30	69.10	67.32	63.17	52.35	47.29	45.17	43.57	52.34	58.65
1834-35,	62.57	65.49	73.68	73.	72.3	70.2	62.94	51.63	45.55	43.9	48.	52.34	60.88
Mean, . .	60.94	65.99	71.44	71.34	70.56	68.76	63.5	51.92	49.42	44.53	45.78	52.34	59,76

How are we to account for this remarkable excess beyond the temperature that the physical position of the province, in regard to elevation and latitude, would seem, from general principles, to entitle it?

Were we now to assume the mean annual temperature of the same latitude in the

* Trans. Roy. Geograph. Soc. Vol. iv. P. 410.

† I have here availed myself of Dr. A. K. Lindesay's Meteorological Register for the year 1830-31, Cal. Med. Phys. Transac. 1831.

plains at Seharungpore for instance*, to be according to the tables of Kirwan, 70·7, or the mean of Mr. Royle's maximum and minimum, which would be 71°. One degree of temperature, which we would lose in ascending the mountains of Kemaon, would be equal to 415 feet of altitude: thus proving the powerful radiation of heat from the plains of India, to be quite beyond any conception that could be derived from isothermal tables, and will account for the mild and temperate climate of Kemaon, even at elevations that ought to be little below the verge of perpetual congelation†.

* We have no register of the temperature of Seharungpore, but Mr. Royle states in his "Illustrations, &c." page 7, that the maximum and minimum is 105° and 37°, and that the station is elevated 1,000 feet above the sea.

† It is difficult to reconcile the following extract, founded on the observations of Captain Webb, with the powerful radiation of heat from the plains of Hindustan above pointed out.

"On the southern side of this immense chain towards Hindustan, under the latitude of 30° or 31°, the snow line is at an elevation of 12,400 feet; but on the side towards Thibet, snow disappears in summer, even at

From the period of the cessation of the rains in October, to the beginning of February, the atmosphere is so transparent and brilliant, that objects are seen as distinctly at a mile, as if they were only half that distance, and produce an effect, which by some peculiar law of optics, is just the reverse of what might be expected—they are magnified, so that goats and

the enormous elevation of 16,000 feet."—(Foreign Quarterly Review, No. xix. Aug. 1832.) Humboldt has attempted to account for this, by the supposed radiation of heat from the plains of Thibet; but we have here proved the existence of a powerful degree of radiation from the plains of Hindustan, unknown in any other part of the world, and calculated to cause an opposite effect to that remarked by Captain Webb.

Mr. Saunders, however, affords from personal observation, on another portion of the Himalaya, a view of the subject in perfect accordance with what we might expect. Standing on a mountain ridge that forms the boundary between Boutan and Thibet, he says:—"The south side of this mountain, to within a few yards of the ground on which we tread, is covered with trees and verdure. On the north side, the eye takes an extensive range of hills and plains, but not a tree, shrub, or scarcely a tuft of grass to be seen."—Phil. Trans. vol. 79.

sheep would be mistaken for buffaloes. Perhaps the impression that distant objects here occasion on the retina, being more distinct than the eye has been accustomed to, from similar objects at the same distance, may account for the illusion. If so, it is just the reverse of that deception of sight by which objects are magnified when seen through a mist, and which M. Le Cat explained to be the case, because their dimness gives the character of undue distance. The cause of this extreme brilliancy of the atmosphere, is no doubt owing partly to the rocky and inclined surfaces of the mountains, casting off the moisture to the rivers, rather than to the air, to the absence of marshes and of lakes, and to the consequent absence of vapour. This state of the air continues with little interruption till February or March, when the snowy peaks of the Himalayas, before so distinctly seen at all hours of the day, now begin to be obscured by clouds about noon. This effect increases as the weather becomes warmer, subject, however, to sudden though temporary interruptions, from occasional falls of rain, or snow, until the air becomes so loaded, that objects become invisible at the distance of a mile. Nor is this alone aqueous vapour, for it is accompanied by a dry westerly wind. The opacity of the air is greatest at noon, when the wind is highest, and subsides with the wind at sunset; the nights are calm and hazy, and a slight earthy precipitate from the atmosphere takes place, sometimes sufficiently intense to be detected before sunrise on the leaves of plants. During the continuance of these phenomena, which are peculiar to the months of May and June, no dew falls; evaporation is accelerated*, the sun is obscured, the skin parched, and more of the natives die at this, than any other season; and the in-

* I found water lose by evaporation $\frac{3}{10}$ of an inch from its surface in 6 hours, when placed in the open air, under a temperature of 82° in the shade, during the continuance of the wind here alluded to, which is more than equal to the quantity that I found the surface of water lose, during ordinary winds at the same temperature in 12 hours.

tensity of all these effects increase until dispersed by a heavy fall of rain, which is ushered in by thunder and hail storms.

The following table exhibits the mean diurnal variations of temperature during the different months.

	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.		MeanAnnual.
1834-35,	6	4.36	2.36	1.4	3.89	3.9	7.71	20	27.5	21.8	16.5	..		..

The highest diurnal temperature at all seasons is the afternoon, about 3 P. M. in the summer, and 2 P. M. in winter. Although the mean temperature of the winter months, is nearly as high as that of the spring or autumn of some of the mildest climates of Europe; yet the excessive diurnal variations of the thermometer, during the winter, in Kemaon, render the climate at this season remarkably severe upon both plants and animals. Thus with a mean temperature of nearly 50°, vegetation is as much interrupted, wild beasts are as much driven from their haunts to seek their prey amidst the habitations of man, as in some of the more northern climates, where the temperature of winter is 20° lower.

Having already published a paper containing some remarks on the climate of Kemaon*, I shall now avoid reverting to any subject that might lead to repetition.

It is stated in the paper alluded to, that I had kept no rain gauge, and I took the opportunity of venturing an opinion as to the quantity of rain that falls in Kemaon. At the time I made those remarks, I had determined to adopt some means by which I might be enabled to form an estimate on this point. My residence at the place was but temporary, I could not therefore send to Calcutta, a distance of a thousand miles, for a rain gauge. Even if it could have been possible to have received one in time, the probability of its being broken on the way, or imperfectly constructed, would have deterred me from doing so, independent of

* India Journal of Medical Science, Feb. 1835.

the exorbitant charges that would be sure to result from the trifling commission; former experience having convinced me of the impossibility of private individuals in ordinary circumstances, procuring accurate philosophical instruments in the interior of India.

Under these circumstances I selected for the purpose, a copper vessel, as near the shape that a rain gauge ought to be as could be procured in a remote mountainous country, without the slightest mechanical resources, and made the best corrections I could for any disproportion between the capacity and orifice.

With such an imperfect gauge, no care or additional labour could of course lead to accurate results; but even allowing that an error of twenty inches exists (which I think is the utmost that could have occurred) the result is still so much in excess, of the greatest quantity of rain elsewhere found to have fallen in one year, that I trust it will induce those who reside in Kemaon, and the adjoining mountain provinces, to keep registers of the rain gauge in their respective localities.

It is a general impression that more rain falls on the top of a mountain, than on a plain; and although the theory on which the belief is founded is perfectly satisfactory in itself, yet in the case of small mountain groups, it is at variance with any experiments that have been made on the subject. Mr. Barrington found by two rain gauges, one placed on the top of Rennig, a mountain in Wales, and another at the foot of the same, that the quantity of rain was equal in both situations.

In alpine countries the case has been found to be different; and according to the observations of Dr. Schenchzer long since recorded, 43½ inches fall annually at Pisa, while only 22 inches fall at Paris. If the estimate of the quantity of rain which fell at Lohooghat, during twelve months, be at all near correct, it exceeds the greatest quantity that has hitherto been noticed in any other country, although it is not by the register of one, but by the mean of a series of years, that we ought to appreciate the moisture of a climate.

	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	Total.
1834-35.	3	2	0	4	37	15¼	26¾	13	¼	6¾	¼	7¼	119 Inches.

The purest rain water that could be collected at Lohooghat, displayed the same property of changing the delicate red colour of the cold infusion of brazil wood, to blue; and I had no doubt, but that this effect was owing to the same principles that had elsewhere been detected in rain waters, until I required to use it for chemical purposes, when it became necessary to examine as accurately as I could, the extraneous impurities of rain water at Lohooghat. Those who feel an interest in this point, may consult the experiments that relate to it, which together with the result, will be found in the appendix to the examination of the waters of Kemaon, (Essay on the causes of Goitre—section vii.)

Earthquakes. The frequent occurrence

of earthquakes in India, during the last three years, is no less alarming than remarkable. They cause while they last, considerable excitement in the public mind; but a few hours usually suffice to allay at once our alarm, as well as our speculations, as to the cause of such mysterious phenomena. They do not appear of late to have been more frequent or severe, in the mountains connected with the Himalaya chain, than in the plains of Hindustan. The following are the dates of those which have been felt at Lohooghat since December, 1831.

1. December 25th, 1831, at 9 P. M.; continued about seven seconds, an undulating motion of the earth on a N. W. and S. E. line.

2. July 2nd, 1832, at 11 P. M.; during twelve seconds the earth shook, or rather trembled and afforded a noise, which is difficult to describe, but which may be compared to the sound of a heavy, but transient rush of water. The noise preceded and succeeded the motion about three seconds.

3. August 18th, 1832, 7 A. M.; the earth trembled for the space of about five seconds: no peculiar concomitant circumstances observed, except that the weather at the time was hot and sultry.

4. September 23rd, 1832, 10 P. M.; an earthquake took place, which resembled in all its circumstances the one of the 2nd July.

5. May 30th, 1833. The earth was found to shake rather violently for about twelve seconds, at 12 P. M. It was attended with a noise like that already described.

6. August 27th, 1833. This earthquake which was so severely felt in the plains, from the 20th to the 26th degree of latitude, was scarcely felt at Lohooghat, and is inserted here on the authority of a friend who perceived it. From this period there is a longer intermission than we have been accustomed to.

7. January 4th, 1835. About 7 A. M., a slight shock was felt which lasted from fifteen to twenty seconds, but the motion of the earth was very gentle, and seemed

to be on a line between north and south, accompanied by a noise as usual.

8. January 14th, 1835. About 1½ A. M. a shock which seemed to lie in the direction of N. W. and more violent than the one on the 4th took place, accompanied by a noise like distant thunder. The motion was tremulous; and in crossing the strata, seemed to affect a single one at a time.

In the year 1803, a great earthquake took place in Kemaon, and the neighbouring provinces, of which I have not had an opportunity of consulting any authentic account; but its effects are said to have been very destructive to houses, and consequently to human life.

The connexion between earthquakes and the eruption of volcanoes, which has been so often observed in other parts of the world, renders a few remarks necessary, on the probable dependance of these phenomena upon each other in Kemaon; or rather, (we may venture to say) in the centre of the Himalaya chain. Thermal springs have been found in many parts of the provinces of Girwal, Bhotan, and probably also in Nepal and Kemaon; but of the nature of these we have no precise information, nor is the existence of such springs sufficient of itself to prove the volcanic nature of the places in which they occur*. The local effect of the spontaneous evolution of heat from pyrites, is generally considered to be the most probable cause of these springs†.

The nearest volcanic countries on the south and south-east of Kemaon, are the islands in the China sea, distant about 1,800 maritime miles. On the north, the Thian-chan, or celestial mountains, which run in the parallel of the 42° N. Lat. and contain, according to the best

* 1 Klap. 290.

† The water of a hot spring in a part of Kemaon that I have not visited, was sent to me for the purpose of analysis, and found to contain about 20 per cent. of its volume of sulphur, both in an earthy and in an oxydised state.

A substance brought down from Thibet and sold for shot, is a silicious topha, the educt of a hot spring, and exactly similar to the topha of the Iceland waters.

accounts we possess, two active volcanoes. The Pe-chan, or white mountain, which is nearly extinct, and the Tourfan, or Ho-tcheou, said to be in great activity. These volcanoes are only distant from Kemaon about 720 maritime miles, and we might be led to look to them, with some suspicion, if we found that earthquakes were more frequent and severe as we approach them; but is this the case?

From the information we possess (though it is slight), regarding the Himalaya, there is no circumstances that would justify the belief of the volcanic agency of any portion of the range, in causing the earthquakes to which it is so subject.

Were we to venture conclusions drawn from the physiognomy of the high peaks of the Himalaya, on principles suggested by the experience of Humboldt in the Cordilleras of the Andes, we should have little hesitation in ascribing the conical, pyramidal, and bristling forms of these stupendous peaks to the agency of former volcanoes; but without some more direct proofs, we cannot adopt a belief at variance with what is positively known respecting the geological structure of the Himalayas generally. In the mountains of Kemaon, which may be said to constitute the pedestal, or base of some of those lofty summits, there is the same regularity in the constitution and superposition of rocks that we observe in mountains, whose connexion with volcanoes we never suspect. When we witness the decay of the more solid and massive summits of ordinary mountains, we can have no difficulty in ascribing the pointed and leaning appearance of many of the peaks of the Himalaya to the perturbations of the atmosphere to which they are so peculiarly exposed, and to the falling of masses overloaded with ice. I have been assured by those who had personal knowledge of the fact, that from the time the ice and snow begin annually to melt at the base of the peaks, an uniform precipitation of masses of rock also takes place and accompanies the thaw.

Within a distance of from thirty to fifty miles from the district described in the foregoing pages, above twenty conical and bristling peaks may be counted, which vary in altitude from nineteen to twenty-six thousand feet. Had these stupendous summits been active volcanoes, they would have emitted lava with a force proportionate to their height; they would have scattered volcanic rocks and scoriæ throughout the neighbouring countries, to an extent that cannot be contemplated from examples such as exist in other parts of the world; yet, in the vicinity of the Himalaya, volcanic minerals are seldom found, and have never occurred to my observation during the course of my researches in Kemaon.

NOTE.

The following imperfect Sketch of the general Zoology of Kemaon, though only commenced a little before my unexpected departure; may be sufficient to shew the extraordinary intermixture of northern and tropical species, by which the province is occupied.

PART II.

GENERAL VIEW
OF THE
ZOOLOGY OF KEMAON.

CHAPTER XII.

QUADRUPEDS.

THREE species of the genus Simia are found in Kemaon.

First. Large grey monkey. Tail as long as the body, black hair on the face: generally seen in pairs. The length is about two and a half feet from nose to tail. They inhabit rocks and caves, which are inaccessible to beasts of prey.

Second. Smaller grey monkey, about a foot shorter than the first species: are always found assembled in large communities, consisting of many hundreds. They prefer the warmest and deepest valleys. They carry their young suspended to their bodies like the Phillippine monkey.

Third. Small brown monkey, probably the *Simia Maura.* About the size of a cat: face naked.

Vespertilio Murinus—Common Bat.

Elephas—Elephant. These animals inhabit the Tarai, where they exist in great numbers in a wild state, but they are too unweildy to enter the mountains. Not so high as even the lowest ridge of hills, that bound the plains, has one of these animals ever been seen: yet I have been assured that their fossil bones are found in the highest elevations that man has attained in Thibet, and a skull said to be that of an elephant was brought down from a very high elevation to the Commissioner of Revenue in Kemaon, during my residence in the province; but not having inspected the fossil, I cannot answer for the fact*.

* Interesting discoveries of bones of enormous quadrupeds, are now in progress in the mountain provinces on the N. W. of Kemaon, under the indefatigable zeal of my friend Dr. Falconer and Captain Cautley.

Hystrix Cristata—Common porcupine.

Mus Zibethicus—Musk-rat.

Mus Decumanus—Common rat.

Mus Musculus—Common mouse.

Mus Minutus—Pigmy shrew.

Sciurus Volans—Flying squirrel*. This animal is eight or ten inches from the nose to the tail. Its skin, a fine soft fur.

Lepus Timidus—Common hare.

Lepus Cuniculus—Rabbit.

Rana Temporaria—Common frog.

Of the genus *Lacerta*, there are numerous species, which I have been unable, for want of opportunity, to distinguish. One particular kind, probably the Iguana of Buffon, I chanced to disturb when basking in the sun; and on being alarmed, instantly escaped into the thicket. It appeared to be about three feet long, including the tail, which was half the length of the body, and tapering rapidly to a point from a broad base. The body was broad and clumsy, the neck short, and nearly as broad as the body. It had

* Probably a species of the genus Petaurista of Cuvier.

four legs, very short. Its colour was dusky grey, without stripes or spots.

Canis Familiaris—Common dog. There is a wild variety of this species found on the borders of the mountains next the plains. They are said to hunt in packs, and to prove formidable enemies to much more powerful animals. I happened to see two of these wild dogs: they were both of a reddish yellow colour, approaching to light-brown. The hind legs were longer than the fore; the tail was rather large and hanging; the ears erect and thick, terminating in a point; eyes obliquely placed, and elongated between the angles of the tarsus: their skin emits an offensive smell. One of these animals was taken when young, and every endeavour made to tame him, but to no purpose. They utter, when pressed by other dogs, a plaintive shrill cry, very unlike the hideous howl of the jackal; and unlike the latter, they have no dusky colours on the tips of their hair.

The domestic dog of the higher Himalaya regions, a variety of mastiff of great size and power, is different from any of the dogs of Europe. He is distinguished by the smallness of his eyes, in proportion to the breadth of his forehead, by a short thick neck and body, with rather long hair, and of a stupid expression, and sulky indifferent manner. These dogs accompany the merchants of Bhotan in their travels across the mountains, between Tartary and Hindustan, during which, the hardy mountaineers pass the nights in the forests, equally secure under the protection of their dogs, both from wild beasts and robbers. The necks of dogs are decorated with strong collars of brass or iron, which answers the purpose of armour, during their encounters with wild beasts. They are extremely docile, but uncertain in their temper. They are also said to be more liable to hydrophobia in hot climates than other dogs. They are of ali colours, such as grey spotted, black sides, white breasts, reddish, yellow, brown, &c.

Canis Aureus—The jackal. This animal is much larger than the jackal of the plains. He is distinguished from the wild dog above described, by being of a stronger make; by having a dusky hue on the back, the crown of the head, and tail; by its eyes as well as head being rounder; by being tamable, while the wild dog is not, and by its hideous howl.

The jackal is remarkably shy and cautious, so much so as never to allow itself to be caught in a trap. They have in Kemaon, much of the intelligence ascribed in England to the fox, from the dexterity with which they elude pursuit; and if hunted by a single dog, other jackals assemble and intercept his return, and unless quickly relieved, the dog is soon destroyed.

Canis Vulpes—The fox. He has grey legs, becoming darker to the feet; dark, sharp nose; bushy tail—that of the male having a white tip: the upper surface of the ears velvet black, inner surface cream yellow. They are somewhat larger than the English fox, and are very easily caught in traps.

Felis Tigris—The tiger is one of the greatest scourges to which the inhabitants of Kemaon are subject. Their haunts are the deep valleys and lower ranges of mountains which skirt the plains, where the warmth of the climate is congenial to them in the cold season; but during the hot-weather, and the rains, when the herds return to the higher altitudes, the tigers then penetrate into the interior of the mountains, keeping possession of the deep valleys, where they prey upon unfortunate travellers; or when pressed for food, they even approach the villages in open day, and seize the first animal they meet. It is calculated, as I have been informed, that the loss of human life by tigers, in Kemaon alone, amounts on an average to no fewer than two hundred and fifty per annum. This is a most frightful proportion of victims out of a country so thinly inhabited. Extensive tracts are indeed quite deserted from this cause; and although the Government allows a reward of ten rupees for every tiger's head that is produced at Almorah, their number is very slowly, if at all diminished. There is, however, some reason to fear, that in the remote parts of the province, great abuses exist, as to the payment of the reward so humanely given by Government, and thus the important object for which it was intended, is in some degree thwarted.

Felis Leopardus—The leopard is the most numerous of the feline genus in Kemaon. Unless on the defensive, they never attack human beings; but they are very destructive to sheep, goats, and to cattle in general. Dogs are also their favorite prey; and to procure them, I have known instances of the greatest audacity and cunning resorted to by the leopard; such, for instance, as concealing himself in a dark corner close to his intended victim, and there awaiting a favourable opportunity, when, by one spring, he seizes his prize, and carries him off in defiance of the yells and bludgeons of surrounding spectators. Some of the leopards are nearly as large as the panther, and others, as small as the common hunting leopard; but except in size, there does not appear to be sufficient reason to describe them as distinct varieties. If the form of the spots be a sufficient criterion, they would all be described by some authors as panthers.

Felis Ocelot—The size of a common cat. Colour, bright yellow, clouded with brown streaks, longitudinally on the back, and in other respects, the same as the Ocelot No. 1, of Hamilton Smith, (Griffiths Cuvier;) so that these animals do not appear to be peculiar to the new world, as stated by Mr. Smith. One of them which was taken when young from the forest, and presented to Mr. Liptrott, of the 30th regiment, became quite tame, and is still, I believe, in his possession.

Felis Serval, or Mountain cat. The animal to which I here refer, is somewhat different to any of the figures which are given by authors. It is twice the size of the common domestic cat; of a dusky grey colour, with dark stripes along the back, and long coarse hair.

The domestic cat is of an ash-grey, with stripes of darker grey, diminishing in size and intensity towards the extremities. The beautiful species known by the name of Persian cat are now becoming quite common in Kemaon, from the numbers of them that have been lately introduced. Their docility and faithfulness render them an exception in these respects to the general character of the genus to which they belong.

Viverra Martes — The pine martin. Musky weasel, commonly called in India, the musk-rat. It is the smallest of the Weasel tribe, and is well known from the strong smell of musk which it diffuses.

Lutra Vulgaris—Common otter.

Lutra Lutreola—Smaller otter. Otters are very numerous in all the rivers of Kemaon, so that a small trade might be afforded by the collection of their fur, as well as of the skins of leopards, tigers, &c.

Ursus—The bear. A bear is found in Kemaon; and whether it belongs to any of the three peculiar species lately discovered by Dr. Wallich, M. Duvauncel, Dr. Buchanan, and Sir J. S. Raffles, to inhabit the mountains of India, I cannot pretend to determine. It is larger than the *Ursus Thibetanus* of the two first mentioned naturalists; while it is farther distinguished from that species by its powerful limbs and claws, and by its disposition to climb trees. The hair on the back is an inch and half long, straight and glossy black. It is long and coarse on the fore-legs and anterior part of the shoulders, from which situations to the ears, a ridge of long and thickly set hair extends along each side of the neck. A white stripe passes along the front of the chest and neck, and is crossed by a transverse stripe of the same colour on the throat. The head is small in proportion to the size of the body; the nose is elongated, but not more so than that of a mastiff dog; but upon the whole, I think we may consider this animal to be the *Ursus Labiatus*. The bears in Kemaon are exceedingly numerous, and emerge from their dens in May or June, and remain in open forests and thickets till December. On making their appearance, their first food is esculent roots, young shoots, and the blossoms of the Rhododendron, as well as honey and ants. In the months of June and July, while these supplies continue, the bears are frequently seen on the branches of trees in retired places; but in August they approach the villages in quest of grain, more especially Indian-corn, an article of which they are very fond: accordingly, when this grain is ripening, a few bears usually establish themselves in the nearest thicket that can afford them concealment during the day; from this they emerge at night, committing the most destructive depredations on the gardens, and thus exciting the just indignation of an enemy, to whom they often pay the forfeit of life.

On two or three occasions I have accidentally surprised these animals in their native haunts, and invariably found them disposed to avoid personal contact. On other occasions, I have accompanied friends on excursions to shoot them, when it appeared that unless too closely pressed, they shewed no disposition to attack their pursuers.

There was a story prevalent at Petoragur, of a bear who took up his position in a thicket in that neighbourhood, and who killed four men in different attempts to dislodge him. Another instance of a bear who having entered a corn mill, and on being disturbed by a man who suddenly entered, the bear seized and killed him, ate a portion of the body, and threw the remainder into the river.

Both these circumstances occurred during my residence in Kemaon, but whether these were *black* bears or not, I am quite unable to say. Such instances of the ferocity of bears in Kemaon are extremely rare, and may be considered as exceptions to the nature of the animals. In both cases, however, we may suppose the attack to have been made upon the bears; and as the natives of Kemaon usually enter into such conflicts with swords alone, it is only to be wondered, that a creature of such power as the bear, is not more frequently successful.

In December, they retire to their dens, which are usually situated in the most inaccessible and solitary places. From their enormous size, their great numbers, and the ease with which they may be procured, it is much to be regretted that such a profitable source of trade should be altogether neglected*.

* "The hunting of the bear," says Buffon, "without being very dangerous, is extremely lucrative when performed with success. The skin is a valuable fur, and the quantity of oil drawn from a single bear is considerable. The flesh and fat are boiled together in a caldron, and the oil is easily separated." "Afterwards," says M. du Pratz, "the oil is purified, by throwing it, when very warm, into a quantity of salt and water; a detonation ensues, and a thick smoke rises, which carries off the disagreeable odour of the grease. While the smoke ceases, and while the grease is still warm, it is put into a pot, where it is allowed to remain for eight or ten days. At the end of this period, a clear oil is seen swimming on the top, which is taken off with a ladle. This oil is equally good, and answers the same purpose as the best olive oil. Beneath, we find a lard as white, but a little softer than hog's lard. It serves for culinary purposes, and has no bad taste or smell." M. Dumont, in his Memoirs of Louisiana, agrees with M. du Pratz, and adds, that "from a single bear they obtain more than 120 pots of oil."—VI. Buff. 111, 112.

Cervus Axis—Spotted axis. A species of elk is also found to inhabit the higher ranges of mountains; but except two young individuals, which were not sufficiently developed to denote the characters of their species, I have not had an opportunity of seeing any of them.

Capra Hircus—Common goat.

Capra Riversa—Long-horned whidaw goat, or shawl goat. This animal is not a native of the province, but it is occasionally brought down from Thibet.

Ovis Aries, or common sheep. They are used by the Thibetans for transmitting merchandize between Hindustan and Tartary. Each sheep carries about eight pounds. Borax is the article with which they are loaded on their way to Hindustan; but on their return to Thibet, they carry rice and other grains, which are not produced in their own frozen regions.

Common Ox, belongs to the small Indian breed, but is considerably less than the same species in the plains.

Bos Bubalus—The buffalo. These animals are very common in the domestic state in Kemaon.

Sus Scrofa—The wild boar.

REPTILES.

Boa Murina—Rat boa.

Coluber Gramineus—Grass snake.

CHAPTER XIII.

GENERAL VIEW OF THE INSECTS OF KEMAON.

Scarabæus Goliathus, or goliah beetle. It makes its appearance about twilight during the warm season, and continues till September.

S. Melolontha.—The cockchaffers appear annually a few weeks before the setting in of the rains. They appear, after sunset, to rise out of the ground with a humming noise, which they continue until they alight on some devoted plant, which they continue to devour until every atom of the foliage disappears; they then quickly decamp to other plants of the same species, (should the insects not be sufficiently numerous to attack them all simultaneously,) and so on in succession, until they either convert the most fruitful and promising plantations into desert, or become themselves destroyed by some fortunate change of weather, which usually happens in Kemaon, before their depredations are very seriously extended beyond one or two species of plants: the chesnut tree is always selected as the first victim. There are two varieties of this destructive insect, which are only distinguished from each other by size; the one is an inch in length, and the other only about half an inch.

S. Auratus, or golden beetle.

S. Fullo, or variegated beetle; and various other species that would come under this head are very common in Kemaon.

Byrrhus Pylula and *B. Scropulariæ*.

Silpha Vespillo.

Cassida Virida—Green cassida.

C. Marginata—This insect changes from the bright sparkling lustre of the most beautiful gem, to dull; but still elegant colours, by keeping in the cabinet.

Coccinella Septempunctata—Seven spotted lady-bird. This very handsome, but mischievous little insect, is even more destructive to fruit trees in Kemaon, and to gardens in general, than it is in England; nor can any pains or attention save the foliage of the peach-trees at Lohooghat, annually, from being destroyed by it.

Chrysomela Betulæ, and several other very brilliant species of this genus, are met with during the rains.

Cerambyx Gigas—I think I have seen a specimen of this insect. A second fine species of this genus occurs in Kemaon; it is larger than the *C. Damicornis*, but without the projecting curved jaws of that insect. It has two sharp spines on the thorax. The upper extremities of the wing-sheaths are rough, and spiny. The colour of the whole insect is cream yellow; but in large specimens, a dark-brown appears from beneath the colouring matter.

C. Coriarius.

C. Ædilis.

C. Moschatus—Cerambyx is here a numerous and splendid genus.

Leptura Aquatica.

L. Arcuata, and numerous insects of this genus, as *Leptura Hastata, L. Arietis,* &c.

Lampyris Noctiluca—Common glow-worm. Flying glow-worms are also very numerous during the months of July and August.

Cantharis Bipustulata—Green cantharis.

Carabus Bimaculatus.

Tenebrio Globosus—A black insect, shaped like an hour-glass, very common in the gardens during July and August.

Forficula Auricularia—Common earwig.

Mantis Oratoria, or Camel-cricket. This insect is sometimes seen of a green colour; sometimes grey, yellow, &c. It possesses in Kemaon the same pugnacious propensities ascribed to it in other countries, and when an adversary is presented to it, it seldom condescends to fight, but commences eating him outright.

Gryllus Migratorius.—The common Locust. This insect often makes its appearance immediately before, or just after, the rains. I have not known any very extensive injury to result from locusts in Kemaon.

G. Acrida—The grasshopper, with the elongated conical head.

Saltoria of Cuvier are very common and familiar insects during the whole year.

G. Domesticus—The house cricket.

Cicada Spumaria—Cuckoo-spit cicada.

Cimex Flavicollis.

C. Annulatus.

C. Lectularius—Common bug.

Aphides—These are not so numerous as might be expected.

Aphis Rosæ, and *A. Salicis*, are, however, common species.

LEPIDOPTEROUS INSECTS

Embrace in Kemaon, probably, most of the select and beautiful varieties that have been found in all other parts of the world.

1. *Papilio*, or Butterfly. Of this splendid genus, my collection, which was made in the course of a few weeks, consists (perhaps) of upwards of fifty different varieties, and two-thirds of these exceed in

beauty the most select species that have been found in England.

The *Troes*, or *Trojans*, and the *Achivi*, (*Greeks*,) are the largest, and by far, the most splendid; this applies to one species of the latter in particular, whose upper wings measure four inches, and are of a deep velvet black colour, divided into rays of greyish black, with blood-red spots on the lower wings. A second species, about the same size, is a dark-green colour, changing in the centre of the wings into azure blue, with eye-like spots on the inner margins of the lower wings, displaying a deep black centre, surrounded with blood-red and white rings.

The following are a few of the remaining species.

P. Machaon—Presenting many elegant varieties. *P. Hector*, *P. Piera*, *P. Leitus*, *P. Brassicæ*, *P. Midamus*, and others of the divisions *Danai Candidi* and *Danai Festivi*. In short, if we were to enumerate all the varieties of this genus, that are seen on every tree and flower in Kemaon, it would be only to transcribe the names of perhaps the whole of the most splendid species that have been described by authors; and to this might be added several new kinds, were the requisite attention paid to the subject.

The genus *Sphinx* also presents some elegant species.

The succeeding genus, *Phalæna*, or Moth tribe, are scarcely less numerous and beautiful than the butterflies; and in this we recognize nearly all the species described by authors.

Libellula Varia, or great variegated Dragon-fly. I have seen this insect above four inches long; the body was annulated, not striped, and the colours of the rings were light-green and bluish black.

Libellula Virgo, *L. Puella*, and other elegant examples; some with bright scarlet, others with light-blue bodies, tipped with black, and wings of the most brilliant green, are common during the rains. Nothing can surpass the agreeable effect of an assemblage of these insects, when mingling their various colours on the surface of a mountain stream. Here the contemplative mind might embrace, at one view, a wondrous range of excellence in nature---from those incomprehensible powers, which elevated the strata of mountains from beneath the waters of the deep, to those which give beauty to the structure of the insect---what versatility, and yet what perfection prevails!

Other genera of Neuropterous insects are common in Kemaon, as some of the species of Ephemera, many of those of Phryganea, Hemerobius, Myrmeleon, (*M. grande,*) and Panorpa.

Of the order Hymenoptera may be mentioned *Cynips Viminalis*, and a peculiar species that is very destructive to the leaves of the peach-tree.

Sirex, Ichneumon, and Chrysis, are genera which afford in Kemaon various species of insects.

Vespa Vulgaris, or Common wasp, is often met with; but the *V. Holsatica* are still more commonly seen, their nests being usually placed over the doors and windows of houses. The most important of this order of insects is the following variety:

Apis Mellifica, or Common bee. Kemaon is so well adapted to the nature and wants of the bee, that honey and wax might be made valuable articles of commerce, with but common industry on the part of the peasantry; but no attention is paid by them to the bee, or to the product of its labour, further than that they avail themselves of the honey as a common article of food, as long as it is found in the forests.

Apis Lapidaria, and *A. Terrestris*, are also common varieties.

The genus Formica, or Ant, also affords many varieties.

Ord. DIPTERA, genus *Œstrus*, or Gad-fly, affords numerous species: also the succeeding genus, of which *Tipula Crocata*, and *T. Cornicina*, are very familiar examples.

Musca, or Fly. It is almost unnecessary to say, that this is very common genus, especially during the months of July, August, and September. *M. Carnaria*, and *M. Vomitoria*, Linn., constitute a very serious grievance in the houses.

Tabanus Bovinus, and other insects of this genus, are very tormenting, especially to strangers. There is a very small species, scarcely the size of a gnat, met with in all the warmer valleys. It leaves a red mark, that remains on the skin for weeks, after the infliction of the wound.

Pangonia Longirostris.

The genus Culex affords the common gnat. *Canops Irritans.*

Lepisma Saccharinum, or Wood-fish, is very numerous in libraries in Kemaon; though I have not observed it in other parts of India. It is said to be destructive to books; but I have found its ravages confined to substances containing starch, such as paste-board.

TERMES—*T. Bellicosus*, and *T. Arborum*, are both very common. The buildings of the first species, called ants' nests, may be seen in all the forests and shaded places. They are usually four or five feet high, of pleasing proportions, resembling diminutive towers of gothic architecture. During the month of August, in tolerably dry seasons, I have seen the atmosphere for the space of a few hours in the afternoon, for several successive days, quite a living mass of these insects. After the different individuals remained about twenty minutes, or half-an-hour in the air, they fell, lost their wings, and disappeared in the earth, where a few may have succeeded in establishing new communities.

Acarus Exulcerans, or Itch-mite.—This insect is not at all uncommon in Kemaon, if we may be allowed to suppose it to be the ring-worm.

Aranea Diadema—The insect here referred to, differs from the *A. Diadema* of Linn., or indeed of any other author that I have had an opportunity of consulting; but its peculiarity is confined merely to the distribution of colour on its body. A broad red stripe passes from the middle of the abdomen, obliquely upwards to the back. Deep blue and yellow are distributed, like the delineations of tortoise-shell, on the back.

In autumn, this insect covers almost every shrub and tree with its web, which is composed of a highly superior silk, both as to lustre, elasticity, and strength. Its colour is a bright golden yellow.

During the early part of the last century, it was proposed to cultivate the spider for the manufacture of silk; but the scheme was abandoned, on finding it difficult to domesticate the insects sufficiently. A considerable quantity of silk might, however, be annually collected in Kemaon from the wild insects, without any expence whatever.

Scorpio. Of this I have seen but one species in Kemaon, namely, *Scorpio Europæus.*

Julus Indicus.

Of the genus *Lumbricus*, *L. Terrestris*, or earth-worm, is the only common species.

Hirudo Sanguisuga, or horse-leech, and a small variety of *H. Medicinalis*, are quite a plague during the rains; at which season, they abound in such numbers, that it is impossible to walk in the open air without exposing the feet to their attacks; nor are shoes, or even boots, a sufficient protection.

CHAPTER XIV.

GENERAL VIEW OF THE BIRDS OF KEMAON.

Vultur Indicus—A brown vulture, seldom seen, unless when the dead body of some large animal lies exposed on the surface of the ground, when, especially in hot weather, the vultures collect in large numbers.

Vultur Percnopterus—A white vulture, with yellow beak.

Falco Coronatus—Crowned eagle. *F. Chrysaetos*, or golden eagle. *F. Fulvus*. *F. Milvus*, or common kite. I have not had an opportunity of identifying more species of this extensive genus.

Strix Bubo, or great horned owl. A very fine example of this bird, I found to be five feet ten inches across the wings.

Of smooth headed owls, there are numerous varieties, which I cannot pretend to distinguish.

The following description refers to a species of shrike that is very common in Kemaon. Upper part of the body and neck bluish grey, becoming reddish grey on the belly. Wing coverts black, slightly tipped with white. Crown black, and crested in front. Outer margins of the wing and tail feathers light-blue, slightly streaked with black. Tail, the length of the body. Legs grey, and beak yellow at the point.

This bird is about the size of a magpie. It resembles the grey shrike, and the *Lanius Neugeta* of Brazil.

Lanius Jocosus, or bulbul.

Corvus Erythrorhynchos, or red-billed jay. *C. Frugilegus*, the rook. *C. Corax*, or raven. Also the *C. Graculus*, or red-legged crow; but it is met with only in the higher altitudes of the Himalaya, on the verge of perpetual snow.

Oriolus includes many varieties of the birds of Kemaon. Among the species of this genus may be mentioned the *O. Nidipendulus*, or hang-nest oriole.

O. Gulbula—Golden oriole, &c.

Gracula—Indian grakle, or minor. An olive-green grakle, with a rufus yellow belly; throat white, legs grey. It is about ten inches long.

Alcedo—King-fisher. Of this genus the *Alcedo Rudis* is the most common.

Cerithia Muraria, or wall-creeper.

Trochilus, or humming-bird. In Kemaon, this is a very splendid genus, but so numerous, that it would be impossible to enter into an enumeration of the species.

Psittacus—The *P. Guianensis*, or green parakeet, is exceedingly common.

Cuculus Canorus, or common cuckow.

Picus Viridis, or spotted wood-pecker, and a small grey wood-pecker. Striated on the shoulders, spotted wings with white and black; breast grey; vent feathers red; crown greenish yellow; tail black above, but barred reddish yellow and black underneath. The length of this bird is about five inches.

Passeres—The following examples of the genus *Alauda* may be mentioned.

Alauda Arvensis, or sky-lark. *A. Minor*, or lesser field-lark. *Turdus Pilaris*, or field-fare, and *Turdus Merula*, the blackbird*.

Loxia Chloris—The greenfinch. *Emberiza Citrinella*, the yellow-hammer.

Fringilla Domestica—The sparrow, and *F. Montana*, the mountain-sparrow. *F. Longicauda*. *Montacilla Cinerea*, the grey wagtail, and a variety of this species, which may be described as follows:

Lower part of the body white. The throat and lower feathers of the wings black; two outer tail feathers white; the others black and tipped with white. A white spot on the forehead; beak black; legs white and slender. It is a little larger than the common wagtail.

There is a species of *Sturnus*, or water-ouzel, in Kemaon, about the size of a

* There is a species of turdus larger than the thrush of Europe, in Kemaon. The following is its description: upper part of the body, wings, and tail, bluish or brownish grey; the lower part spotted with brown and light yellow; outer tail feathers, greyish white towards the tip; quill feathers, outer margins, light grey; inner margins, blackish brown. This description is of the hen bird; the cock is smaller, and of the same colours, but much brighter.

black bird, but heavier. Plumage short and compact; every part of the bird is a dusky brown colour, except the legs, which have a leaden hue and fishy lustre.

One of these singular birds was shot in a small rocky river near Lohooghat, and when wounded, it dived into the water, where it remained a very considerable time. It differs from the English water-ouzel, (which is quite black, with a white spot on the forehead,) in being entirely brown.

Parus Cristatus, or crested titmouse. The genus *Columba* contains some species, which I have not seen described, and which I had not the opportunity of investigating. The following are, however, very common and well known varieties. *C. Oenas*, common pigeon; *C. Domestica*, domestic pigeon; *C. Palumbus*, the ring-dove, or wood-pigeon; *C. Turtur*, or turtle dove.

A brown-spotted pigeon*, and another variety which I suspect to be imperfectly known, are occasionally seen. The latter

* Spotted-necked turtle—Hardwick.

is about the size of the domestic pigeon, and coloured brown and white.

The order *Gallinæ* is particularly rich, both in genera and species. In the first genus we have the *Tetrao Pictus*—Black partridge. *Perdix Chakoor**. The latter is I believe peculiar to these mountains. *Tetraro Coturnix*, or quail, and *T. Lagopus*, or ptarmigan†. The succeeding genus is equally splendid. *Phasianus Gallus*, or wild cock. There is a species of pheasant in Kemaon, without the caruncles on the throat and crown of the head, while its tail is compressed like that of the *P. Gallus*. The head is crested and striped over the eyes with red fleshy papillæ, like the common pheasant. Feathers on the upper

* Bill and legs red, throat yellow, and bounded by a black stripe, which passes across the forehead and breast, and a small tuft of brown feathers behind the ears. Feathers on the belly bright yellow, barred with brown and black. Each leg armed with a knob or blunt spur.

† The Nepal pheasant, *Meleagris Satyrus*, is supposed to belong to this genus.—See Griffith's Cuvier, vol. viii. p. 241, Lond. 1829.

part of the body black, and emarginated with grey. Breast feathers long and narrow, and striated with white at the tips, and black at the bases. The hen bird is brown. They nestle in trees, and are about the size of the common cock*.

Nepal, or *horned pheasant*—There is also a large grey pheasant occasionally met with on high naked ridges; the tail is long and wedge-shaped, and marked with dark-grey eye-shaped rings. The head is crested, and a stripe of red fleshy papillæ pass along the cheeks. It is called by the natives *Chikras.*

Of the genus *Scolopax*, are the *S. Rusticola,* or wood-cock. These birds make their appearance in November, and continue till February.

S. Major, or great snipe.

S. Gallinago, or common snipe, and *S. Gallinula,* or jack snipe.

* This bird is more numerous than all the other varieties of phasianus in Kemaon, which would not be the case if it were a hybrid, produced between the common pheasant and the common cock; for such a bird would be incapable of reproduction, whereas this species is known to breed.

Of water fowls, the following species are the most remarkable: *Anas Boschas*—The wild duck. It is marked like the domestic duck, but is nearly twice the size, and much brighter in its colours.

Anas Crecca—The teal.

AN

INQUIRY

INTO THE

NATURE AND CAUSES OF GOITRE.

NOTE.

In the first part of the VII. Vol. Cal. Med. Trans. are published some conclusions derived from the earlier portion of the following researches.

Since then, the subject has occupied much of my time and attention, without affording sufficient reasons to alter any of the main facts contained in those conclusions, although they might certainly be put in a less objectionable and dogmatic form; but as I here take the liberty of submitting to the public, the whole of my inquiries on the subject to which those conclusions relate, the necessity of making any alteration in them is quite superseded.

I have here retained the Swiss name *goitre*, or *gotre*, as the one by which the disease is most universally and commonly known.

PART III.

AN INQUIRY

INTO THE

NATURE AND CAUSES OF THE GOITRE.

" 'Tis certain that true knowledge is the knowledge of causes."

BACON.

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SECTION V.

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INQUIRY

INTO

THE CAUSES OF GOITRE.

INTRODUCTORY SECTION.

Before commencing the following researches on the subject of Goitre, it may not be devoid of interest to submit a brief comparison between the military posts of Lohooghat and Petoragur, including the condition of health and local circumstances of the troops at each place.

To be successfully treated, the subject of Goitre only requires to be taken up systematically, and to be pursued independent of theory, with a view merely to the collection of data, or what Bacon called—*Forms*. Such a method of inquiry may be repugnant to the finer qualities of the mind, which are naturally impatient of the restraints of methodical philosophy, but the records of medicine fully shew, how inadequate the common mode of reasoning has proved, when applied to the elucidation of this disease.

Lohooghat is a small valley elevated about 5,562 feet above the level of the sea*, it is half a mile broad, and one and a half long, lying in the direction of east and west. Its mean temperature is about 60° Fahrenheit. It is surrounded by hills that rise from five hundred to a thousand feet above the cantonment, (which is situated in the centre of the valley,) except on the west, where the circle is broken, giving the whole the character of a crescent, with its aspect to the west.

Clay-slate, containing occasional small beds of gypsum and quartz, and covered by a stratum of red ferruginous clay, and a layer of vegetable mould, constitute all the rocks that occur. Numerous springs emerge from the clay-slate, causing streams which unite in the southern extremity of the valley, before they join the Racessa, or Lohoo river; these waters only contain

* Webb, vol. iv. Geograph. Trans. Lond. p. 410.

a little earthy matter, together with a small portion of muriat of soda and sulphat of lime; the whole solid extracts not amounting to more than $\frac{1}{13000}$ part of the volume of water.

A detachment of two companies of the 30th Regiment Native Infantry took possession of this post in December, 1831, and after three years subsequent residence at Lohooghat, not one of the sepoys, or of the numerous train of camp-followers, consisting of about 400 men, women, and children, had contracted the slightest affection of the thyroid gland.

The cantonment of Petoragur is fifteen maritime miles, in a northerly direction from Lohooghat, and is erected near the summit, but rather on the southern acclivity of a low ridge, that extends into the centre of Shore valley. The general level of the valley is 5,000 feet, while the site of the cantonment is 5,462 feet above the sea. The situation is consequently more open and commanding than that of Lohooghat, there being no higher elevations within the distance of three or four miles, and from these, direct communication is broken off by a broad expanse of richly cultivated valley, which intervenes, except on the west, where a mountain ridge, equal in height to the loftiest elevations at Lohooghat, approaches within a mile; and it is from this ridge that the eminence on which the cantonment is erected is given off.

A lofty mountain, above 8,000 feet high, forms at a distance of five miles the southern boundary of the valley. On the west, and north-west, altitudes of seven thousand feet approach within from one to two miles; and on the east, and north-east, we have altitudes of seven thousand feet at three miles distance. On the south-west, on the north, and on the east, the mountains are divided by deep chasms and ravines, which open the lowest portions of the valley to the currents of air passing from these directions.

From simultaneous experiments made at both places with thermometers, it may be inferred, that the mean annual temperature is at Petoragur about 1° 40′ higher than at Lohooghat. The rocks of which this vicinity is composed, are clay-slate; supporting extensive deposites of transition and floetz limestones, which give a rugged aspect to the surrounding mountains, as well as to the site of the cantonment.

Beds of greenstone and graphite, containing copper and iron pyrites, are extensively interspersed between the limestone and slate. The pyrites are also found disseminated through the strata seams and rifts of the limestone; while the lower levels of the valley are composed of beds of gravel—the debris of surrounding mountains cemented with calcareous matter. An examination of four of the principal springs, whose waters are used by the residents in this cantonment, proved them to contain a considerable excess of carbonic acid, in combination with very minute portions of alkaline and earthy matters, so as only to afford one part of solid extract out of from four to eight thousand parts of water. Two of the springs discovered a trace of iron and sulphurated hydrogen gas.

This post was also occupied by two companies of the same regiment, and both detachments entered the hills together and were each of the same strength, and attended by the same number of camp-followers.

During the first year, no case of Goitre occurred in either detachment; at the end of the second year, five cases were discovered among those composing the force at Petoragur; and during the next six months, three or four more were affected; and at the end of the third year, fifteen cases of Goitre had appeared at the same place.

It will be seen from the annexed table, that the whole number of sick admitted into Petoragur Hospital, is nearly twice that of the admissions into the Hospital at Lohooghat; and that dysentery, diarrhœa, and fevers, are above one-third more numerous at the former, than the latter place—a circumstance which is indicative of the greater intensity of endemic disorders generally in the district where Goitre is found.

COMPARATIVE VIEW

Of the Sickness that occurred respectively at Lohooghat and Petoragur, during the same period of time, amongst an equal number of strangers similarly situated.

Detachment of two companies 30th Regiment N. I. stationed at Lohooghat, from December, 1831, to December, 1834.

DISEASES.	Remaining Sick on entering the mountains.	Since admitted into hospital.	Total.	Discharged from hospital.	Died.	Remaining 31st Dec. 1834.
Asthma,	0	3	3	3	0	0
Diarrhœa,	0	32	32	32	0	0
Dysentery,	0	7	7	7	0	0
Fevers,	0	167	167	167	0	0
Mania,	0	1	1	1	0	0
Opthalmia,	0	1	1	1	0	0
Pulmonary affections,	0	6	6	6	0	0
Rheumatism,,	0	19	19	19	0	0
Enlarged spleen,	0	1	1	1	0	0
Syphaloid diseases.	0	7	7	7	0	0
Small-pox,	0	1	1	1	0	0
Ulcers, chiefly on the feet,	0	44	44	44	0	0
Wounds,	0	2	2	2	0	0
Total, Lohooghat,	0	281	281	281	0	0

Detachment of two companies 30th Regiment N. I. stationed at Petoragur, from December, 1831, to December, 1834.

DISEASES.	Remaining in hospital on entering the mountains.	Since admitted into hospital.	Total.	Discharged from hospital.	Died.	Remaining 31st Dec. 1834.
Apoplexy,	0	1	1	1	1	0
Cholera,	0	4	4	4	0	0
Dysentery,	0	88	88	88	1	0
Diarrhœa,	0	5	5	5	0	0
Fevers,	0	232	232	232	1	0
Opthalmia,	0	2	2	2	0	0
Pulmonary affections,	0	10	10	10	1	0
Ulcers chiefly of the feet,	0	58	58	58	0	0
Rheumatism,	0	46	46	46	0	0
Syphaloid diseases,	0	14	14	14	0	0
Slight injuries,	0	21	21	21	0	0
Sprains,	0	3	3	3	0	0
Enlarged spleen,	0	2	2	2	0	0
Total, Petoragur,	0	486	486	486	4	0

Fourteen persons received medicine in the lines of Petoragur for the cure of incipient goitres; while one person who took no remedy, left that post with a goitre of considerable size.

SECTION II.

INHABITANTS OF PRIMITIVE ROCKS.

In the Philosophical Transactions for the year 1784, it was shewn by Mr. Saunders, that the theory which ascribed the cause of Goitre to the use of snow water, was incorrect*. It would be useless to enumerate the different theories which have since been suggested, in order to explain the cause of the complaint. A reference to the latest of these will shew

* The merit is bestowed on Dr. Saunders, the author of a celebrated treatise on mineral waters, which work I have never had an opportunity of seeing. Mr. Saunders, a surgeon in the service of the East India Company, refers to the frequency of Goitre in the island of Sumatra, where snow never falls, long before Dr. Saunders's work on mineral could have been published.

the little success that has attended the inquiry.

It has perhaps been my good fortune to be more favourably placed for conducting the inquiry, or more indefatigable in collecting facts of a nature, that it would have been utterly impossible to have collected without great labour. Not indeed, such as deserves to be ranked either scientific or literary, but bodily labour, such as few could endure in a foreign climate.

During the course of the inquiries contained in the foregoing part of this work, I was struck with the frequency of Goitre in one portion of the district; while the other was almost perfectly exempt from the complaint, although an equality of moral as well as physical circumstances appeared to affect the whole. The external alpine characters of the province are the same in every part, the inhabitants all belong to the same tribes of Hindoos, and are subject to fewer irregularities in their mode of life than any other people in the world. In such a field, there could be little merit in eliciting highly important facts connected with this intricate subject.

That portion of Kemaon which lies on the south of the Ramesa river, is composed of siliceous and argillaceous rocks of the primitive class. The oldest of these is granite, which penetrates through the newer members of the series, and forms a lofty ridge about eight thousand feet high. In the centre of this ridge there are numerous small valleys, some of them seven thousand, and others as low as three thousand, feet above the sea, inhabited by persons who, some to avoid the winter's cold of their native mountains, and some to avail themselves of pasture for their cattle, descend into the plains, and are absent from their villages for five months every year. From inquiries which I made amongst these people, I found them to be affected with Goitre in the proportion of one in five hundred; but as they do not constantly reside in the mountains, they are excluded from the more minute statistic details.

The north-eastern acclivity of the chain of mountains above-mentioned, is intersected by numerous deep river valleys and ravines, as well as by low mountain ridges, which afford a climate more congenial to the feelings and wants of the inhabitants, who here reside constantly in their villages. Of these villages, forty-six have been visited; but two of their number having been only occupied for three or four years, are excluded from the general view: so that the number of villages on the south of the Ramesa river, which we are now to consider, amount to forty-three, and contain a population of 3,700: of this number, which I examined, I found only seventeen persons affected with the Goitre, and these were exclusively adults. The different localities of these villages are as diverse as can well be imagined. Some are erected on narrow ridges, others in deep valleys, surrounded by abrupt and lofty mountains; others on rugged declivities, between lofty peaks on the one side, and dark ravines on the other, into some of which the sun can scarcely penetrate. The different altitudes of these villages vary from two thousand to six thousand feet.

Let us now cross the Ramesa river, and enter the district of Shore, whose geological distinctions have been pointed out in a former part of this work; and we find that an eighth part of the people are affected with Goitre. Yet the whole inhabitants of the province are equally circumstanced with respect to religion: they intermarry, have the same customs, and are affected alike by moral and political influences; and finally, the tract in which the disease prevails, is the richest and most fertile portion of the province.

The natives themselves impute to the quality of waters, a powerful influence over their state of health; and when it is recollected, that water and farinaceous vegetables constitute the chief diet of Hindoos, any impurity of that fluid would produce effects more readily upon them, than on persons whose food and habits are less simple; but whether they are right, or wrong, in ascribing the prevalence of Goitre to the impurity of particular waters, I shall not here stop to inquire. A subject on which so many conflicting opinions exist, requires to be elucidated by such facts as from their number, force, and simplicity, can lead to no erroneous interpretation; and in collecting these facts, the method I adopted, on observing the prevalency of the disorder in one great section of the district, and its absence in another, was to mark the physical characters by which these places were distinguished from each other. The consequence was, a perfect agreement in external aspect, altitude, and climatology, but a very marked difference in their geognostic relations; and this distinction, which was even traced down to the very villages in which the disease is found, with such perfect nicety as to enable one almost to pronounce *a priori*, on examining the rocks of a neighbourhood, whether the inhabitants of it are affected with Goitre or not.

In pursuing the inquiry farther, it is found that every village is not equally affected in the same neighbourhood, but that some are quite exempt, and others affected to the extent of half their population; and this difference is not found to depend on any accidental or transitory cause, such as usually influence epidemic complaints; but has always affected the inhabitants of a particular village, while those of adjoining hamlets have continued perfectly, and permanently free from the complaint.

That this does not altogether depend on hereditary predisposition is rendered certain, by the numerous cases of persons who, having changed from a healthy to an unhealthy village, have become the subjects of the disease; and from the tumors of those affected becoming stationary, and even disappearing entirely during a residence in a healthy village. The following details of facts on which the foregoing statements are founded, will not, I trust, (although they are tedious,) be thought unworthy of attentive perusal. In order that we may proceed on some fixed and sure principles, I shall not include in the statistic notices, any village that has not been inhabited for at least nineteen years, or since the period at which the province fell into the hands of the British. For the same reason, I shall also exclude the villages adjoining and connected with the military posts; but I shall avail myself of these sources when they may serve to illustrate any fact of importance. To prevent the confusion of names on the map, I shall distinguish the various groups of villages to be noticed in this section alphabetically.

A. Villages of Rykote and Patan, six in number; they are situated two miles north of the military post of Lohooghat. The Patan villages are erected on the southern foot of a lofty mountain, and those called Rykote are surrounded by mountains distinguished by the same name, which ascend from 1,000 to 1,500 feet above them. The villages are elevated about 6,000 feet above the sea, and are erected on an iron-clay, derived from the disintegration of clay-slate. Their mean annual temperature is about 60°.

They contain 200 inhabitants, all of whom are free from Goitre.

B. Nine villages situated on the N. W. acclivity of the mountain called Gome-dace: their names are Nakote, Gourouly, Choka, Pimtolly, Jata, Borinkora, Nelto-kora, Chopota, and Seiligna. They contain 800 inhabitants. Four cases of small Goitre only, have been found among them, and the four persons are aged; they informed me they acquired the disease in their youth, while residing in a distant part of the country. These villages are erected on primitive and transition clay-slates—mean altitude about 4,300 feet, mean annual temperature about 64°.

C. Four small villages on the eastern declivity of Gome-dace. They contain 150 inhabitants, who are all free from Goitre. These villages are erected on primitive, and transition clay-slates—mean altitude 3,800 feet. The situation of these villages in the valley of the Mahi Kalee river, renders their temperature high, particularly as they are sheltered from all but the north and south winds.

D. Villages of Pansall, Cheemrouly, Konera, Leno Simela, Chomonnee, Lund, Katee, and Katully, nine in number, which contain 800 inhabitants. They are situated on low ridges and deep ravines. Mean altitude, about 3,700 feet. Mean temperature*, 70°. They are erected on primitive clay-slate: only three cases of Goitre could be found amongst their population.

E. Villages of Agee, Nina, Choura, Rye, Deortola, Gorong, Sutura, Chakora, Wallishone, and a few others, contain 600 persons, amongst whom four persons are affected. These villages are erected on primitive clay-slate. Mean altitude, about 4,000 feet.

F. Villages of Bentally, Jarig, Babra, Goumana, Biouly, Guinora, Kakur, and Barakote, situated in deep valleys, and on high ridges and declivities. They contain 500 inhabitants, six of whom have Goitre. They are erected on primitive

* Temperature does not always depend on altitude in these cases, but rather on local circumstances, such as aspect, shelter from prevailing winds, &c.

slate, siliceous sandstone, and transition slate. Their altitude varies from about 2,500 to 6,500 feet.

G. Jeercoonee is the name of a mountain which is given off from the Sooee group, about four miles N. W. of Lohooghat. It extends into the valley of the Ponar river on the west; is exceedingly rugged, and for the most part inaccessible. Deep ravines enclose it on three sides: in these are situated, on the north, three villages, which are named from the mountain; on the south are the villages of Junera, Dootee, Thur, and Mura: in all seven. They contain about 400 inhabitants, without a single case of Goitre. Nothing can be more frightful than the localities of these villages, from the lofty cliffs and mountains which seem to overhang them; while deep chasms lie at angles of 30° below. The altitude of these villages is from about 2,200 to 3,500 feet, and their mean temperature about 70°. They are erected on primitive slate and siliceous sandstone.

H. Rigong, Chimtouly, Bursolly, and

Popoulee. The two first are erected on low ridges of transition slate, surrounded by deep ravines and extensive forests; but the last is erected near the summit of a mountain of hornblende-slate. These villages contain 250 inhabitants, of whom none are affected with Goitre.

The following table exhibits the result of the details we have gone over in this section, in a way that will be convenient for comparison, with the result of similar inquiries in other portions of the province about to be detailed.

ABSTRACT OF SECTION. II.

PURGUNAS OR DISTRICTS.	Number of high-caste inhabitants.	Number of low-caste inhabitants.	Total.	Rocks in which the springs are situated.	Number of high-caste inhabitants affected with Goitre.	Number of low-caste inhabitants affected with Goitre.	Rocks composing the sites of the villages.
A. Rykote and Patan,	200	0	200	Clay-slate,	0	0	Clay-slate.
B. and C. Gome-dace,	850	100	950	Transition slate,	3	1	Transition slate.
D. Pansall, Chimtouly, Konera, Leno, &c.	700	100	800	Clay-slate,	3	0	Clay-slate.
E. Agee, Nina, &c.	550	50	600	Clay-slate,	4	0	Clay-slate.
F. Bentally, Jarig, &c.	460	40	500	Clay-slate,	4	2	Clay-slate.
G. { Jeercoonee, north side,	200	0	200	Siliceous sandstone,	0	0	Siliceous sandstone.
G. { Ditto, south side,	150	50	200	Clay slate,	0	0	Clay-slate.
H. { Popoulee,	50	4	54	Hornblende slate,	0	0	Hornblende slate.
H. { Rigong and Bursally,	170	26	196	Transition slate,	0	0	Transition slate.
	3330	370	3700		14	3	

NOTE.—To the abstract might be added, a population of about four thousand, who inhabit the gneiss and granite district, and who reside a few months of the year in the plains. These persons are affected with Goitre, in the proportion of one in five hundred, which would make the whole population of the primitive mountains embraced by the map on the south of the Ramesa river, 7,700 souls; of these, about 25 are affected with Goitre, or about one in three hundred and eight.

SECTION III.

STATISTICS OF SHORE VALLEY.

THE general situation of the district of Shore, as well as its geological structure, has been described. I shall now proceed to notice the villages which are situated in it, specifying the number of inhabitants in each, and their circumstances in relation to Goitre; but from the great extent to which the disease here occurs, it will be necessary to attend to more minute particulars than were observed in the last section, in order that nothing may escape that might be calculated to aid the inquiry.

I. A village, called Beesty, is situated on the southern extremity of a low group of hills, in the centre of the valley of

Shore. It is erected on clay-slate, and supplied with water from the same rock. It contains 60 inhabitants, all of whom are free from Goitre, except an elderly person, who came some years ago from another part of the neighbourhood, and the tumor has rather diminished than increased during a residence in this village.

II. Panda is half a mile north from the last described, and is erected on clay-slate; but scattered blocks of limestone partly cover the surface of the slate, and a small bed of the limestone terminates in a knoll, on which the village is erected. It contains 25 inhabitants, and all are free from Goitre. It is supplied with water from clay-slate, and is elevated about 100 feet above the level of the valley. The inhabitants of this and the last village belong to the caste of Rajpoots.

III. Salmora, the name of a few huts, situated at the northern extremity of the valley, about a mile from the last described village. It is inhabited by two families of distinct castes, seven persons in each family, and four individuals of the caste of Doms, and two of the Rajpoots, have Goitre; in all, six out of 14 individuals. This, like the former village, is elevated a little above the valley, and differs from it only in being erected on transition limestone, from which rock it is supplied with water. One of the Rajpoots is deaf and dumb, with a large head, and idiotic expression of countenance, which are all symptoms of Cretinism.

IV. Celouly, a small village, situated on the northern acclivity of the same knolls on which the two first hamlets are erected. It is elevated 300 feet above the valley. Its altitude and aspect render its temperature less than that of any of the former villages. It is erected on clay-slate, from which it is supplied with water. It contains 25 Rajpoot inhabitants, all of whom are free from Goitre.

V. Murh, a larger village than any of the foregoing; it is situated close to IV., but on the base of an opposite mountain, and contains 70 inhabitants, who belong equally to the castes of Rajpoots and

Doms; two of the former and three of the latter are affected with Goitre. It is erected on the junction of clay-slate and limestone, and an extensive bed of granatine, composed of dolomite spar, calc-spar, and steatite, advances close to the village. The basins of the springs are situated in this rock, but the waters are most likely derived from the substratum, as the granatine in question is seldom observed to afford springs.

VI. Goseragong—is situated a mile N. N. E. of Murh, and contains 18 inhabitants, 10 of whom are Rajpoots, and the rest are Doms: seven of the former, and five of the latter, have enormous Goitres. The inhabitants of this village assured me, that they seldom exceeded the age of 50, being generally cut off by this disease: and a person died of it only a few days before my first visit. The village is erected on a coarse conglomerate of calc tuff and rolled masses. Lofty precipices of alpine limestone ascend abruptly behind it to the height of two thousand feet; but the site is not more alpine than that of the seven villages at Jeercoonee. (G. Sec. II.) Goseragong is elevated about 200 feet above the level of Shore valley, and has an open aspect only on the S. E.; its temperature is consequently higher than that of the generality of villages in its vicinity, but in none of these respects is it more objectionable than either of the villages of Jeercoonee.

Water is supplied for the use of this village by a fountain, which issues from the limestone rock.

VII. Teebee. This village is situated three-quarters of a mile from VI., on an arm of the same mountain which extends into the valley. It contains 20 inhabitants, seven of whom have large Goitres. It is erected on clay-slate, coated with an incrustation of calcareous matter, and is elevated about 200 feet above the level of Shore valley, and is watered by a stream, which issues from the same source as that which supplies VI.; but in the present case, it is taken for use after running about a quarter of a mile in a natural channel.

VIII. Satgalinge is erected on an arm of a mountain which extends the same distance into the valley as the last. It has the same elevation, and is erected on the same rock, and the localities of both are close together, with a precisely similar aspect. It contains 40 inhabitants, and only two of them have Goitre. It is supplied with water from a spring in clay-slate. The inhabitants are Domes.

IX. Panère. The name by which three small groups of houses are distinguished in the north-western extremity of the valley, at an elevation of about 200 feet above it. Two of these groups contain 30 inhabitants, and four of these have Goitre. They use the water of a stream that descends a short way from its source, in the limestone cap of the mountain above them. The third portion of the group contains 24 persons, and is furnished with water from a spring in clay-slate. They belong to the Rajpoot caste, and are free from Goitre. The 30 persons first mentioned are Domes. Panère is built upon clay-slate.

X. Bajeetee is erected on the southern acclivity of a low ridge which intersects the valley from east to west. It contains 20 Bramins, and 30 Domes: of the former, three, and of the latter, 13 are affected with Goitre. These people derive the waters which they use for culinary purposes from two distinct wells sunk near the bed of a stream which issues from the limestone cap of the adjoining mountain. The wells are so situated with regard to the stream, that they do not seem to be supplied by any independent spring, but rather from the stream, particularly during the dry season. The rock surrounding the wells, as well as that on which the village is erected, is clay-slate, coated with calcareous matter, especially in all fissures, exposed surfaces, and rifts of the strata.

XI. Popdeon is situated half a mile west of X. and contains 80 inhabitants, 50 of the higher and 30 of the lower caste; of the former, eight, and of the

2 o 2

latter, 10 are affected. There are no distinctions in the physical relations of the inhabitants of the last village (X.) that the persons of this do not possess in common with them.

XII. Panorah is a village which is situated in the western extremity of Shore valley, about a mile west of the last. It contains 70 high caste inhabitants, and 20 Domes; of the former, one only is affected with Goitre, while six of the latter have large tumors. One of these swellings, which was the largest, I had an opportunity of seeing: measured two feet one inch round the neck, and one foot eleven inches from one angle of the under jaw, to the other on the opposite side.

The Bramin, or high caste inhabitants of this village, derive their water from a spring in clay-slate; and as the prejudice of the Hindoos denies to Domes the privilege of partaking of the water of the same spring, the excluded caste are forced in this, as in many other cases in Kemaon, to use this fluid from what they, as well as the Bramins, believe to be impure sources; and in this instance, it is taken from a stream that issues from the same limestone caps that afford waters to the two last-described villages. Panorah is built on clay-slate, slightly coated with calcareous matter.

XIII. Paruree. This village is lower down in the valley than any of the foregoing, and is about a quarter of a mile south of the small knoll on which Bajeetee is erected.

It contains sixty inhabitants of the Bramin caste, and there is no case of Goitre among them. This village is erected on clay-slate, and surrounded by fine springs in the same rock.

XIV. Dungaunee contains 25 inhabitants. They are free from Goitre. This village is situated half a mile south of the military cantonments, on the southern side of the low ridge which intersects the valley from west to east. It is supplied with water from a spring in clay-slate.

XV. Bagalla is a village situated a little lower in the valley than the last. It contains 18 persons of the higher, and 22 of the lower caste: none of them have Goitre. It is surrounded by springs in clay-slate, and erected on the same rock.

XVI. Kumora is situated a quarter of a mile east of Dungaunee, and contains 70 inhabitants, of whom two are slightly affected with Goitre. This village is elevated 50 feet above the valley on a small knoll forming part of the low ridge that intersects the valley, and which has been before mentioned: the ridge rises behind this, and the following seven villages to the height of about 200 feet above them, at a distance of 300 yards in their rear. This and the following villages are erected on clay-slate, and plentifully supplied with water from springs in that rock. The first three in the list are situated close to the limestone, which forms in tabular masses the rugged cap of the ridge.

XVII. (*a*) Jakane, 30 inhabitants, all free from Goitre.

XVIII. (*b*) Chouser, 50 inhabitants; no case of Goitre.

XIX. (*c*) Beera, 40 inhabitants; no case of Goitre.

XX. Boorikote, 100 inhabitants, no Goitre.

XXI. Kaseena, 15 inhabitants; no Goitre.

XXII. Kosooly, 25 inhabitants; no Goitre.

XXIII. Lailure, 100 inhabitants; no case of Goitre.

It is a remarkable fact in the history of this disease in Kemaon, that as far as we have yet proceeded, it will, on reference to the map, appear to extend in lines parallel to the direction of the strata. This important observation is strongly indicative of the influence of particular rocks on the remote cause of Goitre. The villages which are exempt from the morbid influence, are those which lie in a line along the base of the central ridge of the valley, beginning with Paruree (XIII.) and extending eastward to Lailure (XXIII.) and Murakote; on each side of these are the villages which are affected. They consist of two groups: one a mile distant, in the S. E. portion of the valley; and the other the same distance in an opposite direction; and both are disposed in lines parallel to the line of healthy villages we have just noticed, as well as to the direction of the strata.

The locality of the three following villages in the S. E. portion of the valley, bears a striking resemblance in external appearance and geological structure, to the site of those villages marked *a*, *b*, *c*, whose inhabitants may be said to be insulated from the limestone strata, inasmuch as they derive their supply of water from springs in another rock.

XXV. (*d*) Kutkora, 15 inhabitants, 5 Goitres.

XXVI. (*e*) Baldakote, 14 inhabitants, 7 Goitres.

XXVII. (*f*) Batuda, 16 inhabitants, 10 Goitres.

These three villages are those which compose the south-western line, and are erected on a conglomerate of calc-tuff, inclosing fragments of clay-slate and other rocks, and partly on clay-slate coated with calc-tuff. A clay-slate mountain supporting a massive cap of transition limestone, ascends to an altitude of 300 above them; pouring out numerous fountains, from which the immense beds of calc-tuff, on which the villages stand, have been derived. The waters are beautifully clear and limpid, and are taken for use as they jet from the rock. The peculiarity in the rocks from which their waters are derived, are the only relations in which the inhabitants of the villages *d*, *e*, *f*, differ from those of *a*, *b*, *c*: the altitude, aspect, temperature, religion, and morals of the inhabitants of both groups of villages being the same.

The villages on the north-eastern extremity of Shore valley, whose inhabitants are affected with the disease, are the following:

XXVIII. Deota. A lengthened village, which occupies half a mile of the foot of Durge mountain. One extremity of it is inhabited by Bramins, the other by Rajpoots and Domes. Of the first caste, there are about 20 persons, all of whom are free from Goitre; of the second there are 40, and two-thirds are affected more or less;

and of the third caste, nearly the whole are affected, 40 in number: so that, including the Bramins, there are only about forty persons in this village exempt from Goitre, out of a population of 100. To what cause can we ascribe the immunity of one caste of the inhabitants of this village, and the almost universal affection of the other two castes? They are all alike well fed, and have little toil; their land producing the requisites of life almost without labour. Difference of caste does not here imply a difference in pecuniary circumstances, and consequently of the comforts of life. In these respects, the three castes in this village are on perfect equality; nor will hereditary predisposition, acquired by intermarriages between affected parties, be sufficient to explain the interesting fact: for the affected parties are confined to the castes of Rajpoots and Domes, who cannot intermarry; while the Bramins and Rajpoots may.

The village is raised about 100 feet above the level of the valley, and the mountain, at the foot of which it is situated, rises with a gentle slope, and is not in this vicinity at all rugged. It is chiefly composed of transition limestone; and the village is erected on a conglomerated rock, composed of calc-tuff, inclosing masses and fragments of other rocks. There is a spring situated in the valley, at the distance of about a hundred yards from the village, which from its first appearance has the character of a mineral spring. The water bursts forth with strong ebullition from numerous veins, in the quantity of at least forty gallons a minute, and communicates adhesive properties to the sand and gravel by which it is surrounded*. The temperature and quantity of the water is the same at all seasons.

The former inhabitants of this village, aware perhaps of the noxious effects of the spring, had an aqueduct formed, by which water is conveyed into the Bramin portion of the village, from a distant source. The aqueduct being allowed to go out of repair, the quantity of water

* This is merely the effect of calcareous tuffa, deposited in loose aluminous and sandy earth.

it transmits is reserved exclusively for the Bramins; but during the rainy season, when water is plentiful, the Rajpoots also use the water of the aqueduct; but the Domes have no alternative at any season, but to use the water from the spring.

The circumstances of this village, with respect to Goitre, might of themselves be sufficient to confirm the doctrine of mineral waters; but so much difference of opinion has hitherto prevailed on the subject, that it is not likely such evidence alone will prove satisfactory, more especially as we are in the habit of overlooking occasional facts, as decisive as the above, though they have been brought to light by philosophers, whose names would have been sufficient security for their truth on any other question.

XXIX. Ninee. This village is also erected on the foot of Durge mountain, within a mile of the last described village. It contains 80 inhabitants, and there is not one case of Goitre among them. These people belong to the Rajpoot caste; their village is erected on clay-slate, which is partly detached from the base of the mountain by a small ravine, only a few yards wide. The mountain is here rugged and inaccessible; the village is supplied by a small but sufficient spring, in clay-slate.

XXX. Chonda. Also on the foot of Durge mountain, about two miles east of Deota. Chonda is built on a conglomerate of calc-tuff, inclosing fragments of slate and limestone. The inhabitants use the water of a stream which descends from the acclivity of the mountain depositing calc-tuff. For convenience, a few years ago, a portion of the stream was conducted in an artificial channel, through cultivated land, to the village—a circumstance, which there is some reason to believe, had modified the virulence of the water, for the tumors of those affected have not increased latterly, as they used to do; and children continue free from the complaint: of 25 inhabitants, seven are affected.

XXXI. Sunn. A little village, about a mile eastward of Chonda, on the opposite side of the ridge on which Lailure is erected. It is inhabited by a family of Bramins, 10 in number, and five of them have Goitre. This village is also watered by a stream which descends from the mountain acclivity.

XXXII. Oliel and Cubulcola. Two small hamlets, situated three miles eastward of Sunn, in the direction of the strata. These two villages are situated in a most pleasing amphitheatre, completely sheltered from northerly and westerly winds, and partly also from those of the south; but exposed to the full power of the sun, until a few hours before he sets, when the valley is left in shade. There are 25 inhabitants in these villages, 13 of whom have Goitre, and 10 of them are Cretins: of these a whole family is deaf and dumb. Their deafness appears to depend more on a general insensibility to external impressions, than on any morbid or preternatural conformation of the ears. They seemed also to be deficient in sight, and quite insusceptible of the passions of joy and fear. The mountains around the locality of these villages are composed chiefly of limestone.

XXXIII. Bagultolly, lies in continuation of the same line, and two miles east of the last-described, and probably about 1,500 feet below the level of Shore valley, in what now may be called the valley of the Mahi Kalee. Its aspect and locality are confined by mountains, which from this low situation seem, to be of great height.

It is erected on clay-slate, and partly watered by a spring in that rock, and partly by a stream from the mountain. It contains 25 inhabitants, four of whom have Goitre. The little arable ground around this village is in a high state of cultivation.

XXXIV. Bescolly. This village is on nearly the same level with the last described, but instead of being an inclosed valley, it is situated on an exposed though low ridge, composed of clay-slate, but covered by the usual calcareous conglomerate, and watered by fountains that are poured from the mountain acclivities:

these are composed of transition limestone, along with which serpentine here makes its appearance. Of 25 inhabitants in this village, 10 of them are affected with Goitre.

XXXV. Gooraght, situated two miles N. E. of the last-described. It is built partly on clay-slate, and partly on the conglomerate which now contains, in addition to the usual rocks, blocks of common serpentine. Water is procured from the mountain acclivity. Of 24 inhabitants, 10 have Goitre, and a father and two sons are Cretins: the sons are both deaf and dumb.

The two villages which we have noticed last, are less interesting in a scientific point of view, as the inhabitants at certain seasons are compelled to retire to some neighbouring locality, in consequence of the rapacity of wild beasts. I have, however, added them to complete the account of the population in this direction. For a similar reason I may add the following villages, which are situated in the eastern extremity of Shore valley.

They are permanently occupied, and are a continuation of the line of villages that are exempt from the Goitre. The three first are erected on clay-slate.

XXXVI. Chupuckea, 40 inhabitants, no Goitre.

XXXVII. Suakote, 40 inhabitants, no Goitre.

XXXVIII. Murakote, 40 inhabitants, no Goitre.

Some blocks of overlying limestone are strewed about the neighbourhood of these villages, but clay-slate affords a plentiful supply of water for their use.

XXXIX. In the lowest part of the water-shed of Shore valley, where the different streams have collected their waters into a river, which escapes through deep chasms in the mountains, there is found a partial sandstone formation, on which the following two villages are erected.

(a) Kotilla, 50 inhabitants, no Goitre.

(b) Ruena, 50 inhabitants, no Goitre.

XL. Deorcolla and Dingas are situated lower down the valley of the small river just mentioned; they are erected partly on a magnesian limestone, and partly on clay-slate. They are surrounded by many of the highest mountains in Kemaon. The two villages contain 40 inhabitants, and none of them are affected with Goitre. The surrounding acclivities are overspread with overlying masses of limestone.

ABSTRACT OF SECTION III.

Paragraph in the section under which the villages are described.	Bramins and Rajpoots.	Domes.	Total of both castes in each village.	Rocks from which the water is derived for the use of the inhabitants of each village.	Bramins and Rajpoots affected with Goitre.	Domes affected with Goitre.	Total of both castes in each village affected with Goitre.	Rocks on which the villages are erected.
I.	60	..	60	Clay-slate.	..	..	..	Clay-slate.
II.	25	..	25	Clay-slate.	..	..	..	Clay-slate.
III.	7	7	14	Transition limestone.	2	4	6	Transition limestone.
IV.	25	..	25	Clay-slate.	..	..	..	Clay-slate.
V.	40	30	70	Granatine.	2	3	5	Granatine and clay-slate.
VI.	10	8	18	Transition limestone.	7	5	12	Conglomerate of calc-tuff, slate, and limestone.
VII.	..	20	20	Transition limestone.	..	7	7	Clay-slate, coated with calc-tuff.
VIII.	..	40	40	Clay-slate.	..	2	2	Clay-slate.
IX.	48	6	54	Limestone and slate.	3	1	4	Clay-slate.
X.	20	30	50	Limestone ?	3	13	16	Clay-slate, incrusted with calc-tuff.
XI.	50	30	80	Limestone ?	8	10	18	Clay-slate, incrusted with calc-tuff.
XII.	70	20	90	Limestone and slate.	1	6	7	Clay-slate.
XIII.	60	..	60	Clay-slate.	..	..	..	Clay-slate.
XIV.	25	..	25	Clay-slate.	..	..	..	Clay-slate.
XV.	18	22	40	Clay-slate.	..	..	..	Clay-slate.
XVI.	70	..	70	Clay-slate.	2	..	2	Clay-slate.
XVII.	30	..	30	Clay-slate.	..	..	..	Clay-slate.
XVIII.	40	10	50	Clay-slate.	..	..	..	Clay-slate.
XIX.	..	40	40	Clay-slate.	..	..	..	Clay-slate.
XX.	100	..	100	Clay-slate.	..	..	..	Clay-slate.
XXI.	15	..	15	Clay-slate.	..	..	..	Clay-slate.
XXII.	25	..	25	Clay-slate.	..	..	..	Clay-slate.
XXIII.	100	..	100	Clay-slate.	..	..	..	Clay-slate.
XXV.	15	..	15	Transition limestone.	5	..	5	Clay-slate, coated with calc-tuff.
XXVI.	..	14	14	Limestone.	..	7	7	Clay-slate, coated with calc-tuff.
XXVII.	..	16	16	Transition limestone.	..	10	10	Conglomerate of calc-tuff, slate, and limestone.
XXVIII.	60	40	100	Limestone ?	27	33	60	Conglomerate of calc-tuff and fragments of slate.
XXIX.	80	..	80	Clay-slate.	..	..	..	Clay-slate.
XXX.	25	..	25	Limestone.	7	..	7	Conglomerate of calc-tuff and fragments of slate, &c.
XXXI.	10	..	10	Limestone.	5	..	5	Clay-slate ?
XXXII.	10	15	25	Limestone.	4	9	13	Clay-slate and calc-tuff.
XXXIII.	25	..	25	Limestone ?	4	..	4	Clay-slate and calc-tuff.
XXXIV.	25	..	25	Limestone ?	10	..	10	Clay-slate and calc-tuff.
XXXV.	24	..	24	Limestone ?	10	..	10	Conglomerate of calc-tuff, slate, and serpentine.
XXXVI.	40	..	40	Clay-slate.	..	..	..	Clay-slate and scattered blocks of limestone.
XXXVII.	40	..	40	Clay-slate.	..	..	..	Clay-slate and scattered blocks of limestone.
XXXVIII.	40	..	40	Clay-slate.	..	..	..	Clay-slate.
XXXIX.	100	..	100	Partial sandstone.	..	..	..	Partial sand-stone formation.
XL.	40	..	40	Clay-slate.	..	..	..	Clay-slate and magnesian limestone.
	1,372	348	1,720		100	110	210	

SECTION IV.

STATISTICS OF VARIOUS VALLEYS AND DISTRICTS.

AFTER a few more statistic notices of the district which surrounds Shore valley, we may then proceed to the analysis of the whole of the details, and render them into a more interesting shape than we have yet been enabled to do. As far as the nature of the subject may admit of it, the remaining details shall be shortened, by generalizing the villages with the valleys in which they are situated.

XLI. The great valley of the Ramgungah river is situated eight miles west of Shore. It is here, about 1,800 feet above the level of the sea; and the lowest villages are about 400 feet above the bed of the river. The mountain acclivities on each side ascend at angles of about 20° to the height of three or four thousand feet. They are composed almost entirely of limestone, of the transition and floetz periods; these rocks rest on primitive slate, which occasionally crops from under them. The direction of the valley is from north to south, and of the strata from S. E. to N. W.; the limestone formations consequently cross the valley obliquely. There are in this valley eight villages, viz. Bursar, Kuttygong, Tulsar, Sangur, Domera, Chumalloo, and two others. These villages are interspersed through the valley, at different altitudes, and are all erected on limestone. They contain 100 inhabitants, chiefly of the Rajpoot caste, and 60 of them are affected with Goitre. The following are the limestone rocks found to compose this part of the valley.

(a) Extensive beds of the transition rock.

(b) Compact limestone, which abounds in such quantity as to form the peculiar alpine character of this portion of the valley.

(c) Extensive deposites of calcareous tuffa inclosing rolled masses of other rocks.

XLII. The valley of Kalapany. This valley adjoins the northern extremity of Shore, and extends six or eight miles to the westward, where it falls into the valley of the Ramgungah (XLI.) It is probably one of the lowest inhabited places in Kemaon, and is closely surrounded by mountains, some of which ascend six thousand feet above the river, at angles subtending from 20° to 30°. It contains few villages, and the presence or absence of Goitre is here marked by the same concomitant circumstances that have been observed in Shore valley. The following are the two most considerable villages, and are most remarkable in the contrast they present to each other with respect to Goitre.

A. Beechelly. Situated in the lowest part of the valley. It contains 70 inhabitants, 30 of whom have Goitres. This village is closely surrounded by mountains of transition limestone, and is erected on an alluvial deposite, which is formed of the debris of other rocks, and cemented loosely with calcareous matter: 50 of these persons are Rajpoots, the remainder are Domes.

B. Reunna. Situated a mile to the eastward of Beechelly; contains 50 inhabitants, only one of whom has Goitre.

This village is as much inclosed by surrounding mountains as the last, and is only about 50 feet higher.

It is erected on the side of a knoll of transition slate, and having no spring, the inhabitants use the water of the river, which comes from the valley of Barabice. The inhabitants of this village are Rajpoots.

XLIII. Valley of Barabice is situated twelve miles north from the valley of Shore, and is elevated about 4,000 feet above the sea. It is somewhat of an oval shape, extending about four miles from east to west, and two miles from north to south. The eastern extremity of the valley is composed of clay-slate containing beds of talc. There are five villages in this end of the valley, which contain a population of 152; and I could not perceive, or learn upon inquiry amongst them, that there was a single case of Goitre in these villages.

The western extremity of the valley is bounded by a low ridge, which is formed of a coarse kind of satin spar (fibrous limestone), and first floetz limestone: these rocks rest on clay-slate, and six villages, which contain 192 inhabitants, are erected on them; and out of this number, 70 are affected with Goitre: but it must not be supposed, that these 70 persons belong equally to the six villages. The following two instances will illustrate the diversity that prevails in this respect.

(a) Ager. This village contains 50 inhabitants, 40 of whom have large Goitres, and twenty of them are Cretins. They use the water which issues from the drift of an old copper mine, which is situated in first floetz limestone. The people were earnestly solicited to discontinue the use of this water in future; and I pointed out a spring at some distance that they might substitute for it, in the full confidence of being benefitted by the change.

(b) Ducygong, situated within half a mile of Ager *(a)*, on the same rock, and contains the same number of inhabitants, and not one of them affected by the disease. They use the water of a spring in clay-slate, and belong to the Bramin and Rajpoot castes.

XLIV. The valley of Deodara is situated on the southern side of Shore valley, from which it is only divided by a detached mountain of clay-slate, with a slight deposite of tabular limestone on its summit. The opposite side of the valley is bounded by Takill, a very lofty mountain.

This valley contains two large villages and several smaller ones. It is well watered by numerous springs in clay-slate. It contains 250 inhabitants, of whom four persons only are affected with Goitre, and these are confined to a small village, which contains 20 inhabitants, and which is erected immediately beneath the limestone cap of the mountain which divides the valley from Shore.

XLV. The valley of Goron is situated on the western side of Shore valley, from which it is separated by a considerable ridge. It contains seven villages, and 179 inhabitants, 16 of whom have Goitre, and nine of these affected persons belong to a small village of 24 inhabitants, called Majara: the inhabitants of this village derive their water from a stream which rises in the limestone of the Oudepore mountains on the south side of the valley.

This valley is composed of a variety of rocks; but the villages are generally erected on clay-slate, which abounds in springs of pure water.

A village in this valley called Chana, is erected on the same granatine as that which occurs at Murh (V): it contains 30 inhabitants, two of whom are affected with Goitre.

XLVI. The valley of Roilputty extends along the S. W. foot of Takill, and is about seven miles distant from the valley of Shore. It is extremely wild and alpine, and contains only two villages, 25 persons in each.

1st. Tomilly is erected on transition slate, which contains no water: this fluid is consequently procured from a stream which falls in a small but picturesque cascade over the rocky precipices of lime-stone that here form the declivity of Takill. Six cases of Goitre are found in this village, and a third of the whole of the inhabitants approach nearly to the condition of Cretins.

2nd. Kurkolly, the second village, is erected on the same rock with the first, but at a lower and more distant portion of the valley. It is furnished with water from the same rivulet, after it has run about a mile and a half along the valley. In this village there is but one Goitre.

XLVII. The valley of Beechar is connected with the south-western extremity of Shore valley, and is only divided from it by a low narrow ridge. The water-shed of the valley descends from the north-west, and is composed of clay-slate: on this is situated a village containing 40 inhabitants; and all are free from Goitre. On the lower side of the valley, and near the base of a lofty mountain, are two villages erected on a knoll of argillaceous slate, whose surface is coated with a slight calcareous incrustation. One is occupied by Bramins, the other by Domes; about 20 of each sect. Five of the Bramins and ten of the Domes are affected with Goitre. Some of the tumors are extremely large, even in persons of the age of ten years. Water is here afforded by two springs, situated close together. They resemble the spring at Deota (XXVIII.) in almost every particular. The waters boil up in such quantity as at once to occasion a considerable stream. They were surrounded by so much sand and gravel, that I was unable to ascertain the rock from which they emerge; but limestone is found within a short distance of the springs on the one side, and clay-slate on the other, so that the geognostic position of the veins from which the waters issue, may be presumed to be situated between these two rocks.

ABSTRACT OF SECTION IV.

	Names of the valleys.		Bramins and Rajpoots.	Domes.	Total of both castes in each village.	Rocks from which the water is derived for the use of the inhabitants of each village.	Bramins and Rajpoots affected with Goitre.	Domes affected with Goitre.	Rock on which each village is erected.
XLI.	Valley of the Ramgungah river,		100	0	100	Limestone,	60	0	Limestone.
XLII.	Valley of Kalapany,	A.	50	20	70	Limestone,	20	10	Conglomerate of calc-tuff, &c.
		B.	50	0	50	River,	1	0	Transition-slate.
XLIII.	Valley of Barabice,	Eastern extremity,	120	32	152	Clay-slate,	0	0	Clay-slate.
		Western extremity,	110	82	192	Limestone,	30	40	Limestone.
XLIV.	Valley of Deodara,		145	80	225	Clay-slate,	0	0	Clay-slate.
			25	0	25	Limestone,	4	0	Clay-slate.
XLV.	Valley of Goron,		0	24	24	Limestone,	0	9	Limestone.
			90	35	125	Clay-slate,	5	0	Clay-slate.
			30	0	30	Granatine,	2	0	Granatine.
XLVI.	Valley of Roilputty,		25	25	50	Limestone,	1	6	Clay-slate.
XLVII.	Valley of Beechar,		40	0	40	Clay-slate,	0	0	Clay-slate.
			20	20	40	Limestone,	5	10	Clay-slate, incrusted with calc-tuff.
			805	318	1123		128	75	

RESULTS ATTAINED FROM THE FOREGOING SECTIONS.

TABLE V.

ABSTRACT VIEW OF THE INQUIRY GONE OVER.

Names of rocks.	Number of villages.	Number of inhabitants.	Number of persons affected with Goitre.	Number of Cretins.	Mean altitude.	Mean temperature by Fahr.	General remarks.
1 Granite and gneiss—see note at the end of Section II. ~	0	0	0	0	6500	68°	Doubtful, in consequence of the temporary residence of this portion of the population in the plains; but the proportion of Goitre is about 1 to 500.
2 Hornblende slate and mica slate, ~	1	50	0	0	6000		
3 Clay-slate, ~	71	3957	29	0	4100	78°	
4 Steatitic sandstone, ~	3	200	0	0	3500		
5 Granatine, ~	2	100	7	0	4000		
6 Partial sandstone, ~	1	40	0	0			
7 Transition floetz and alluvial limestones, ~	35	1160	390	34	4000	78°	
	126	6543	430	34			

OBSERVATION.

XLVIII. From the above abstract it appears, that the proportion of the inhabitants of each rock, who are affected with Goitre and Cretinism, will stand to the healthy in the following order:

Granite and gneiss—Goitre, $\frac{1}{300}$; Cretins, none.

Mica-slate and hornblende-slate—Goitre, none; Cretins, none.

Clay-slate—Goitre, $\frac{1}{136}$; Cretins, none.

Transition-slate—Goitre, $\frac{1}{249}$; Cretins, none.

Steatitic sandstone—Goitre, none; Cretins, none.

Calcareous rocks—Goitre, $\frac{1}{3}$; Cretins, $\frac{1}{67}$.

Are we to suppose that these interesting results are the effects of chance, or of an accidental association of circumstances confined to a particular spot? When we recollect that a space of upwards of a thousand square miles has been made subject to the inquiry, and that in every portion of this space, the same invariable circumstances attended the presence of the disease, and that its absence was invariably distinguished by the absence of those circumstances, it is more philosophic to view them in the light of cause and effect.

SECTION V.

DESCRIPTION OF GOITRE AS IT OCCURS IN KEMAON, WITH AN ATTEMPT TO ACCOUNT FOR THE FOREGOING RESULTS.

XLIX. It is not because the subjects of this disease are in general peculiar to remote districts, that they are the less to profit by the zeal and sympathy of their more fortunate fellow creatures. There is a mistaken notion expressed by some authors, who, speaking of the comparative innocence of the disease, set forth its unsightly appearance as its worst effects; and thus they deprive the inquiry of that interest which is felt in prosecuting researches into the nature of other disorders. Those who express themselves so, cannot have had sufficient opportunities of witnessing the misery entailed on the inhabitants of tracts of country in which the Goitre prevails to the extent it does in Kemaon. There is no other disease for which the people have greater dread, or from which they are more anxious to be relieved. It is true, the victim is not suddenly cut off; the ultimate effects of the disorder are, however, scarcely less fatal than those of any other complaint to which we are subject; nor is the patient entitled to less commiseration because his sufferings are protracted.

The next object is to inquire whether the Goitre in Kemaon be a peculiar disease; and this point will be best determined by a brief description of the nature and treatment of the complaint.

The tumor does not always originate in the thyroid gland; but in a third of the cases I have seen, it appeared to commence with a fulness of the base of the neck, on one or both sides over the middle of the clavicle: from thence the swellings ascend, and in a longer or a shorter time, reach the situation of the thyroid gland, when both tumors unite.

In its progress up the neck, the tumor sometimes appears to become entangled, as it were, in the folds of the *fascia cervicalis ;* it then becomes indurated and forced between the trachea and œsophagus, where it displaces these organs, and often proves fatal by interrupting their functions before it increases to any considerable size; and without even extending to the thyroid gland, being apparently confined to the lymphatics, which accompany the great vessels of the neck.

In its more common form, the thyroid gland is first affected, and the tumor increases to a great size, without causing much inconvenience, especially if it be loose and pendulous; but in many cases of this form of the disease, the tumor is probably compressed by the same cause as was observed with respect to the first variety, and dyspnoea becomes the most prominent symptom; the lips become darker than natural, the eyes blood-shot and protuberant, and the patient dies from protracted strangulation.

The disease begins at any period of life after the age of three years; and never as far as I have seen, arrives at its full size sooner than six years from the time of its commencement, but is generally much slower: its progressive augmentation seldom, however, becoming perfectly suspended during a residence in an affected village.

This description must be received as in some measure empirical, the prejudices of the Hindoos of Kemaon being such as not to suffer the dissection of their dead.

The usual size of a full-grown Goitre is about one foot ten inches in circumference, including the neck; and about two feet from one angle of the lower jaw to the other of the opposite side, (measuring under the tumor.)

Incipient tumors of only a few months' or a year's duration are easily dispersed by stimulating linaments, and a few alterative doses of calomel; but without the change of the accustomed water, these means will only afford temporary relief.

L. From the above description, there

can be no reason to doubt the identity of this disorder with the strumous endemic of Switzerland; and wherever it is found, from Abyssinia and the Chinese Wall, to Sumatra and Derbyshire, it appears to present the same characters, and is less under the influence of climate than perhaps any other complaint. Does not this fact establish the importance of the singular results of these statistic inquiries, by opening a new field to our researches into the nature of endemic contagion?

The next point is to inquire into the manner in which the results in question are affected, by what is generally known respecting the physical structure of those countries in which the disease is endemial.

LI. From the writings of geologists, we learn that alpine limestone does not occur to any great extent in the mountains of Ireland, nor in those of Scotland and Wales; and in these countries, Goitre is unknown. In England, the disease is known by the name of the Derbyshire neck, and is principally confined to Derbyshire, where the particular rock in question forms the characteristic features of the county*.

In the Alps of Switzerland and Tyrol, where Goitre and Cretinism both prevail, we have the authority of geologists, that alpine limestone and *nagelflugh* compose the greatest portion of the mountains. Humboldt mentions (Pers. Narr.) that nagelflugh covers the greatest part of Switzerland to the height of a thousand toises. Now this *nagelflugh*† is the same

* In Cumberland and Wales, there are more lofty mountains than in any other part of England, Scorfell and Snowden being nearly 3,300 feet above the sea; while Axe-edge, the highest peak in Derbyshire, taken by Colonel Mudge, is only 1,751 feet: so that Goitre in that country cannot be owing to the height and magnitude of its mountains, but the cause must be sought in their structure; accordingly, we find the mountains of Derbyshire are composed of alpine limestone, while those of Cumberland and Wales consist, for the most part, of granite, clay-slate, porphery, and sienite.

At Fribourg, Valteline, Berne, Pay-de-Vaux, Dresden, Savoy, and Piedmont, the most remarkable districts in Europe for the prevalence of Goitre, alpine limestone constitutes the principal rock formation?

† "Nagelflugh," says Professor Jameson, (Syst. Min. 1808,) "is usually composed of fragments of limestone,

rock (or nearly so) as that on which the villages of Goseragong (VI.), Batuda (XXVII.), Deota (XXVIII.), and Chonda (XXX.), are erected villages, whose inhabitants are affected with Goitre to the extent of half their population. This rock is composed in Kemaon of a basis of calc-tuff, inclosing fragments of other rocks, from the size of a grain of sand to that of a mill-stone. These fragments are either rounded or angular, and the basis in which they are imbedded is either solid or vesicular. The matrix of the rock is a chemical deposite derived from water, and the inclosed masses which it contains appear, at first view, to indicate some catastrophe by which they were broken and precipitated to their present situation. By attending more deliber-

more or less rounded, and of various magnitudes, cemented together by a basis of calc-sinter. It occurs always at a greater or less distance from limestone mountains, and sometimes forms considerable tracts of country." It appears abundantly at the foot of the great hills of alpine limestone that bound Bavaria to the south, and in many other places in the great limestone range that passes through Tyrol, Styria, &c.

ately to the changes that are going on in nature, the formation of nagelflugh appears to be extended down to our own time, as an alluvial deposite, occasioned by the constant crumbling of rocks, and rolling down of masses and fragments separated by the chemical and mechanical agencies of the atmosphere, and again consolidated by the deposite of calc-tuff from the waters of alpine limestone.

The different appearances which a rock of this nature must necessarily assume, has procured for nagelflugh a greater variety of designations than any other formation; calcareous sandstone, breccia, conglomerate, and pudding-stone, are names that have no doubt been applied to different varieties of it by English writers. It is best distinguished by being always subordinate to alpine limestone, and it is on this latter account only, that its connexion with Goitre appears to be important.

LII. Alpine, or compact limestone*,

* It is the erster floetz-kalkstein, or first floetz-limestone of Werner; the lowest stratum of it is the bituminous-marl-slate, or the copper-slate of the miners.

does not admit water by percolation, through its solid substance by means of porous or absorbent qualities; but by open rents and fissures, which communicate with subterraneous caverns in the centre of mountains, where it may either remain for ages, or flow out by counter fissures*.

* Speaking of alpine limestone, Humboldt says, (Pers. Narr.) "It is the rock that so often interrupts the course of rivers, by engulphing them into its bosom."

"The whole of that enormous mass of limestone at Craven (in Derbyshire), from Ingleborough to Whernside and Gordal, is intersected by perpendicular fissures, which are narrow at the top, and become wider as they descend, through which the water may be heard at a vast depth below *******. Castleton and Poolshole, near Buxton, and Yardas Cave, under Whernside, in Craven, Gerdal, Scar, and Weathercock, in the same district, can scarcely be called caverns, as they are open to the day; but the latter was formerly a cavern, of which the roof has fallen in." "In all these caverns, and others which I observed," (says Mr. Bakewell, Introd. to Geolog. Lond. 1815,) "there is a stream of running water; and I am inclined to think, that the caverns have been formed by the agency of water, percolating through fissures; and in the lapse of ages, excavating the softer or more broken part of the rock."

"The mines seem to be, or to have been, open channels, through which the waters pass within the earth, Water thus circulating through confined caverns, without having undergone pre-

and like rivers, have their small branches opening into them in all directions, which are by miners called feeders of the load. Most mines have streams of water running through them ; and when they are found dry, it seems to be owing to the waters having changed their course. ***** Sometimes the mine is lined with an intermediate substance between the load and itself : this is the wall of the load. *** The springs in these parts are always hard, as abounding very much either in stony, or sulphuro-saline particles."—*Dr. Nicholl's Observ. Nat. Hist. of Mines*, 1728.

I might quote farther observations of Dr. Nicholl, one of the most eminent physicians of his time, illustrative of the changes to which water is exposed in the bosom of the earth; but his papers may be consulted in the Phil. Transac.

"The three rivers, as they are commonly called, in Peakshole are only some parts of the cave deeper than the rest, and receiving all their waters from the spring, which comes from the farther end of the cave. The waters which pass through Poolshole are impregnated with particles of limestone, and so have incrusted the whole cave in such a manner, that it appears like one solid rock."—*Nat. Hist. Derbyshire, by J. Martyn*, 1729.

See also the eloquent description of the caves near Bayreuth, by His Most Serene Highness the Margrave of Anspach.—(Phil. Trans. 1794.) Also "Observations on vious percolation, is likely to assume changes dependant on the various vegetable and animal impregnations with which it may be loaded: these engender new agencies, which operate on the numerous mineral substances with which the water comes in contact. In the confinement of narrow caves and fissures of limestone, the surface of this subtile fluid

the Nature of Intermitting and Reciprocating Springs, by J. Atwell, F. R. S.—(Phil. Trans. 1732.) "These mountain caverns will account for the statement of Pliny," (lib. xxxi. 4,) "that earthquakes pour out and drink up waters."—See account of the great earthquake at Naples, 1731.—Phil. Trans. 1733 and 1735, by Dr. Cyrillus.

Mathias Belius describes two caverns in Hungary.—(Phil. Trans. 1739,) "The one emits noxious vapours, and is overflowing with water, which deposites a tophas. **** When subterraneous waters flowed from the interior of the fountain in the hidden passages, the ground began to give way, and at length formed a new opening, when it began again to emit noxious vapours, destructive to birds and other animals.

"In the cavern is heard the murmuring noise of running waters, so that a river probably flows through the interior passages, and at last loses itself in some kind of shallow."

becomes so much extended, that every portion of the surrounding superficies is exposed to its action. No other rocks contain such extensive repositories of extraneous fossil and metallic substances, and no other formation of rocks contains such extensive caverns and fissures, where these foreign substances are exposed to the slow action of this menstruum. Hence the greater number of mineral springs that abound in calcareous, than in any other, rocks*.

LIII. Having endeavoured to explain the influence that alpine limestone is capable of exercising on the waters of a district, it remains to offer a few observations on the effect which calcareous rocks may, under peculiar circumstances,

* Such as the mineral springs of Buxton, Matlock Malvern, in Derbyshire—Bath, Bristol, and the springs of Imaw in Suabia, Carlsbad in Bohemia, and the salt springs of Konigshorn, (Klap.,) and those of Seltzer, Sydchutz, Spa, Pyrmont, and the baths of Carolin in Bohemia, (Berg.;) and probably many other celebrated mineral waters, whose physical topography I am unable to refer to at present.

exercise on the condition of the air in their vicinity.

The peculiarity of air in mountains has been often brought forward as the exciting cause of Goitre, although no attempt has ever been made to explain in what the peculiarity alluded to consists, or why it should exist, farther than that it is supposed to be excited by a warm atmosphere, in situations where the free circulation of air is impeded; but now that we have traced the disease to a peculiar constitution of strata, our notions on this intricate point may soon become more precise: and it deserves to be inquired into, whether or not, the exhalations from limestone rocks contain a larger proportion of carbonic acid gas, than is found to exist in the general atmosphere.

Peculiarities in the physical and chemical constitution of mountain rocks have been hitherto quite overlooked as a source of endemic contagion, which may in some degree perhaps account for the little success that has attended the researches of philosophers upon the subject;

for although it has been known in all ages, that there is a difference in the air in different places, by its effects on the human constitution; yet all that has ever been demonstrated by the eminent men that have entered upon the inquiry, was the imperfection of our most refined chemical tests; that in fact some farther improvements must be made in chemical science, before the nature of contagion can be demonstrated.

Humboldt found the proportion of carbonic acid gas, in the atmosphere, to vary from 0·01. to 0·005. of the bulk of the air; but he does not appear to connect this important variation with local peculiarities of geological structure.

It is well known, that air containing 0·1 of its proportion of this gas extinguishes light, and is speedily destructive of animal life; and as this volatile poison exists in limestone, to the extent of 44 parts in 100 of the solid rock, it is possible to conceive that a sufficient quantity of it, to cause a more or less vitiated condition of the air, may be extricated from limestone by atmospheric heat, assisted by such other causes as promote the decomposition of the rock.

This gas floats on the surface of the earth in places from which it is extricated; it is evolved by mineral springs, and by all waters, which contain it; and it is separated from limestone, the great repository in which it abounds in nature, by *heat;* and the important questions that remains to be decided are, whether the heat of the atmosphere is sufficient to separate it in any noxious quantity; and whether if, by means of pyrites, assisted by moisture and atmospheric heat, an insensible evolution of carbonic acid gas is not constantly taking place in certain localities? These, next to the examination of the waters, are points which are entitled to careful attention.

A reference to the mineral topography of all the villages in Kemaon which I have examined, but one, seems to favour, rather than negative, these views; and even with regard to the village of Ager (XLIII.), the occupation of the inhabitants as miners, to which they have been brought up from childhood, may expose them sufficiently to impure air, to occasion much of their bodily infirmities, independent of any noxious evolution of gas, in the way we were supposing it possible to occur.

If there be difficulties in the way of conceiving the possibility of the emission of carbonic acid gas from limestone, its absorption by lime-water may be suggested, as a means by which it may be attracted by the moisture on the surface, and at the base of calcareous mountains.

The thin incrustation of calcareous matter, so often observed on the surface of clay-slate, composing the site of many of the affected villages in Shore valley, and its vicinity, may have been formed by particles of lime having been partially reduced by heat and drought on the adjoining acclivities, and carried by the winds to the knolls of slate, whose moist and absorbent surfaces arrested their drift, and converted them into a cement, by the attraction of carbonic acid from the general air. Until we are better informed, we should certainly not be too ready to despise the effect, which such operations may have in animate, as in inanimate, nature; and attention to them might assist in explaining the cause of this disease in certain low tracts extending along the base of the Alps, as well as the Himalayas.

SECTION VI.

GENERAL OBSERVATIONS ON THE EXAMINATION OF WATERS.

LIV. In the examination of the waters of a province, or extensive district, it may be necessary to keep in view the geological distinctions by which the several portions of it are characterised, as any peculiarities in the qualities of waters, when derived from springs in the earth, must depend on the nature of the mineral substances which compose their localities. The importance of this observation has always been known, and generally attended to; but it may have derived additional consequence from what has transpired in the preceding sections.

Water constitutes the medium by which living bodies are supplied with new materials. Plants will not vegetate without it, and most of those earthy, alkaline, and metallic substances, which are common to spring-waters in general, have been discovered to constitute a portion of vegetable bodies. There is scarcely reason to suppose, that these substances are formed in vegetables by any property of the living principle; we must therefore believe them to be imbibed from the soil through the medium of water and food, and consequently to differ in some degree with the mineral constitution of the places in which vegetables grow.

The same observations apply to animals; but as they are endowed with locomotive functions, they may be supposed to contain a greater variety of extraneous substances: still, however, differing according to the rocks and soils they inhabit. The presence of lime, sulphur, magnesia, silica, iron, and manganese, in animal bodies, has been long known; although their production is supposed to be incompatible with the functions of living organs. We are thus led to believe, that these extraneous substances may differ in their proportions in living bodies, according to the peculiarities of geological structure in particular places; as, however, a certain proportion of these foreign matters is essential to the healthy state of animals, so any deviation in this respect may be the cause of endemial disease, as Struma, Plica Polonica, and Scorbutus.

Although waters, containing impregnations to a degree that causes powerful medicinal effects on the human constitution, are found in almost every country, it is not a little surprising that the several degrees of impurity between the medicinal and the pure water should be so much overlooked. The difficulty of pointing out the various impurities, and the unusual circumstance of any being perfectly pure, is no doubt the cause of the general indifference of physicians to the quality of water.

It is remarked, (1 Berg. 112,) that the complete analysis of water is one of the most difficult operations in chemistry.

The difficulties, or rather the imperfections, are occasioned by the minuteness of some substances, and the evanescence of others, with which water may be impregnated. Bergman found the active principle of the Lokarne water escape in four hours through a glass vessel, though corked and sealed in the most careful manner, in a northern climate. Those who deny the influence of particular waters in causing the Goitre, merely because they cannot demonstrate the noxious principle, and its *modus operandi*, should recollect, that although snow was found by the illustrious chemist above mentioned, to form the purest natural water, yet he would not venture to deny the effects on animals ascribed to it, merely from the deficiency of common air in the water of newly-melted snow: and although the noxious effects of this water has been found to be imaginary, it serves to shew the importance attached to certain conditions of water, which differ but slightly from a wholesome standard; and should guard us against rash conclusions, on a question of so much difficulty.

The ancients observed the diminutive size and sickly appearance of plants growing on mountains which contained metals: and although this notion has been lately condemned as fanciful, by an eminent authority, I have observed some of the most remarkable metalliferous mountains in Kemaon, without a shrub; yet they are surrounded by others of a more earthy structure, which are clothed with dense forests to their summits.

I have been led to make these remarks from some facts, which tend to point out, that the noxious principle in the waters of alpine limestone is a subtile combination, derived perhaps from those strata of the rock which are called by miners copper-slate, so distinguished from the quantity of metals which they contain, particularly the ores of copper; and in describing the physical locality of the springs which supply those villages, whose inhabitants suffer most from Goitre, they may be said to be generally derived from the strata in question. In the first floetz limestone in Kemaon, the metals are not accumulated in large masses, in particular repositories, such as veins; but they are disseminated in nodules, leaves, and small particles throughout the strata seams and interstices of the rock. Thus I have found copper pyrites in the vicinity of Petoragur and Goseragong, and at the village of Ager, ten miles distant from the former places; and the whole intervening space (including the sites of most of the affected villages) may be considered as one great repository, in which the metal is disseminated in the manner just described; so that every circumstance appears calculated to produce a vitiated state of the waters, which here, at least, it might be supposed, would be easily detected. Such I am sorry to say is not the case, although I have seen enough to justify the views which are here expressed.

Mr. Saunders, in the account of his journey to Boutan, (Phil. Trans. 1784,) alludes to the frequency of Goitre in Sumatra, which allusion destroyed the theory which referred the disease to the use of snow-water. Now, although snow never falls in Sumatra, it is a fact that goes singularly to the support of the above observations, and one, no doubt, that will soon be converted into some new hypothesis, that copper ore is most abundantly disseminated in that island.

"The ore of copper," says Mr. Macdonald, (Asiat. Res. 417,) "is found on, and under the soil of soft rock;" again, "the space affording the ore is considerable, extending over a degree in length, and farther east, or into the country," (Sumatra,) "than has yet been discovered."

With respect to the remark of Werner, in his celebrated Essay on Veins, that "the water which flows from metallic veins ought to carry along with it a quantity of metallic particles, which, however, it does not; and even in those countries, which contain the greatest number of mines, the water rarely contains a small portion of iron; scarcely ever any particles of copper; never silver, lead, tin, zinc, cobalt, mercury, or arsenic:"—without entering into any speculative argument against this apparent paradox, it is sufficient to mention, that metals in their mineral state are insensible to the most powerful chemical tests. Thus copper pyrites and iron glance, as well as iron pyrites, were reduced to the finest powder, and mechanically suspended in distilled water, to which prussiate of potash was added, without affording the slightest indication of their presence. The same was repeated with tincture of galls, with the same result.

It is mentioned by Klaproth, that even iron, a metal for which we have such excellent tests, is capable (when in small quantity, as in Carlsbad waters) of "eluding the senses, as well as the efficacy of re-agents, unless examined at the spring." Hence it is, from the small quantity in which they occur, and the imperfection of analysis, that certain metals have not been found in waters, rather than from any incompatibility that can be supposed to exist with regard to such mixtures.

By adopting this natural conclusion, we give additional scope to our researches into the cause of endemic contagion, without pledging ourselves to particular hypothesis; for although, in the present state of our knowledge, we may suspect the noxious effects of metallic salts and particles of pyrites in the waters of certain districts, we are not insensible to other peculiarities in the constitution of waters, or to the power of other morbid causes to which the inhabitants of particular districts may be exposed.

Our knowledge of the active principles of mineral waters, notwithstanding the advances that have been made in their analysis, is very defective, and philosophers are by no means reconciled, as to whether chemical analyses are capable of discovering the cause of their effects. "This question" (says Dr. Murray, than whom few are so qualified to give an opinion) "some have been disposed to decide in the negative, from finding examples of waters possessed of active powers, in which analysis does not detect any ingredient of adequate activity*;" and Dr. Murray mentions, as an instance, the celebrated Bath waters.

With such proofs of the imperfection of the art, it may be vain to hope to demonstrate by chemical analysis an agent that requires years to develope a comparatively local deformity: nor is the task rendered less hopeless by what Dr. Murray says of the waters of Ilkley, a mineral spring of considerable celebrity, and which is held in high estimation by several eminent medical practitioners; yet he found this water uncommonly free from all foreign matter, and during the time he was engaged in the analysis, Dr. Murray had himself proofs of its medicinal efficacy.

* Edin. Phil. Transactions, vol. vi. pp. 352-3.

SECTION VII.

EXAMINATION OF THE WATERS OF KEMAON.

LV. The first waters to be examined are those of Goseragong (VI.), Deota (XXVIII.), Ager (XLIII.), Batuda (XXVII.), and Beechar (XLVII.)

General accounts of the situation and appearance of these respective springs have been already given; but it may be proper to recapitulate part of what has been said, and to add such farther observations as may complete the account of their physical characters.

1. Goseragong water issues from a crevice at the base of a lofty precipice of limestone of the first floetz formation, and the jet is situated at the junction of

that rock with clay-slate. The quantity of water which issues is about two gallons a minute, and its temperature is 67° Fahrenheit at all seasons, which is about the mean annual temperature of the place. It is perfectly limpid, and sparkles briskly when poured into a glass. The taste is slightly acid and agreeable, and a large quantity of calc-tuff is deposited from the stream, as it falls down the surface of the mountain. Its specific gravity is 1·009.

2. Deota. The basin of this spring is situated in a low part of the valley of Shore, and is composed of red clay, gravel, and marl, loosely cemented. The spring has a lengthened form, extending in the direction of the neighbouring strata; and if two or three adjoining springs of the same character be included, the whole may be said to be about 300 yards long. The surface of the waters is disturbed like boiling furnaces, from the violence with which they issue from the earth. The larger spring discharges enough of water to put in motion the most powerful machinery. Temperature,

65° Fahrenheit, which it retains at all seasons. Taste less agreeable than Goseragong water; but still sweet and equally brisk, but less crystalline. After remaining a certain time in corked bottles, it deposites slight bluish grey flocculi*. Its specific gravity is 1·001.

3. Ager. This water issues from the drift of an old copper mine, in the quantity of about half a gallon a minute: the source of the spring is between the first floetz limestone and graphite, which contains copper pyrites. It is perfectly limpid, and sparkles when poured fresh into a glass.

On standing for a few months in bottle, a slight precipitate of ragged putrescent-

* These flakes were collected on a filter, dried, and found to weigh about a tenth of a grain from a bottle of water. They were very slightly soluble in nitric acid; the residue, which amounted to very nearly the whole, was melted on charcoal, before the blow-pipe, with borax, to which it gave a yellow colour.

The globule thus afforded, being reduced to powder in a glass mortar, and dissolved in nitric acid, was tested with prussiate of potash, and afforded a precipitate of iron.

like matter descends slowly to the bottom*. Its specific gravity is 1·0009.

4. Batuda. This spring is exactly similar to that of Goseragong in all particulars, the jet having the same geognostic position, the water itself crystalline, acidulous to the taste, and possessed of the property of forming calc-tuff. Its specific gravity is 1·0010.

5. Beechar. Here we have an almost perfect agreement in the appearance of the springs with those of Deota. The water ascends in perpendicular columns, so as at once to form a considerable stream. The source of the spring is situated between the strata of limestone and clay-slate, and is concealed by an accumulation of gravel slightly cemented with

* This flocculent matter from a bottle of Ager water was collected and weighed, but though bulky, was too light to make any sensible impression on the balance (not a very delicate one). It was moistened with distilled water, and gave a red tinge to oxymuriate of mercury.

On the application of the white flame of the blowpipe to this matter, it entirely volatilized, so that it may be considered as of an ammoniacal nature.

calcareous tuffa. Temperature 64° Fahrenheit, when the general air in the shade was 82° Fahrenheit, and it never changes: it has consequently the character amongst the natives, in common with the four preceding waters, of being a cold spring in warm weather, and a tepid one in the cold-season. The water is clear and very faintly acidulous to the taste. Specific gravity, 1·0011.

LVI. Effects of precipitants on these waters.

(A) At the spring they very faintly redden litmus, but the change is not permanent.

(B) Goseragong water four hours in bottle, at a temperature of 85° Fahrenheit, but secured as carefully as possible with a common cork, afforded, by the application of lime-water, two grains of dry carbonate of lime from three ounces of the water. Beechar, Deota, and Batuda waters, under similar circumstances, each afforded about the same proportion. I was unable to procure Ager water so fresh, and this test was not applied to it, until after it remained two months in bottle, when it afforded an opalescent precipitate, which it was scarcely worth while to weigh.

(C) Cold infusion of Brazil-wood is rendered blue by all these waters.

(D) Infusion of turmeric is slightly reddened by those of Beechar, Ager, and Goseragong.

(E) Tincture of galls displays slowly, copious, flocculent precipitates in all these waters. The colours are first reddish yellow, changing to greenish yellow, from this to greenish blue, and eventually to black. To complete these changes, a shorter or longer time is required in the different waters; Beechar requires twelve hours, Goseragong fifteen, Deota and Batuda about eighteen, and Ager about twenty-four hours.

(F) Prussiate of potash effects no change in any of these waters, except an acid be added; a faint bluish tinge is then produced, and is more conspicuous in Goseragong and Batuda, but sufficiently perceptible in each of the others.

(G) Nitrate of barytes occasions no change in the appearance of any of these waters.

(H) Oxalic acid causes a slight precipitate in the waters of Goseragong, Deota, Beechar, and Batuda; but Ager water retains its crystalline appearance under this test.

(I) Nitrate of silver affords precipitates in all these waters; but the precipitate is re-dissolved with effervescence in nitric or any acid: and these precipitates are white, except that which is afforded by Goseragong water, which has a tinge of brown. The proportion of these precipitates, from 500 grains of each of the waters, is as follows: Deota, $\frac{1}{6}$ of a grain; Ager, $\frac{1}{8}$; Goseragong and Beechar, each afford $\frac{1}{13}$; and Batuda about $\frac{1}{12}$ part of a grain.

(K) Acetate of lead forms precipitates from each of these waters, and the precipitated lead dissolves with effervescence in acetic acid.

(L) Carbonate of potash causes a slight precipitate from Deota water, and carbonate of ammonia produces an ash-coloured cloud from that of Beechar.

INFERENCES.

1. From experiments A and B, connected with some of their physical characters, it is evident, that disengaged carbonic acid is present, which appears from C and D, to be in excess with a base; and therefore, it requires that it should be present in a quantity equal to one-sixth of the bulk of the water, at least so as to effect a change of colour in litmus.—(Vide note from Kir., 4 tom., p. 200, ed. 1807.)

2. From experiments C and D; as well as those of F, I, K, alkalies are evidently present: for although earthy carbonates or sulphate of lime would change the colour of Brazil-wood to blue, it does not appear that these salts are present in sufficient quantity; and even if they were, they could have no effect on turmeric.

3. From experiments E and F, iron is the only metal whose presence is clear-

ly indicated*. These precipitates are probably modified by the presence of sulphate of lime, although sulphuric acid is not indicated by any of the other experiments.

* I have carefully avoided the notice of any doubtful effect produced by re-agents in this inquiry, especially such effects as I had not the means of proving to be correct, or tracing to their causes. The prussiate of potash, prepared after the simple manner directed by Bergman, indicated a cupreous tinge in the waters of Beechar, Goseragong, and Ager: but I could discover no mineral acid, with which copper could be combined; and I knew by synthetical trials, made for the purpose, that particles of copper pyrites, if held in suspension, would yield no characteristic precipitate of copper with this test. Under these circumstances, I took the liberty to apply to the Medical Board, for permission to be furnished with a small quantity of the prussiate of potash, which is used for chemical purposes in the Honorable Company's Dispensary in Calcutta; and I feel much pleasure in acknowledging the prompt and courteous way in which the request was complied with. The prussiate of potash thus procured, I found to be very powerful in discovering the smallest quantity of the salts of copper in solutions. Yet it did not confirm the cupreous indication of the other alkali; but I found both preparations equally incapable of detecting the presence of metals in their mineral state.

4. Experiments G, I, K, prove the almost total absence of any of the mineral acids, either combined or free, in any of these waters. The precipitates in I and K, are evidently occasioned by an alkali, assisted probably in all but Ager water, by a small quantity of lime. A little earthy matter is indicated in Deota and Beechar waters by experiments L.

5. From a review of the whole of the foregoing, it appears, that the only substances in these waters are carbonic acid, a small quantity of alkaline matter, a little iron and lime (except in Ager water), with a scarcely sensible portion of earthy matter in Deota and Beechar waters.

LVIII. Principles of these waters collected by evaporation.

A wine bottle, or about 13,000* grains

* A quart of water (wine measure), at 62° Fahrenheit, Barometer 30°, weighs 58·443 grains troy; but these waters were exposed to a temperature of above 80° Fahrenheit, and at an elevation of 6,000 feet: so that in assuming 13,000 grains as the weight of each bottle of water evaporated, we may not be far from the truth. Although a table of equivalents between the measure

of each of these waters, were evaporated to dryness by solar heat, to which they were daily exposed in such a manner as to guard against accidental impurities falling into them. The following are the quantities of solid extracts from each, when dried at the temperature of 105° Fahrenheit.

Ager water, 2 grains, equal to $\frac{1}{8300}$ of the whole.
Beechar ditto, 2¼ grains, equal to $\frac{1}{3777}$ of the whole.
Goseragong ditto, 2 grains, equal to $\frac{1}{8800}$ of the whole.
Deota ditto, 1¾ grains, equal to $\frac{1}{8888}$ of the whole.
Batuda ditto, 2 grains, equal to $\frac{1}{8800}$ of the whole.

These precipitates consist, first, of a greyish yellow matter, which was found on the higher margins of the porcelain vessels in which the evaporation was conducted. It was tasteless, and insoluble in water, but soluble with effervescence in muriatic acid, from which it was preci-

and the weight of fluids, at different altitudes and temperatures, would be highly useful in such inquiries; here of course we do not aim at perfect accuracy, and do not pretend to have suffered any inconvenience from the deficiency here alluded to.

pitated by oxalic acid, and thus proved to be carbonate of lime.

Second, below the carbonate of lime, were slight metallic precipitates, distinguished by their lustre and iridescent appearance. They were placed on charcoal, and exposed to the white flame of the blow-pipe, when they gave out an aerial stream, which carried off a considerable portion of them. The remainder blackened in all but the extract from Ager water, which, with that of Beechar, gives a yellow colour to the glass of borax; while the others render that glass dark green. Patches of metal are seen in the globules thus produced from each of the waters; and these globules, separately reduced to powder in a glass mortar, and dissolved in nitric acid, afford in their solutions, under the application of the prussiate of potash, some a purple, and others a deep Prussian blue precipitate.

The gas which first escapes in this process, is no doubt carbonic acid, from saline particles of metal, or probably from adhering portions of the earthy portion of the precipitates; while the blackness which the imperfect scoriæ assumes, is occasioned by the sulphur contained no doubt in particles of pyrites.

The third constituent part of the extract of these waters, is found in largest quantity near that portion of the bottom of the vessel from which the last portion of the water ascended, and consisted, as well as I could ascertain, of carbonate of soda, and a small quantity of carbonate of potash, which gave a deliquescent appearance at first to all the precipitates except Batuda.

As to the proportion which each ingredient in these waters bears to the aggregate extract of the same water, it may not be worth while mentioning, and perhaps might be affecting greater nicety than the means adopted may justify: but as it may afford a brief method of comparison, between the results of these and similar researches, I may as well mention them.

1. *Ager Water.*
Carb. lime, $\frac{1}{5}$
Carb. iron, $\frac{1}{5}$
Carb. soda, $\frac{2}{5}$
Carb. potash, and a trace of sulph. lime and sulph. } $\frac{1}{5}$.

2. *Goseragong Water.*
Carb. lime, $\frac{1}{5}$
Carb. iron, $\frac{1}{5}$
Carb. soda, Carb. potash, Earthy sulphureous, } $\frac{1}{5}$

3. *Deota Water.*
Carb. lime, $\frac{1}{5}$
Carb. iron, $\frac{1}{5}$
Carb. soda, Carb. potash, Earthy. }

4. *Beechar Water.*
Iron, $\frac{1}{5}$
Carb. soda, $\frac{1}{5}$
Carb. lime, Carb. potash, Sulph. earthy, } $\frac{1}{5}$

5. *Batuda Water.*
Carb. lime, Carb. magnes. } $\frac{2}{5}$
Carb. soda, $\frac{1}{5}$
Carb. iron, $\frac{1}{5}$

Beside the above minute quantities of solid ingredients, carbonic acid is also to be considered as present in more than ordinary proportion in these waters. The high atmospheric temperature to which they were exposed, in carelessly corked bottles, for some time before they were submitted to experiment, as well as the want of any pneumatic apparatus, tend to render the quantity of carbonic acid uncertain ; but an estimate may be formed by its effects, even under these unfavourable circumstances, in saturating lime. The quantity of calcareous earth thrown down from lime-water, in the foregoing experiments, must be considerably under what would have been afforded, had proper means been resorted to in order to prevent the dissipation of the gas by the use of stopple bottles at the springs; but I regret to say, the removal of the troops to which I was attached in Kemaon, deprived me of the opportunity of carrying into effect a few experiments (such as my means enabled me to devise) with the view of determining the gaseous contents of these waters.

LIX. Having examined the waters of those villages whose inhabitants are most severely affected with Goitre, the question is not, whether we have detected any ingredient in them, which we can conceive capable of causing the disease; but whether these waters differ in any of their characters from spring waters in general, and more especially from the waters of those springs in their immediate vicinity, which are used by other villages of the same people, but who are free from the complaint. Could such a difference be established on clear and indisputable principles, we might then congratulate ourselves on having reached the second tangible position in this interesting inquiry.

The waters now to be examined for the purpose of comparison, are selected indifferently from those localities whose inhabitants are free from Goitre.

1. The water from the village of Paruree (XIII.)

2. The water from Boorikote (XX.)

3. The hospital spring at Lohooghat*.

4. The spring situated between the hospital and the lines at Lohooghat†.

5. The spring on the east of the lines at Lohooghat, which is used by the troops at that place‡.

6. The spring on the north of the lines, at the same place, also used by the troops§.

These springs are all situated in clay-slate, and the persons who use their waters are perfectly free from Goitre.

* This water was used exclusively by the sick, and by the servants attached to the Hospital.

† Used generally by officers, servants, and other camp-followers.

‡ Used by the 6th Company 30th Regiment, during the residence of the Regiment in Kemaon.

§ Used by the Light Company of the Regiment, during the same period.

Respecting springs in clay-slate generally, it may be remarked, that they are much more numerous than those in limestone, in proportion to the extent of the two rocks, and that they do not appear to be derived from any great depth in the earth.

Their temperature, consequently, falls considerably during the winter, and rises again in summer. They are usually met with in sequestered spots, and covered by dense cupolas of flourishing shrubs. Their waters never rush from the earth with violence, or in greater quantity than to occasion a placid ripple from a few extending circles on their surface. Their waters are clear, but rarely very crystalline or sparkling; and in all these circumstances they form a striking contrast with the springs derived from limestone, whose chemical properties are often developed at first sight, by the immense deposites of tuff with which they are connected, the ruined and broken character of surrounding rocks, the want of vegetation, and the violence and quantity of their waters. It would be tiresome, as well as useless, to describe, separately, the physical qualities of each of these waters: they are all clear and agreeable to the taste, and mix well with soap.

Of eleven different springs derived from clay-slate, which I tried in various parts of the province, including the six waters above enumerated, the specific gravity of nine was found to be 1·001, and the other two, from Paruree and Kumora, (XIII. and XVI.) in the valley of Shore, were each 1·0014.

EFFECTS OF RE-AGENTS ON THESE WATERS.

(A) They have no effect on the colour of litmus.

(B) Lime-water affords no sensible precipitate when mixed with any of these waters.

(C) Cold infusion of Brazil-wood is changed from red to light-blue by Paruree and Boorikote; but the other waters only render it bluish grey.

(D) The natural colour of turmeric is unchanged by any of these waters.

(E) Prussiate of potash occasions no alteration, with or without the addition of acid or alkali, in any of these waters; but tincture of galls occasions a slight precipitate in those of Paruree and Boorikote. This is, during the first six hours, light-coloured; it then gradually darkens, and in about forty-eight hours, it is found to be greenish brown.

(F) Nitrate of barytes occasions no change in the appearance of any of these waters.

(G) Oxalic acid discovers no precipitate in any of them.

(H) Nitrate of silver occasions precipitates in these waters, which, with one exception, are more or less insoluble in nitric acid; the insoluble precipitates are in the following quantities, from three ounces of each water. Large well, east of the lines at Lohooghat, $\frac{1}{3}$ of a grain. Boorikote spring, $\frac{1}{5}$ of a grain. Well, north of the lines, Lohooghat Hospital spring, and spring between the Hospital and the lines at that place, each $\frac{1}{10}$ of a grain. Paruree spring affords with this test a slight precipitate of a brownish hue; but the whole is dissolved in nitric acid.

(I) Acetate of lead affords copious precipitates from all these waters; and the following are the least soluble of them in acetic acid. 1, Boorikote; 2, Paruree: the others are entirely dissolved in distilled vinegar.

(K) Alkaline carbonates afford only a slight separation of earthy matter from Paruree water.

INFERENCES.

1. From experiments A and B, in connexion with those of C and D, as well as from some of their physical properties, it is pretty evident that these waters contain little or no disengaged acid.

2. Experiments C, H, and I, are indicative of a minute portion of a neutral salt, and a trace of muriatic acid is discovered by experiment H, in all but Paruree; in which experiment, I, indicates a slight trace of sulphuric acid. This indication is not confirmed by ex-

periment F; but acetate of lead being more powerful than nitrate of barytes in detecting sulphuric acid, the presence of a sulphate in this and Boorikote waters is scarcely to be doubted.

3. From experiment E, there cannot exist a sensible portion of any of the metals in these waters, unless the change that takes place in those of Boorikote and Paruree, under the application of the tincture of galls, be considered a proof of the presence of iron. It is, however, in confirmation of the presence of sulphuric acid, as indicated by experimentI: the ferruginous indication being here probably modified by sulphate of lime.

4. From experiments G and K, earthy matter is not contained in any of these waters, except in Paruree; and here the quantity detected by K, must be very trifling.

The followingsolid extracts werederived from the evaporation of 13,000 grains of each of these waters, at a gentle sand heat.

1. Paruree afforded 1 grain, which was constituted as follows:	Alkaline and earthy carbonates, $\frac{1}{3}$; Sulphate of lime, $\frac{2}{3}$ nearly; iron, a trace.
2. Boorikote afforded $\frac{2}{4}$ of a grain, which was constituted as follows:	Earthy carbonates, $\frac{1}{3}$; Sulphate of lime, $\frac{2}{3}$; iron, scarcely a trace.
3. Hospital spring at Lohooghat, 1 grain, composed of,	Sulphate of lime, $\frac{2}{3}$; muriate of soda, $\frac{1}{3}$.
4. Spring between the Hospital and the lines at Lohooghat, 1 grain.	Sulphate of lime, $\frac{1}{2}$; Muriate of soda, $\frac{1}{2}$.
5. Spring east of the lines, Lohooghat, used by the 6th Company, 30th Regt. N. I. $\frac{3}{4}$ of a grain.	Muriate of magnesia, $\frac{1}{3}$? Muriate of soda, $\frac{2}{3}$.
6. Spring north of the lines, Lohooghat, and used by the Light Company, 30th Regiment, 1 grain.	Clay, $\frac{1}{3}$; Sulphate of lime, $\frac{1}{3}$; Muriate of soda, $\frac{1}{3}$.

It now appears from comparison, that there is a difference in the nature and quantity of extraneous matters contained in the waters just noticed, which, though slight, yet is sufficient merely to distinguish them from the waters of limestone. When philosophers are reconciled, as to whether chemical analyses are capable of detecting the sources of the effects of mineral waters, we may then venture to speculate with more advantage on this subject. That there are peculiar distinctions between the waters of different rocks cannot be denied, and that these are less conspicuous when reduced to chemical analysis, than when viewed in reference to their physical and morbid effects, is only another instance of the imperfection of chemistry, as a means of developing some of the more complete elaborations of nature. No doubt, my want of skill in the performance of chemical operations, as well as the want of adequate apparatus, tended to render my success much less than it might have been. There is, however, one grand defect in these analyses, which tends still more to render their result unsatisfactory; namely, the smallness of the quantities of the different waters examined.

APPENDIX TO THE FOREGOING ANALYSIS.

Having been unable to procure distilled water of sufficient purity for the foregoing inquiries, owing to the imperfection of the best apparatus I could construct; I instituted a few preliminary comparisons between such distilled water as I could procure, the water of melted snow, and rain water.

As the result of these experiments, in regard to rain water, is different to what has been observed by others, it may not be devoid of interest to describe the process adopted, in order that the nature, or at least the value of the difference in question, may be rightly estimated.

The snow-water was procured in glazed earthen vessels, soon after a heavy fall that took place about the 20th December, 1833; after having been melted, the water was placed in bottles, carefully corked.

The rain water was collected in glazed porcelain vessels, with every care, on the 7th July, 1834, a day on which nine inches of rain fell at Lohooghat; during the previous day, four, and the succeeding day four and a half inches of rain fell at the same place: so that any impurities that this water contained, may be supposed to have been derived from the general qualities of the atmosphere. This water was left a month or six weeks in loosely corked bottles.

A crystal, weighing 3 oz. 6 drs. 4 grs. in air, at 72° Fahrenheit, was weighed in each of these waters, at the same temperature, and found to be 2 oz. 2 drs. 41 grs. in the rain and distilled waters, and half a grain heavier in the snow-water. Each of these waters gave a perceptibly blue tinge to the infusion of Brazil-wood; the snow-water, however, more obscure in its effects than either of the others, which, together with its lighter specific gravity, induced the belief of its being the purest of the three.

In order to ascertain the cause of the effect of the rain water on the delicate test of Brazil-wood; and recollecting that Bergman had discovered rain water to contain muriate of lime; that Morveau had discovered only sulphate of lime in it, while in England it has been usually found to contain carbonate of lime; I was anxious to ascertain the nature of the impurity of this fluid, in a part of the world so remote from those places where the other trials had been made; as well as to know how far rain water might answer as a substitute for distilled water, in the researches in which I was engaged.

1. 13·000 grains, by measure, of rain water, were evaporated spontaneously to 1·000, in a broad porcelain dish, when a very slight deposite was found to have taken place by the rough sensation it occasioned to the end of the finger, on rubbing the bottom of the vessel gently.

The supernatant fluid was decanted and evaporated to dryness by a *gentle* sand heat, when half a grain of a grey precipitate was afforded.

2. This precipitate was at first partly soluble in cold water, slightly deliquescent, and insoluble in distilled vinegar. On standing for a time, it became dry, and assumed the property of effervescing, and dissolving quickly in acids.

3. After exposure to the blue flame of the blow-pipe, it loses the property of effervescing with acids, nor does it acquire the property of lime; for it retains its solid and compact form if immersed in

water—if boiled, its size is increased rather than diminished.

4. About a tenth of a grain was dissolved in sulphuric acid, when after standing, a minute particle of selenite was deposited, nearly equal in quantity to what a thirtieth part of a grain of carbonate of lime would afford. The clear acid solution was then rendered turbid by the addition of carbonate of potash.

SECOND SERIES OF EXPERIMENTS.

1. The dish in which the first part of the evaporation was conducted, and to which a slight precipitate adhered, was washed with half an ounce of the same water: the whole was filtered, when scarcely any solid matter was collected. The clear solution was first tested for sulphuric acid, by instilling a solution of the nitrate of barytes, when no precipitate or change took place. Alkaline carbonates, if present, were then saturated with nitric acid, and nitrate of silver added, when an instantaneous precipitate was formed, which thus detected muriatic acid.

2. Another solution was now made by dissolving, by means of nitric acid, a small portion of precipitate No. 1, of first series of experiments, in a few drachms of the same water, when oxalic acid barely afforded a slight indication of lime; but carbonate of ammonia, added afterwards to the same solution, afforded a precipitate, too slight indeed to be examined; but which, from the experiments already related, may, as far as can be determined from experiments on such a small scale, be considered as carbonate of magnesia.

If the muriatic acid and lime, both of which substances were detected in the above experiments, were alone the only contents of this water, they would be melted on the slightest application of heat; but on mixing equal parts of carbonate of magnesia and muriate of lime, a compound is formed, which is infusible before the greatest heat of the blow-pipe, and which presents analogous characters to those of the extract from the rain water. Thus the presence of magnesia is probably for the first time indicated in rain water.

SECTION VIII.

ON THE CONNEXION BETWEEN GOITRE AND CRETINISM, THEIR NATURE AND CAUSES.

LX. From Goitre, as it appears in Kemaon, in its more distinct form, as well as in conjunction with Cretinism, there are many reasons for believing that both complaints are intimately connected with each other; if not identically the same, they are mere modifications of different degrees of intensity of the same causes.

It may be remarked, that in those little communities or hamlets, where Goitre prevails to a certain extent, the people are characterised by a want of enterprise and bodily vigour, as compared with their immediate neighbours, who are exempt from the disease. The distinction in this respect increases, not always, but in general, with the extent and severity of Goitre, until, at length, both mind and body become so deformed, that the unfortunate Cretin is scarcely to be recognised as belonging to the human species.

LXI. Mr. Bramley, in his excellent account of the Goitre in Nepal, (an adjoining kingdom,) remarks in a note, that he never saw Cretinism, or any thing approaching to it, in that country. If instead of being attached to the *court* of a foreign state, Mr. Bramley had been so situated, that he could have passed from the capital into the interior, and there pursued his inquiries in the huts of the scattered population, he would probably have seen cause to have expressed a different opinion. Nay, if I had been guided by information derived from old residents in Kemaon, rather than by my own labours, this treatise would have contained a similar assertion; and as to information received from the common natives of India, in particular, on any thing relating to statistics, it is not only not worthy of credit in a scientific point of view, but had better in such investigations be dispensed with altogether*.

Most of the conflicting opinions relating to this disease, have arisen from authors and travellers resting their facts on no better foundation, than that of the mere statements they derive from others, and thus but too often make popular error the basis of general conclusions†. I

* I make these remarks generally, in order that we may avoid, as much as possible, a very common source of error.

† From Peeleabit to the confines of Rohilcund and Hurdwar, is stated by Mr. Bramley, on the authority of another author of great respectability, to be a link in the chain of affected districts, in the plains of Hindustan, extending from the 27° to 30° N. Lat. Yet I have traversed the Tarai in this direction from Peeleabit to Burmdeo pass, and from thence to the vicinity of Rudeerpoor, crossing from thence to Moradabad, without having met with a single case of Goitre; although I made it a point to visit every village of the Tarai, or peculiar people, who are the only permanent inhabitants of this unhealthy tract of country, I could, during a march of at least 150 miles. Fairs are, how-

was assured by persons, for whose opinions I have great respect, that no such beings as Cretins existed in Kemaon; yet in the course of my researches, (in which I made it a maxim to take nothing for granted that I did not see and prove by the evidence of my own senses,) I discovered whole villages of these unfortunate people.

LXII. In Goseragong, the people are generally affected with Goitre, yet there are no Cretins among them. The same may be said of Deota; but in the *villages* of Salmora, Oliel, Goraght, Tomilly, and Ager, which contain 138 inhabitants, 76 have Goitre, and 42 are Cretins; while there is not one of the latter class to be found in any of those villages that are exempt from Goitre.

Hence it appears, that in a population in which Goitre prevails to the extent

ever, held in the Tarai, during the cold season, at which the inhabitants of the mountains attend; and in this way, the mistake may have arisen.—See Cal. Med. Trans. vol. vi. p. 182.

of rather more than 50 per cent., 30 per cent. are Cretins; while in the remaining portion of the people, amongst whom Goitre does not extend to above nine per cent., we have no Cretins. Thus far, it is clear, that the two diseases are connected with each other, not merely endemically, but they are complicated and blended together in the same individuals.

LXIII. In describing the disease (XLIX.), it is stated, that children are exempt from it until the age of three years. This is also in conformity with the observation of Mr. Bramley; nor has any authenticated instance occurred of Congenital Goitre, although a condition of the bronchial gland of some of the lower animals is congenital, a circumstance which of itself forms a distinction between the nature of the disease of animals and the Goitre of the human subject, that we cannot possibly overlook.

LXIV. Delicate, (apparently,) ill-fed, and neglected children, in certain villages, become affected by the disease in the course of a year or two after they are taken from the breast. It is usual for them to have long matted hair, large joints, tumid abdomens, and slender limbs.

The tumor on the neck makes greater or less progress for a time; but usually becomes interrupted before it attains a larger size than that of an orange, and the general health now rapidly improves*. In other cases, numerous bronchial glands are simultaneously attacked; and the augmentation of the tumors, which soon unite, suffer no abatement: while the general development of both mind and body, is for the time suspended; or the materials of the latter are rather directed to the formation of irregular accumulations, generally on the neck, than to

* Alibert, from Human Dissections, divides the tumors into simple and compound, according to the nature of their contents. Compound bronchocele illustrates these views; Alibert having found such tumors to contain calcareous, sarcomatous, and fatty matters, as well as other heterogeneous contents, such as hair, &c. Human dissections not being tolerated in Kemaon, I can offer no remark on the pathological character of these tumors.

the uniform increase of the body. Nor does this morbid action, this *error loci,* suffer any interruption, until the subject has attained the adult age.

LXV. With respect to the first of these cases (LXIV.), the interruption to the growth of the tumor does not take place sometimes until it has reached its full size. The necessary period for this varies from ten to thirty years; and often the tumor continues slowly to increase during the life of the patient, but so insensibly, that at an advanced age, it is frequently found of an inconsiderable size. In such cases, the general health continues good; and hence, even in villages, where the exciting cause may be supposed from the number affected to be very intense, we often find strong, robust, and otherwise healthy adults with Goitre of every size and shape—a circumstance which has erroneously induced some to believe, that the disease is merely local; and as these are the sort of cases that usually occur to common observation, the error in question is by this means rendered the more general.

LXVI. The second variety of the disease (LXIV.), or that which occasions the peculiar condition called Cretinism*, is

* Foderé and others ascribe the weakness of the mental energy of Cretins, to the state of the thyroid gland—an opinion which Mr. A. Burns, as well as Mr. Cooper, (Surg. Dic.,) very properly suspect to be without foundation, from the fact of Cretins having been seen without much enlargement of the thyroid gland. These eminent Surgeons were not, however, justified, on this account, in considering the connexion between Cretinism and Goitre, as merely accidental; as if mental imbecility were an essential symptom of Cretinism.

The Cretins in Kemaon are characterised by *general deformity of the body; but especially* of "the head and neck; countenance vacant, and stupid; mental faculties feeble, or *sometimes* idiotic;" sensibility obtuse; mostly with enlargement of the thyroid gland.

This description, with the exception of the words in Italics, is from Dr. Good's Nosology. The deformity of the head, a symptom of the general disorder, may of itself give rise to "the mental faculties feeble," and "sensibility obtuse," as it is only in those who are thus deformed, that these symptoms are very apparent.

It must, however, be remarked, that the "countenance vacant and stupid," in Dr. Good's characters of distinguished, from the last described, by a greater intensity of all the symptoms. The patient is invariably, and indeed necessarily, seized, during the first stage of life, i. e. before the age of five years; and the disease continues without interruption throughout the stage of adolescence. During this time, the living materials of the body are wasted by a depraved action of the absorbent system, on the monstrous development of certain organs; while the natural growth of others is proportionably prevented, or suspended. Hence the limbs are short and crooked, the spine distorted, the head often of enormous size, the features bulky and idiotic, and glandular swellings are common on various parts of

Cretinism, are very arbitrary distinctions, and may often be only the false effect of disproportionate features. In proof of which, I have only to mention, that although the Cretins of the village of Ager have these characters in an extreme degree; yet they perform the practical duties of working a copper mine in their vicinity—an occupation in which they display at least some mechanical skill.

the body, but seldom entirely absent on the neck, where the first signs of the disease are displayed in the enlargement of the bronchial glands*. The progress of all this deformity usually continues until the end of the period of adolescence, when it happily is not farther extended.

Such physical derangement, affecting three-fourths of a whole community, is calculated to impair, in a moral point of view, their intellectual faculties; but notwithstanding any allowance we can make for this, there is still reason to fear that, in the majority of cases, both mental and corporeal functions suffer alike. Yet the Cretins do not in general, even in their most deplorable state, equal the imbecility of natural idiots; but on the contrary, they retain at least the full

* Cretins are sometimes seen without any great enlargement of the bronchial glands; but such cases are rare, and they are generally otherwise much deformed, so as not to be mistaken for congenital idiots. Tumors on the elbows, knees, and other joints, as well as along the course of the lymphatics, are common with the Cretins of Ager (XLIII.), and other villages in Kemaon.

extent of mental power they acquired in childhood, previous to the attack of the disease. To this merciful peculiarity in the character of their affliction, which thus spares to after-life the intellectual integrity they acquired in infancy, they owe that glimmering of reason, which enables them to afford those offices of humanity to each other, which their unfortunate condition and retirement, must call so frequently into requisition.

LXVII. From the above description of the phenomena of the disorder, it must be evident to those who are at all conversant with what is at present known, regarding the laws which regulate the animal economy in health and disease, that Goitre and Cretinism are but varieties of the same disorder, and that the proximate cause of both, is an *error loci*, or derangement of the functions of the absorbent system.

ON THE REMOTE CAUSE.

LXVIII. In conformity with the custom of pathologists, the remote cause may be divided into predisposing and exciting causes. In the present instance, indeed, this division is indispensable.

A. Predisposing cause. The liability of some to certain diseases, and the immunity of others, though equally exposed to exciting causes, are facts that have been universally observed in all ages, and with respect to all diseases, even including perhaps the plague*.

"There are many reasons to induce us," (says Dr. Robertson,) "to regard Goitre as a particular variety of Scrofula; in this country," (England,) "it is only seen in highly scrofulous constitutions." Now although I cannot venture the length Dr. Robertson has gone; although I cannot venture to say, that Goitre is only seen in Kemaon in highly scrofulous constitutions; yet I must bear testimony to the accuracy of the remark to a certain extent; and beyond this, what is stated (LXV.) will explain the cause of numer-

* Of the plague, Bacon observes, "'Tis likewise noticed to go in a blood, more than from stranger to stranger."

ous healthy, or at least stout healthy-looking persons being seen with Goitre. The opinion of Dr. Robertson has often been suggested without assigning adequate reasons, and as often opposed on still more inadequate grounds; while the great bulk of those to whom arguments on both sides were addressed, were unable to decide, for want of practical acquaintance with the points at issue. I shall here transcribe from Mr. Cooper's Surgical Dictionary, the distinctions stated to exist between Goitre and Scrofula, as enumerated by Dr. Postiglione; and to save repetition, I shall take the liberty to refer the reader to the articles in this section, by comparison with which, each of the supposed distinctions will be found to give way.

"1. Scrofula is a disease of the general system, but Bronchocele is merely local."

This distinction is removed by what is stated (LXV.), where the error is accounted for, and explained: in farther refutation (LXIV.) (LXVI.) (LXVIII.)

"2. Bronchocele begins at a later age

than Scrofula, and does not, like the latter, spontaneously disappear*."

This distinction is completely refuted by what is stated (LXIV.) (LXV.) and (LXVI.)

"3. Scrofulous glands often suppurate; Bronchocele rarely undergoes this change."

This is the only real distinction, and is to be referred merely to a modification of the effects of the same latent cause, by exciting powers somewhat different in their nature, and consequently in their effects.

"4. The thickening of the upper lips of scrofulous subjects, is not an attendant on Bronchocele."

I observed this character, in particular, in some of the strangers who contracted

* All authors agree, that the usual period for Scrofula to appear, is between the age of three and seven years: but that it may arise any time before puberty, seldom afterwards; so that here we have really no distinction between Scrofula and Goitre. It might be difficult to conceive, how a large tumor could spontaneously disappear; but it is very common for the augmentation of the tumor in Bronchocele to become permanently suspended, without the aid of any remedy.

Goitre at Petoragur* ; but it is not, after all, a more unequivocal sign of scrofulous diathesis than many of those enumerated (LXIV.) as characterising those who are subject to the Goitre.

The only other distinctions between Scrofula and Goitre, pointed out by Dr. Pastiglione, are very trifling; and the whole of them, merely refer to the difference between the simple form of Goitre and Scrofula; but if the connexion of the former with Cretinism be granted, as I believe it must, the difficulty of longer defending any sound distinction between these diseases, except as varieties, is much increased.

From what has been said during the consideration of the predisposing cause, we are led to the conclusion, *that the same inherent diathesis, that under certain circum-*

* The person alluded to (in the table attached to the Introductory Section), page 263, who contracted a larger Goitre at Petoragur, had not merely the thick lips, bnt the expanded nostrils, and the strumous frown on the brows. He was a servant in the employment of the officer who commanded the post, and is still, I believe, a camp-follower of the 30th Regiment.

stances gives rise to Scrofula, would, under exposure to the exciting cause of Goitre, occasion that peculiar form of disease.

B. Exciting cause. This cause has been traced in the foregoing inquiry to certain strata of the earth, under circumstances that are calculated to convince us, that the waters are the mediums by which it is conveyed to the bodies of men; but that the analysis of such waters, like those of some of the most celebrated mineral springs*, are incapable of detecting any ingredient to which we can directly ascribe their effects, LIV. p. 329.

Finally, that having thus far traced the source of the endemic, we have reached, in regard to the exciting cause of Goitre, the utmost limit of our knowledge of endemic contagions generally: but whether there be any other strata, capable of yielding this peculiar contagion, than those we have described; and whether the waters are the only mediums by which it is conveyed, are points which still remain to be determined.

* As the Bath waters, for instance.

DESCRIPTION OF PLATES.

PLATE I.

Fig. 1. Physiognomy of the Himalaya range. The red line is intended to mark the inferior limit of snow. See pages 27, 28, 29.

PLATE II.

Fig. 1. Delineations on the surface of magnesian limestone in the bed of the Ponar river. See page 91.

Fig. 2. Concentric disintegration of gneiss at Chompawut; *a a a* mark the strata seams, and *b b b* the enclosed nodules of granite, or more compact gneiss.

PLATE III.

Represents the strata of hornblende slate ascending from the bed of the Ramessa river near the bridge, and assuming a more horizontal form as it approaches the surface of the declivity of the mountain, where it is subject to the greatest pressure from above. This is referred to in pages 121 and 122.

PLATE IV.

This plate represents the mountains on the north-eastern boundary of Shore Valley.

A. Clay-slate. B. Granatine. C. Talc, and fibrous limestone. D. Alpine limestone. E. a bed of floetz limestone, which in some places contains distinct concretions resembling small fishes (one of which is presented to the Asiatic Society), and in others, lignites, and even whole trees. Of the latter, there is, near the spot here represented, an immense example, about 45 feet long and six feet in diameter: it is called by the natives, Mahadeo's Wand.

PLATE V.

Figs. 1, 2, 3. Represent the side, the back, and the section of a concretion resembling a fish, found in floetz limestone.

Fig. 4. Is a section of the rocks composing the bed of the river that drains Shore Valley.

A. clay-slate. B. overlying limestone of the transition period. C. magnesian limestone. D. floetz limestone.

PLATE VI.

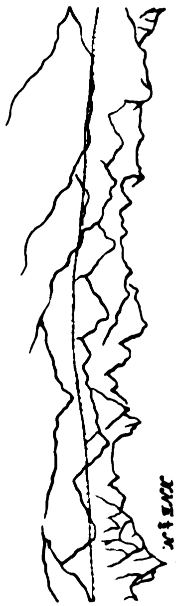
Impressions of leaves found in calc-tuff in Shore valley. Fig. 4, represents what is supposed to be the impression of the leaf of some unknown species, or perhaps genus, which has probably become extinct.

PLATE VII.

Fig. 1. Is a shell from the same bed of tuff. It belongs to a very numerous genus, many species of which are peculiar to the fossil state. The other figures are leaves from the calc-tuff of Shore Valley.

PLATE VIII.

Impressions of leaves from the newest layer of tuff.



Pl. I.

J. Mc Clelland del.

J. B. Tassin lith.

fig. 1

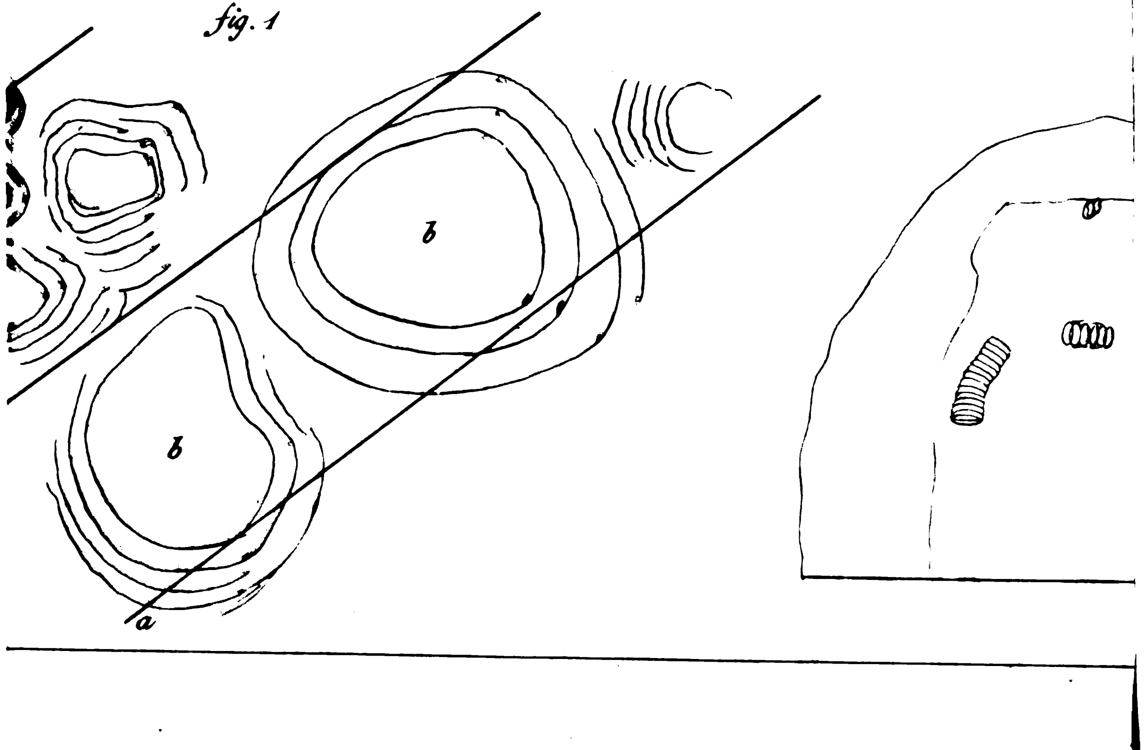


fig. 1

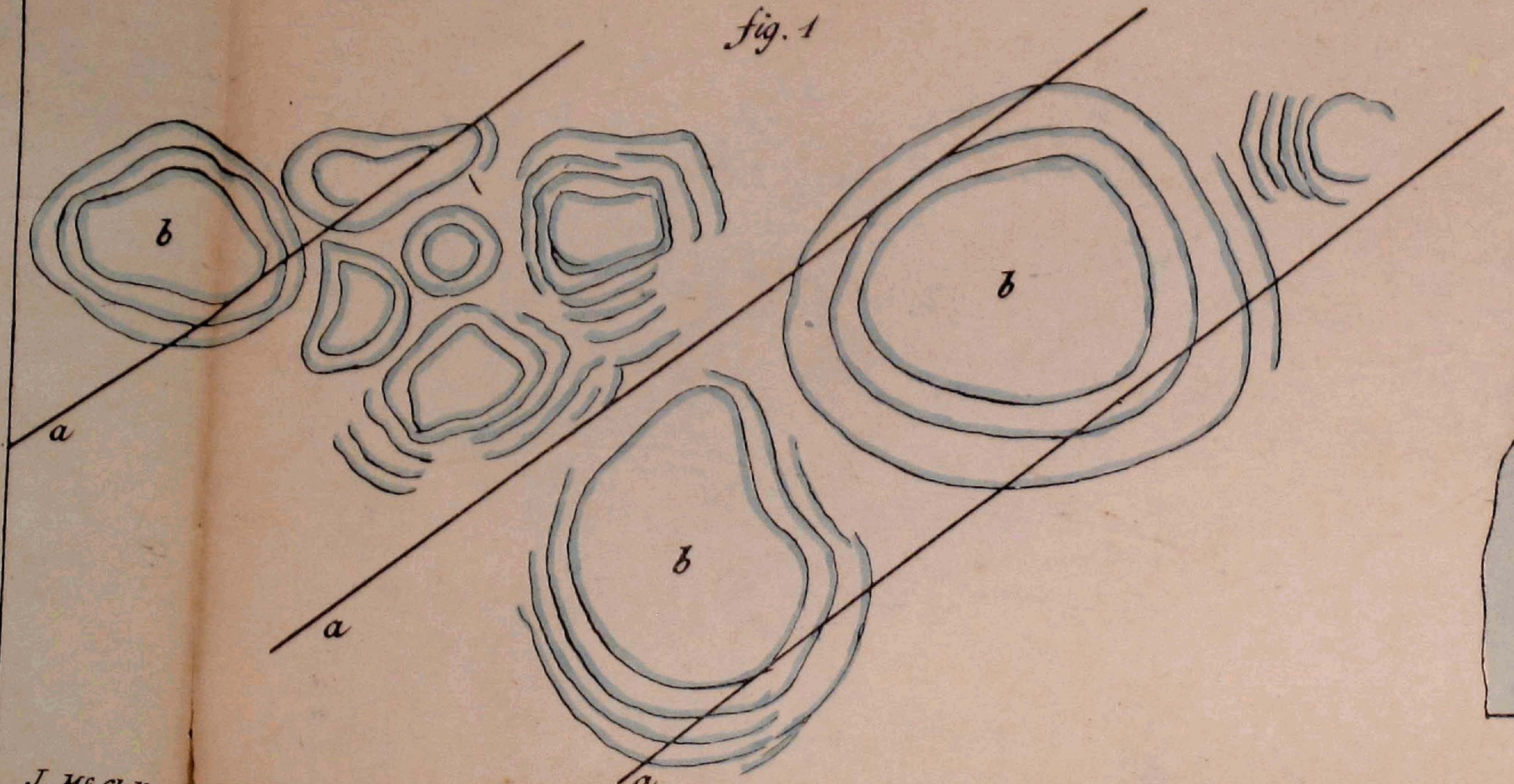
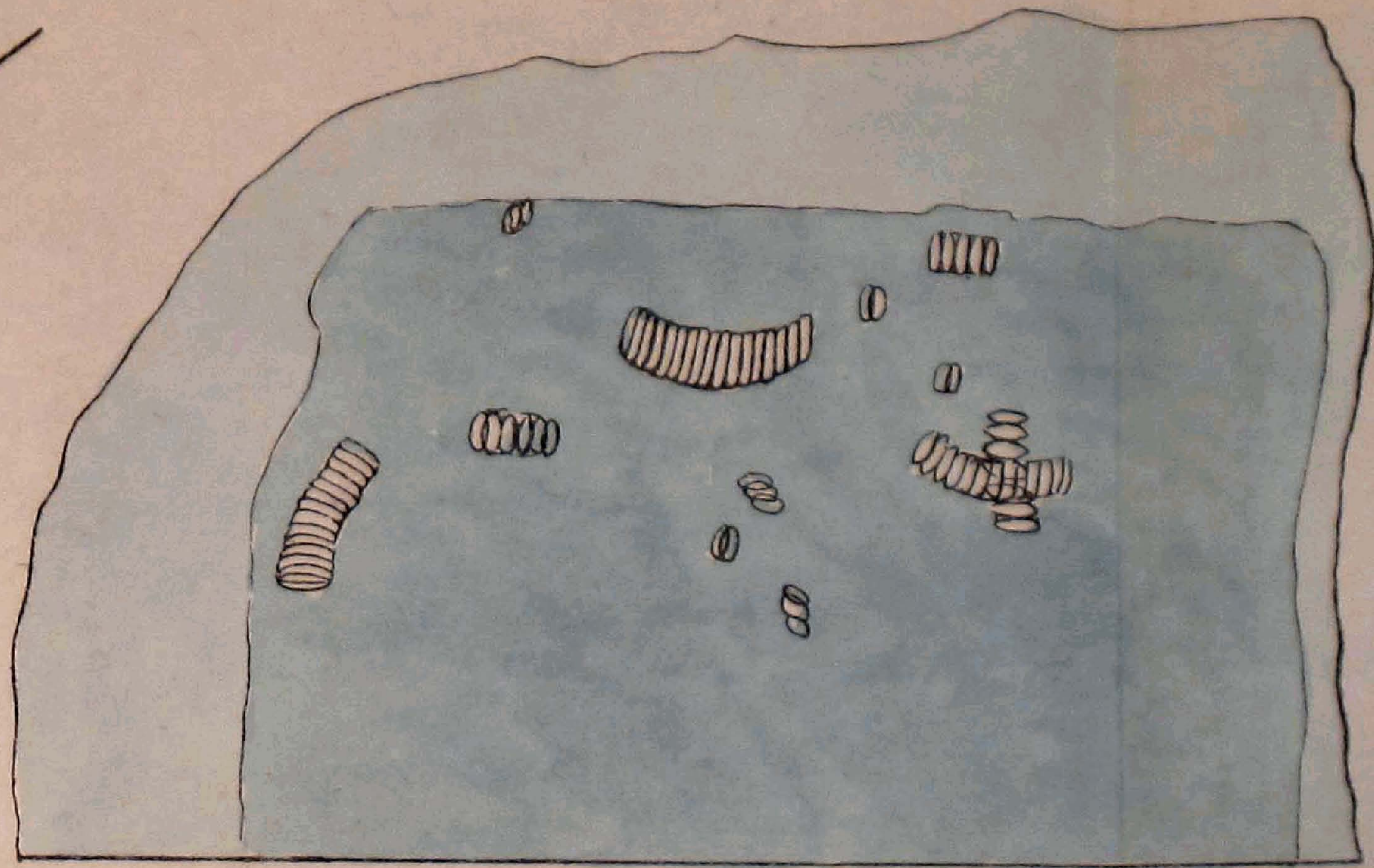
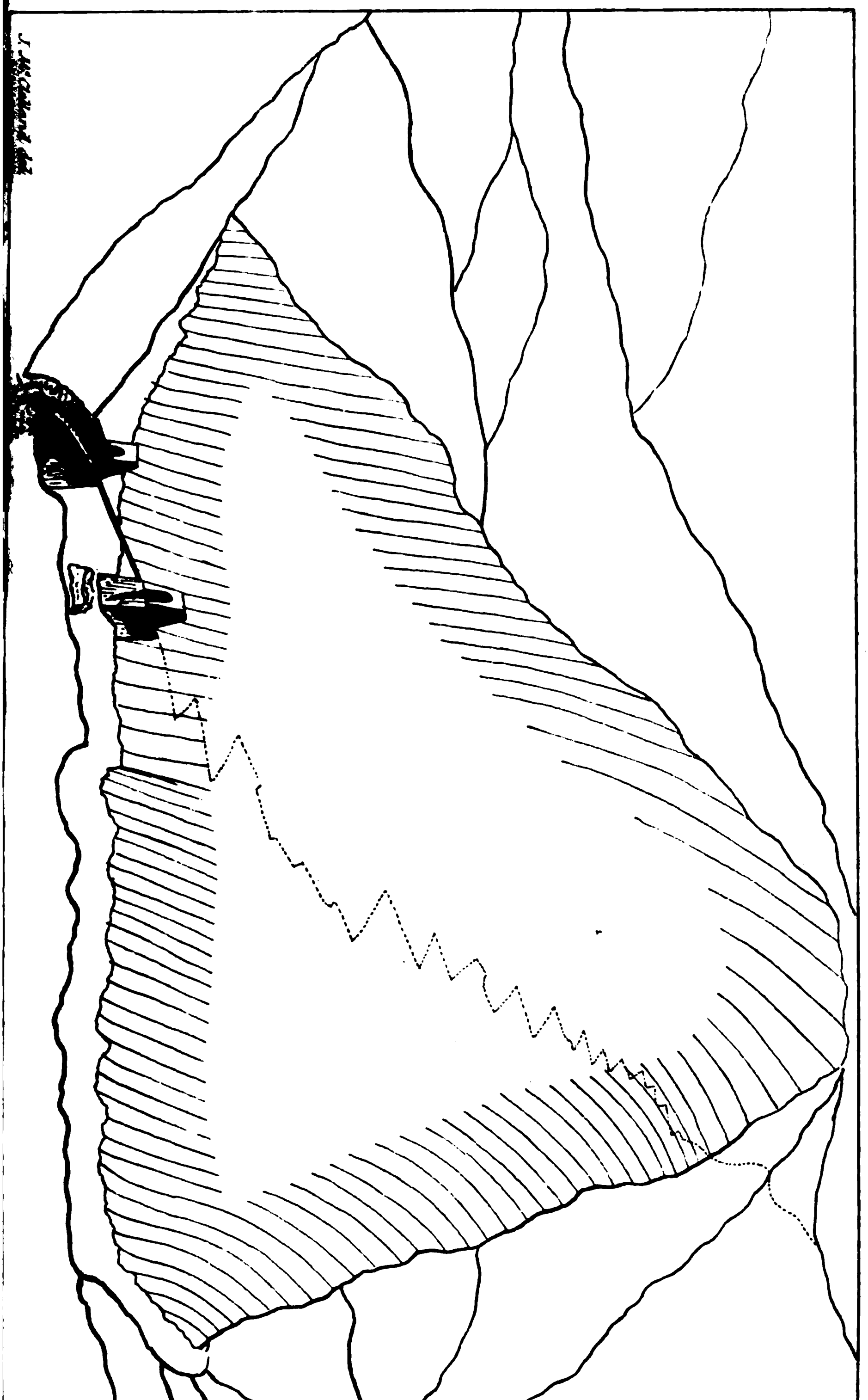


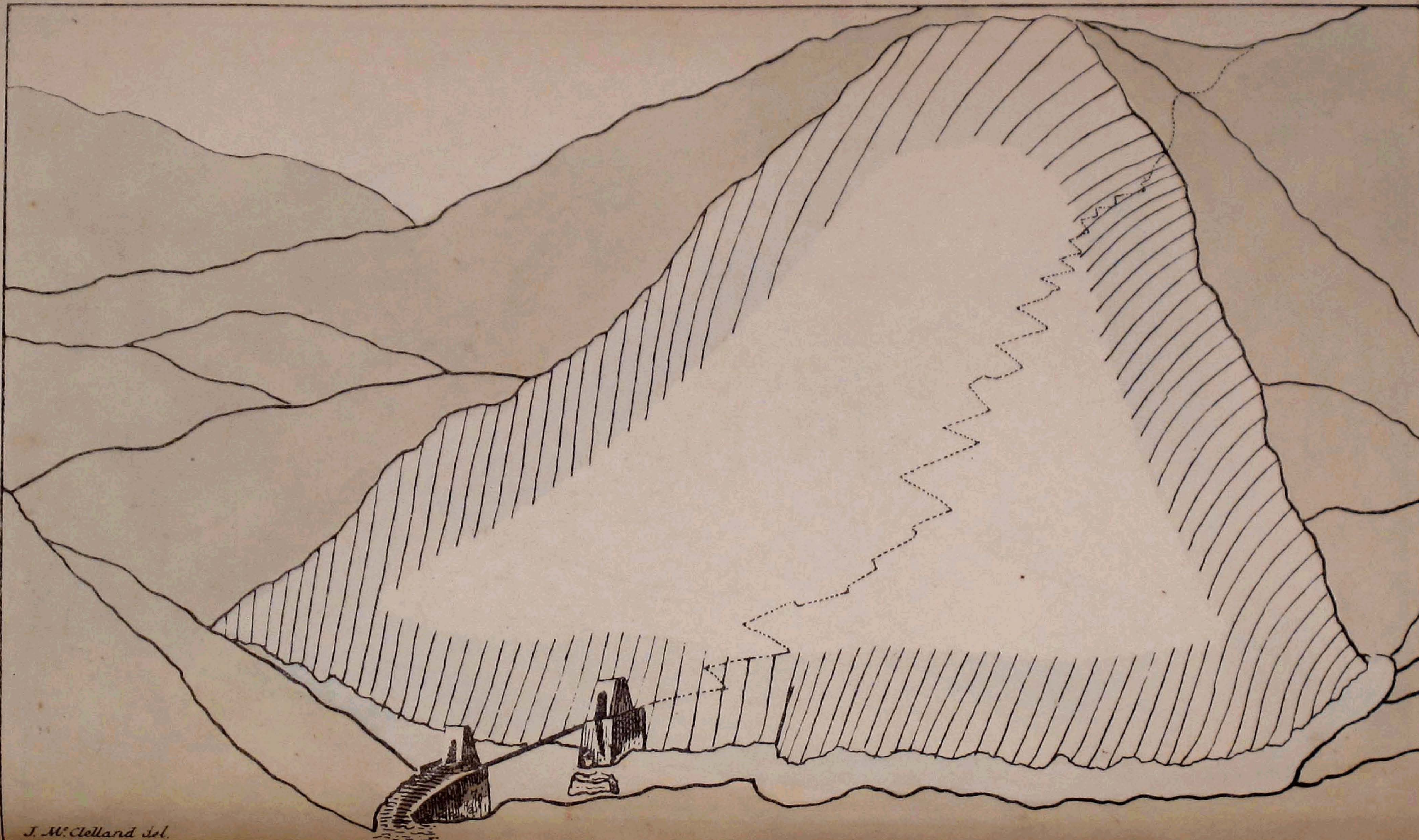
fig. 2



J. Mc Clelland del.

J.B. Tassin lith.

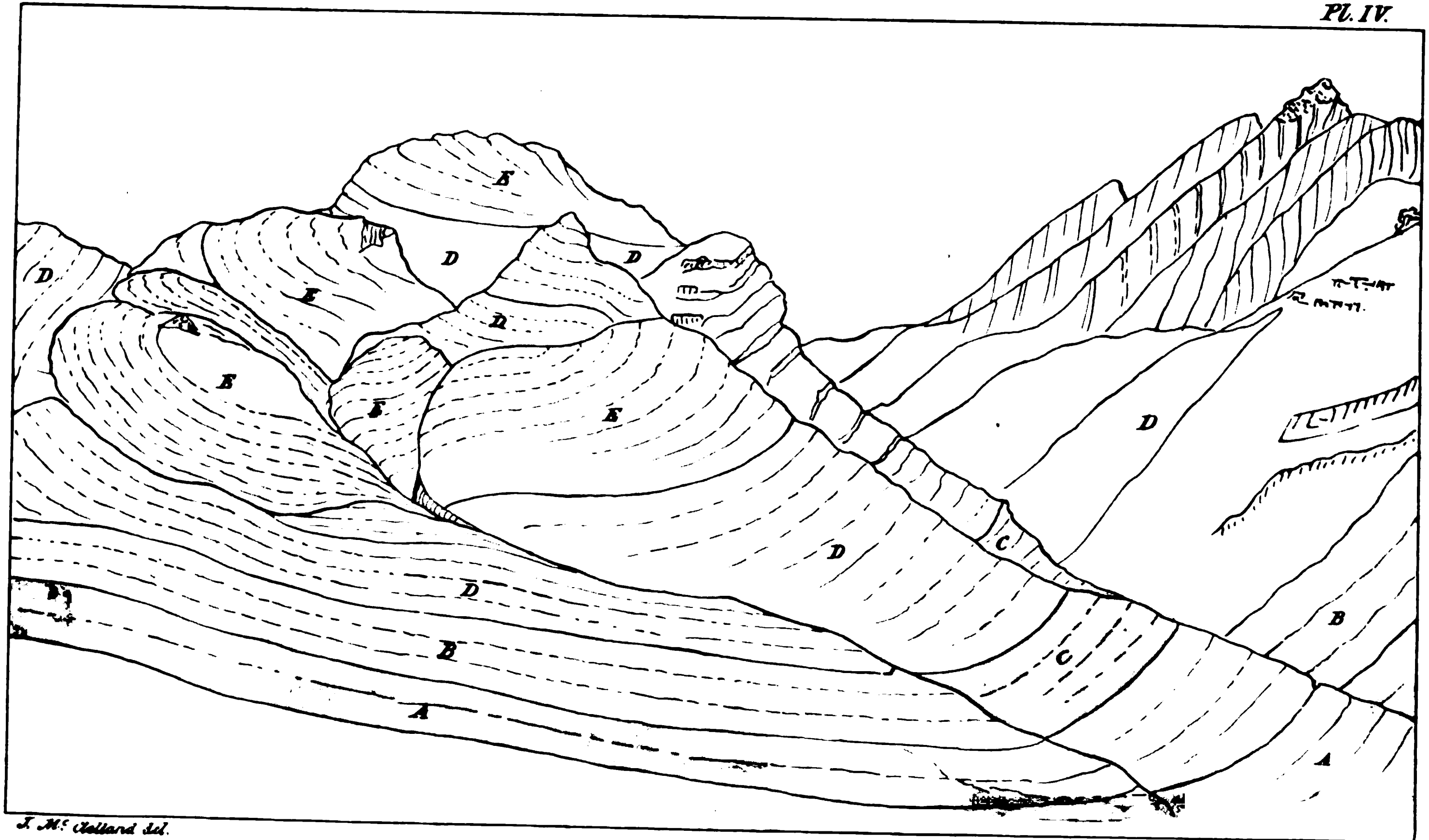

J. McClelland del.



J. Mc. Clelland del.

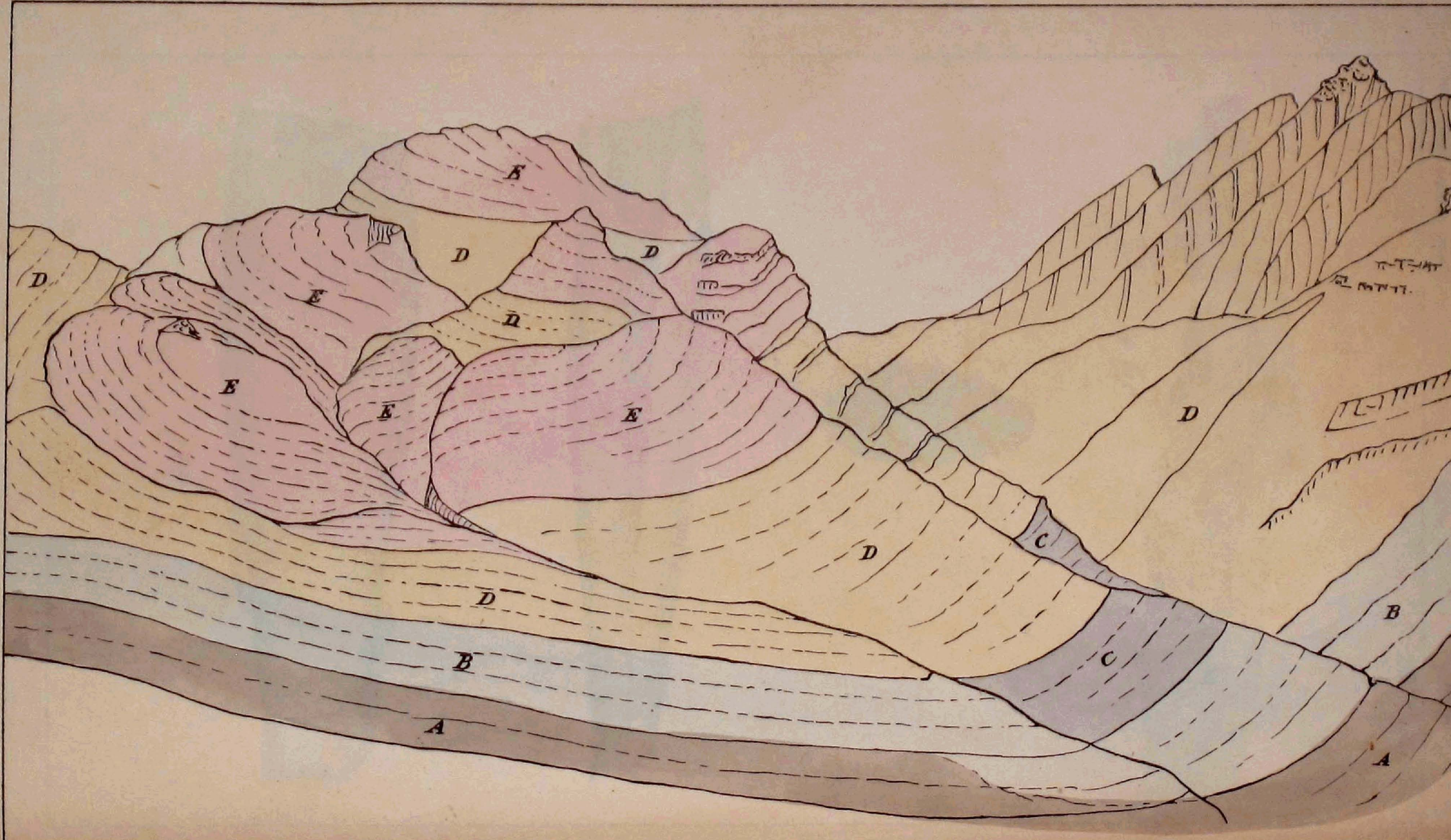
J. B. Tassin del.

Pl. IV.



J. Mc Clelland del.

Pl. IV.



J. McClelland del.

J. B. Tassin lith.

Plate V.

fig. 1

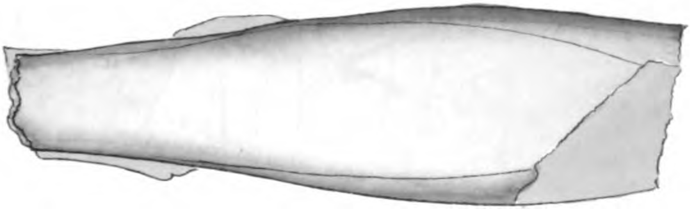


fig. 2

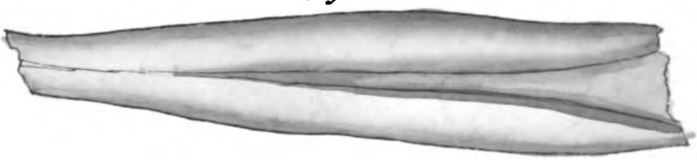


fig. 3

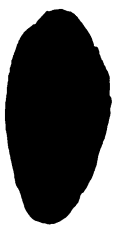


fig 4.

J. M^{c}Clelland del

J. B. Tassin lith.

fig. 1

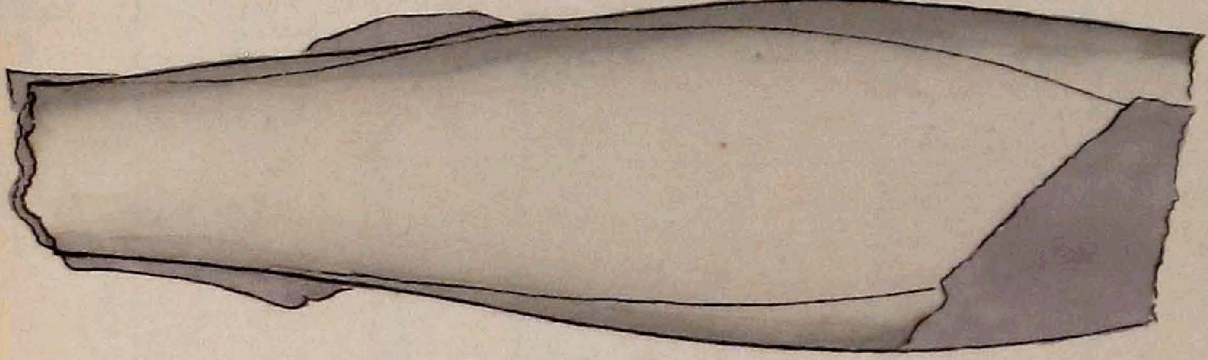


fig. 2.

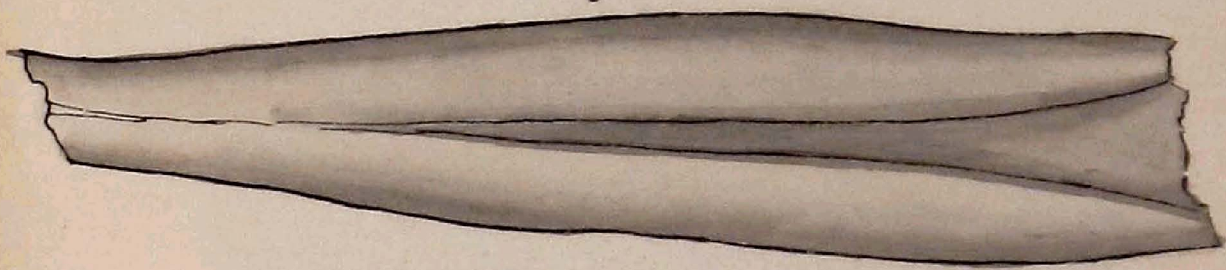
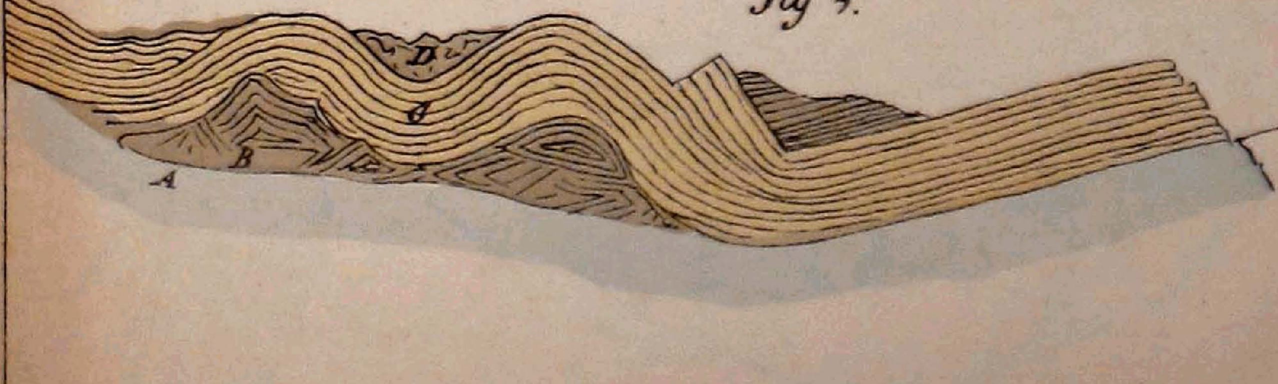


fig. 3

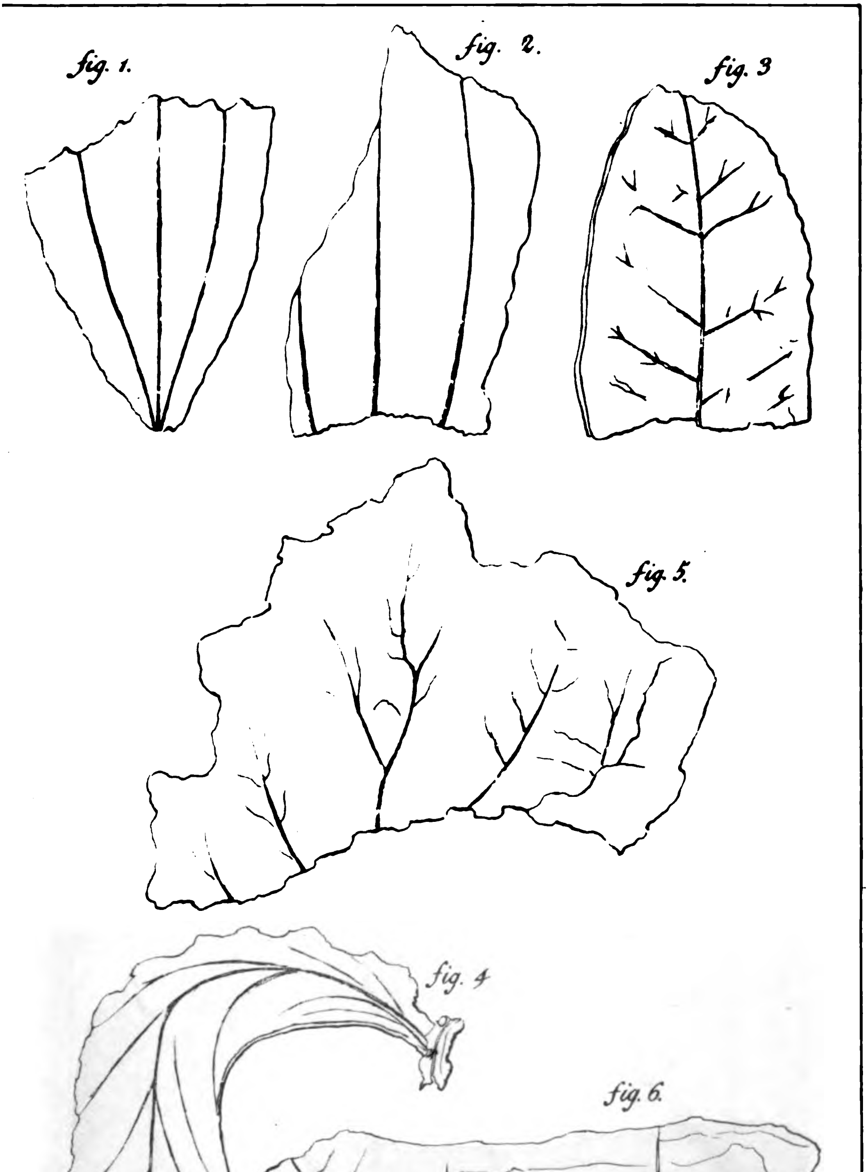
fig 4.



J. M^c. Clelland del.

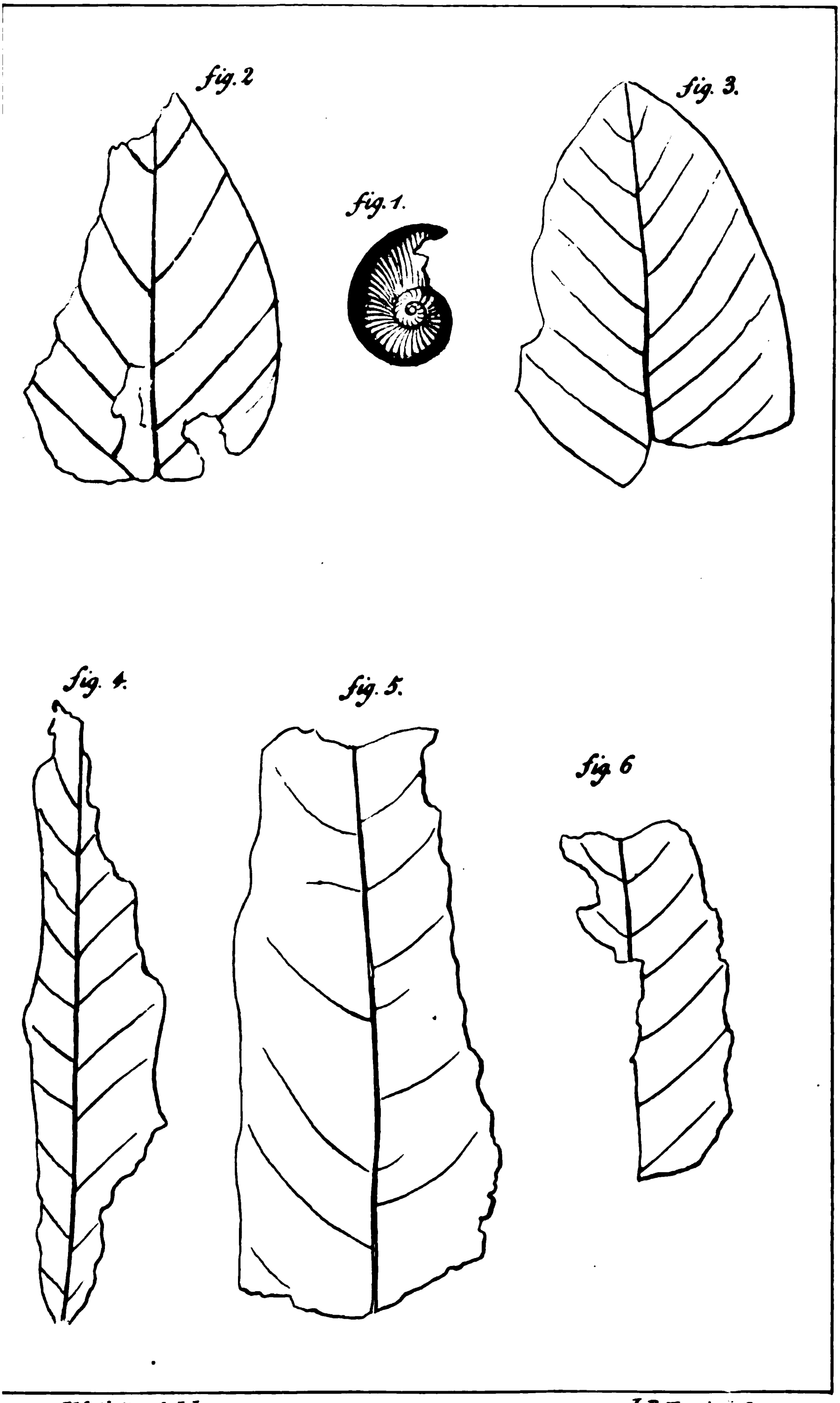
J. B. Tassin lith.

Pl. VI.



J. Mc Clelland del. J. B. Tassin lith.

Pl. VII.



J. McClelland del.

J. B. Tassin lith.

fig. 2

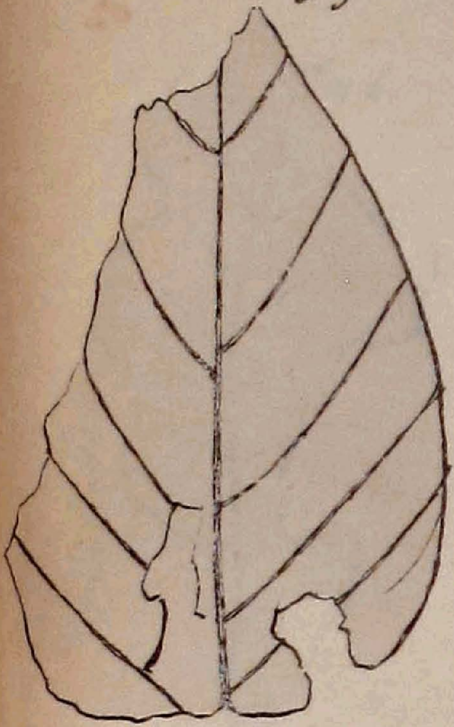


fig. 1.

fig. 3.

fig. 4.

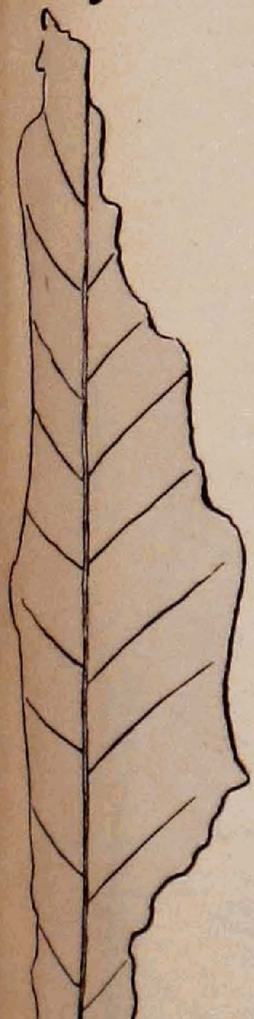


fig. 5.

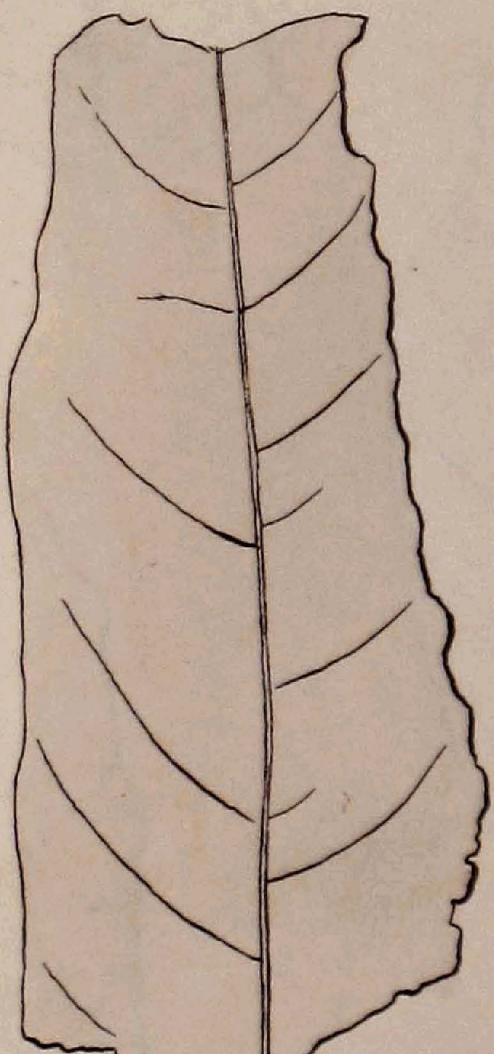
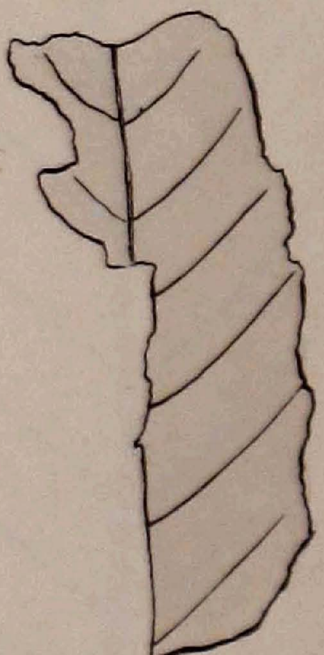
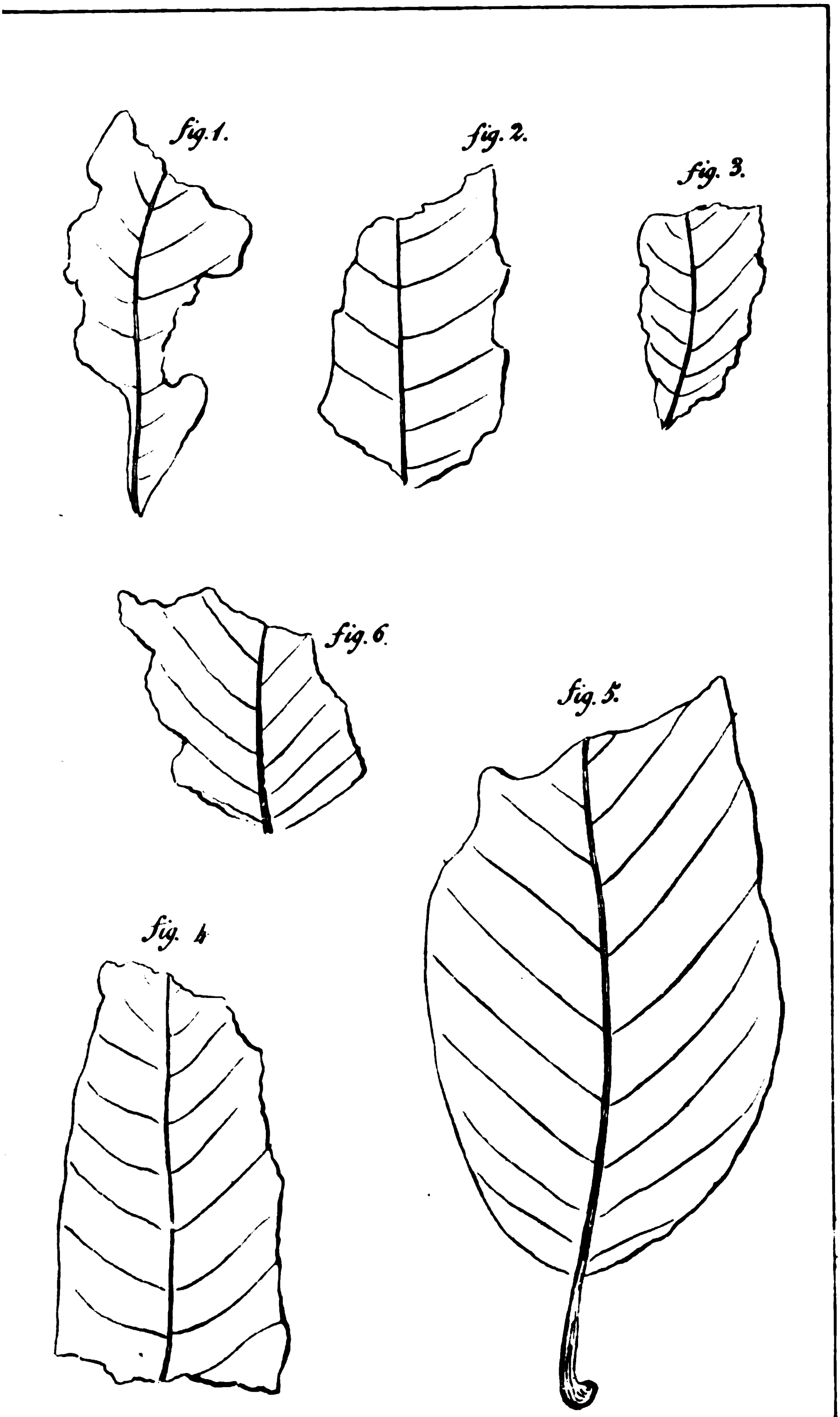


fig. 6

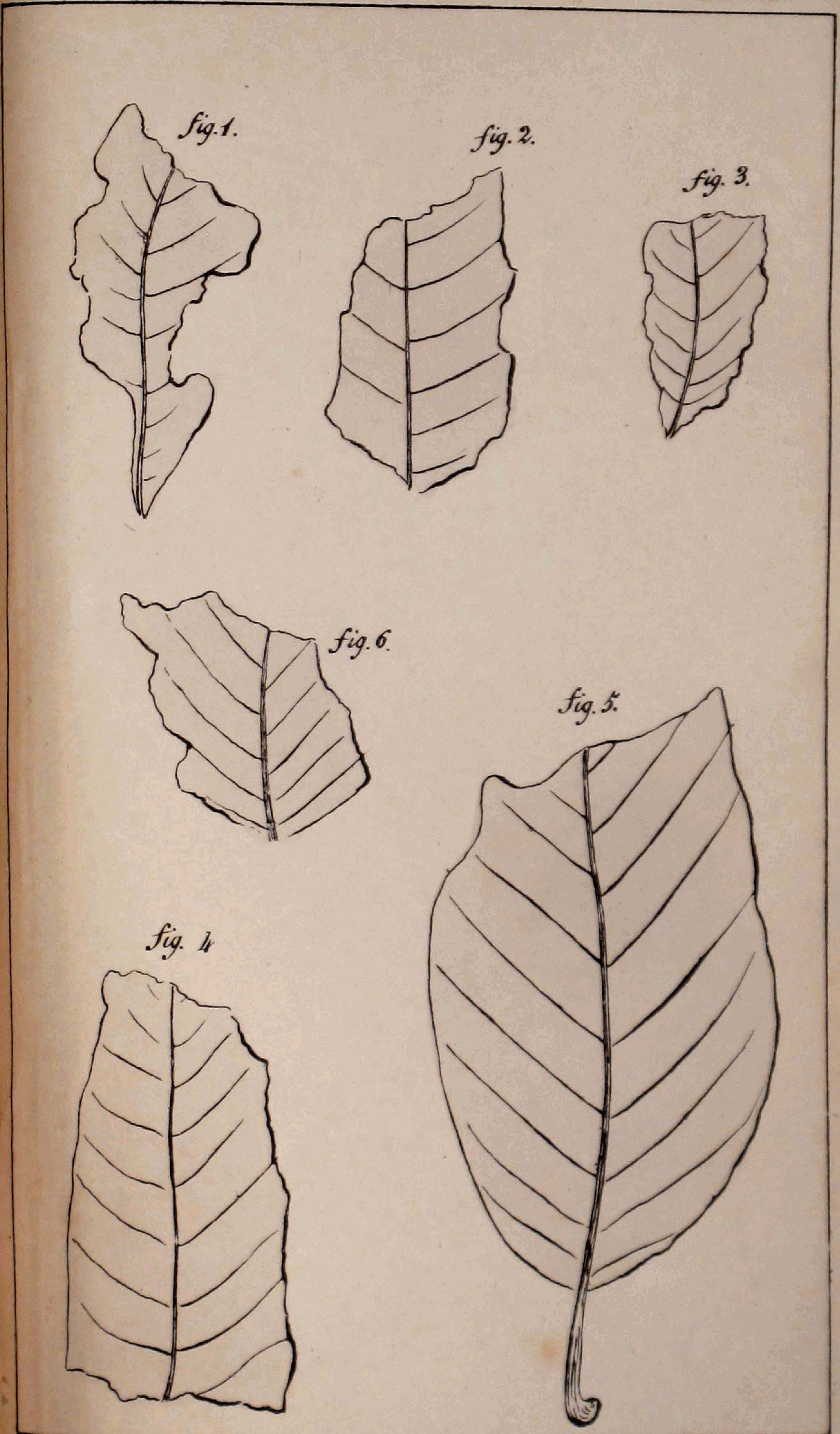


J. Mc Clelland del.

J. B. Tassin lith.

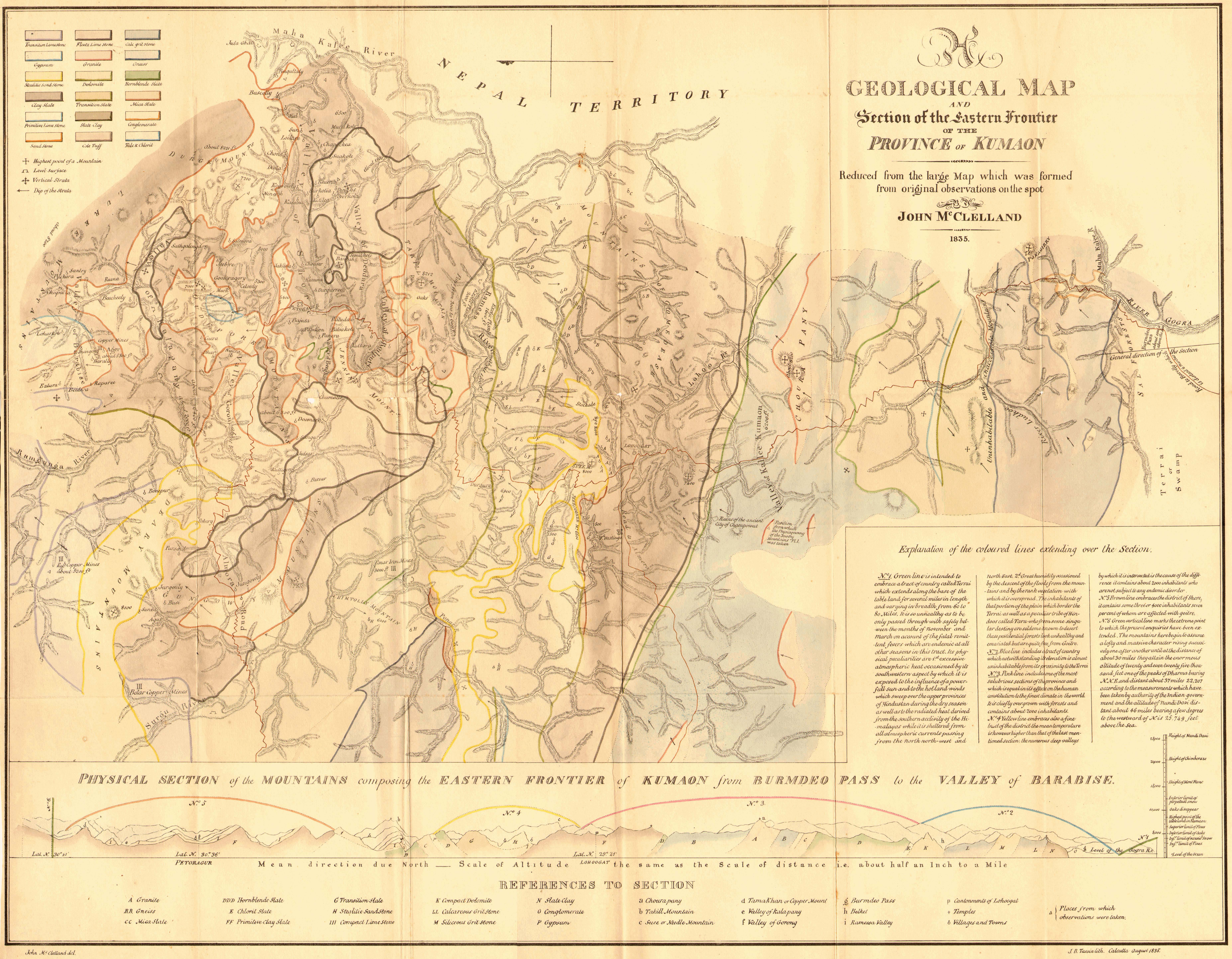


J. McClelland del. J. B. Tassin del.



J. Mc Clelland del.

J. B. Tassin del.


GEOLOGICAL MAP
AND
Section of the Eastern Frontier
OF THE
PROVINCE OF KUMAON
Reduced from the large Map which was formed from original observations on the spot
BY
JOHN McCLELLAND
1835.
Transition Limestone
Floetz Lime stone
Calc. grit stone
Gypsum
Granite
Gneiss
Stealitie Sand Stone
Dolomite
Hornblende Slate
Clay Slate
Transition Slate
Mica Slate
Primitive Lime stone
Slate Clay
Conglomerate
Sand Stone
Cole Tuff
Talc & Chlorit
Highest point of a Mountain
Level Surface
Vertical Strata
Dip of the Strata
NEPAL TERRITORY
Maha Kalee River
RIVER GOGRA
Rumgunga River
Terrai or Swamp
CHOURA PANY
Ruins of the ancient City of Champawat
General direction of the Section
Explanation of the coloured lines extending over the Section.
N.o 1. Green line is intended to embrace a tract of country called Terrai which extends along the base of the table land for several miles in length and varying in breadth from 60 to 80 Miles. It is so unhealthy as to be only passed through with safety between the months of November and March on account of the fatal remittent fevers which are endemic at all other seasons in this tract. Its physical peculiarities are 1.st excessive atmospheric heat occasioned by its southwestern aspect by which it is exposed to the influence of a powerfull sun and to the hot land winds which sweep over the upper provinces of Hindustan during the dry season as well as to the radiated heat derived from the southern acclivity of the Himalayas while it is sheltered from all atmospheric currents passing from the north north-west and North East. 2.d Great humidity occasioned by the descent of the floods from the mountains and by the rank vegetation with which it is overspread. The inhabitants of that portion of the plain which border the Terrai as well as a peculiar tribe of Hindoos called Taru who from some singular destiny are seldome known to desert these pestilential forests look unhealthy and emaciated but are quite free from Goitre.
N.o 2. Blue line includes a tract of country which notwithstanding its elevation is almost uninhabitable from its proximity to the Terrai
N.o 3. Pink line includes one of the most salubrious sections of the province and which is equal in its effects on the human constitution to the finest climate in the world. It is chiefly overgrown with forests and contains about 2000 inhabitants.
N.o 4 Yellow line embraces also a fine tract of the district the mean temperature is however higher than that of the last mentioned section: the numerous deep valleys by which it is intersected is the cause of the difference it contains about 2000 inhabitants who are not subject to any endemic disorder.
N.o 5 Brown line embraces the district of Shore; it contains some three or 4000 inhabitants seven per cent of whom are affected with goitre.
N.o 6 Green vertical line marks the extreme point to which the present enquiries have been extended. The mountains here begin to assume a lofty and massive character rising successively one after another until at the distance of about 30 miles they attain the enormous altitude of twenty and even twenty five thousand feet one of the peaks of Dharma bearing N.N.E. and distant about 37 miles 22,207 according to the measurements which have been taken by authority of the Indian government and the altitude of Nundi Davi distant about 46 miles bearing a few degrees to the westward of N. is 25.749 feet above the Sea.
Height of Nundi Davi
Height of Chimborazo
Height of Mont Blanc
Oaks disappear
Level of the Ocean
PHYSICAL SECTION of the MOUNTAINS composing the EASTERN FRONTIER of KUMAON from BURMDEO PASS to the VALLEY of BARABISE.
N.o 5
N.o 4
N.o 3
N.o 2
N.o 1
Lat. N. 30° 21'
Lat. N. 30° 36'
PETORAGUR
Lat. N. 29° 21'
LOHOOGAT
Level of the Gogra R.r
Mean direction due North — Scale of Altitude the same as the Scale of distance i.e. about half an Inch to a Mile
REFERENCES TO SECTION
A Granite
BB. Gneiss
CC Mica Slate
DDD Hornblende Slate
E Chlorit Slate
FF Primitive Clay Slate
G Transition Slate
H Stealitie Sandstone
III Compact Lime Stone
K Compact Dolomite
LL Calcareous Grit Stone
M Siliceous Grit Stone
N Slate Clay
O Conglomerate
P Gypsum
a Chourapany
b Takill Mountain
c Suce or Needle Mountain
d Tama Khan or Copper Mount
e Valley of Kalapany
f Valley of Gorong
g Burmdeo Pass
h Belkel
i Ramessa Valley
p Cantonments of Lohoogat
+ Temples
Villages and Towns
Places from which observations were taken.
John McClelland del.
J. B. Tassin lith. Calcutta August 1835.