

III.—On the Gypsum of the Himalaya. By Capt. P. T. Cautley,  
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While there appears to be a general unwillingness on the part of geologists to admit the gypsum of the Alps as a recent formation, the leading authorities in that science are divided whether to consider it as *primitive*, or to class it among the indefinite *transition* formations.

M. Brochant has reviewed the gypsum formations of the Alps, and given his opinion on their relative antiquity: we have also accounts of other countries, betraying the same uncertainty with reference to the point at question: and perhaps we may not be far wrong in attributing many of the doubts in the classification of gypsum and other similar minerals, to the very interpolation of the order *Transition*, an arrangement convenient enough as offering a resting place for every variety not stamped with the decided mark of primary or secondary, but to the scientific inquirer a most deplorable bar to *precision*, a term not inapplicable altogether to the science, as we may hope to find it under a revised, well arranged, and *permanent* nomenclature.

The gypsum of the Paris basin, that accompanying the red marle of England, and that of other similar localities, have been acceded to as secondary formations by all geologists; while those found in the higher mountain ranges of the globe have from their singular and generally ill-defined position, placed authors in doubts as to their classification. M. Brochant argues, that from the similarity of appearance in Gypsum rocks, he should be led to ascribe them all to the same æra; and from his own observation decides, that they all belong to the *transition* series, with this difference, which he deems important, that the ancient secondary gypsum of Bavaria, Saltzburg, &c. &c. reposes on strata essentially posterior to the transition class; an objection, as De la Beche observes, nugatory from the frequent conjunction of the primary and secondary strata, exemplified by the oolite of the Jura resting on gneiss in the Rhine, &c. But although we find the superior classes of the secondary rocks in *conjunction* with the higher classes of the primary, the latter order is never found reposing on the newer formations; indeed the only example given of an occurrence of this sort is by McCulloch, of gneiss on a secondary rock, which is noticed in the preface to Conybeare's work, and exemplified by a drawing, most satisfactorily explaining the deception.

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\* The term *secondary*, as here used, includes what is generally called *tertiary*  
—Ed.

Saussure, Daubuisson, and others, have conceived some of the Alpine gypsum to be primary; that of Cogne, mentioned by Brochant; as discovered and considered primitive by Daubuisson, obtaining the distinction from a superincumbent stratum of lime-stone "a little crystalline, blueish grey, and very schistose from a mixture of talc;" the gypsum having no outcrop whatever, and consequently being imbedded in the above rock; and, as M. Brochant says there is every reason to suppose that the schistose limestone of the roof contains quartzose veins, as also happens in transition limestone, he, rather gratuitously, concludes that the formation is contemporaneous.

The presence of these quartzose veins, which is the *type of transition*, and the absence of outcrop, rest on the mere ipse dixit of the villagers, and can hardly be received as proofs in a matter where direct geological accuracy is concerned. The deposit also of Val Canaria is a very doubtful proof of the existence of gypsum primarily. The fact of its underlying mica slate is contradicted by Brochant, who thinks the same of his transition variety. The proof of its being primitive is therefore still far from being ascertained, and I propose in a future part of this paper to suggest causes that might place in doubt, even the superincumbence of mica slate as a proof of its antiquity. The general description given by writers on the subject of Alpine gypsum, so closely applies itself to the mineral lately found in the line of mountains north of the *Dehra Dūn*, both in regard to its position and its attendant rocks, that a comparison becomes exceedingly interesting, as illustrative of the difference, if there be any, of the gypsum decidedly secondary, and that which is accompanied by rocks of evidently a more ancient formation.

The localities which have come under my immediate observation are two of those adverted to by Captain Herbert, in his communication to the Society. The first near *Sansardhāra*, immediately on the skirts of the mountains bounding the valley of *Dehra*, on the north: the second about four miles further north, near the village of *Salkoḥh*, differing in position most essentially from the former, though resembling it in character; to enter into a detail of each, with its respective peculiarities will be necessary in furtherance of the history of the rock in question.

#### *Gypsum opposite Sansardhāra.*

Immediately opposite the stalactitic caves, and beyond the rapid stream that runs towards the village of *Naguḥ*, a passage into the mountains is effected up the course of one of its tributaries, which branching off to the left, leads you at once to the gypsum, the prox-

imity of which becomes apparent from the masses and broken pieces in the bed of the stream. A considerable slip in the mountain, of a very recent date, displays the position of the rock, which would doubtless otherwise have remained concealed, as no vestige whatever can be found on the unbroken surface of the mountain. To give therefore an explicit account of its actual dimensions, or even to describe the locality, is perfectly impossible, further than what is exhibited to the eye: from the confusion attending on these fractures, and the precipitous and irregular structure of the mountain, covered with vegetation and an impervious wood. The gypsum is apparent here in two beds or strata, separated by a reddish argillaceous schist, and reposing upon a blueish limestone, in contact with which there are evident signs of passing one into the other. Independent of these beds or strata, unconnected and insulated masses of gypsum appear throughout the schist, the whole lying horizontal without any apparent dip or inclination. Beneath the blueish limestone, on which the lowest stratum rests, are varieties of a lime rock, of a darker color, reticulated with veins of calcareous spar, large rhomboidal crystals of the latter being found of considerable size, and in a much greater proportion than in the neighbouring mountains: indeed, the debris formed by the slipping of this face of mountain is altogether composed of these varieties of limestone, fragments of calcareous spar, and the pieces of broken gypsum and schist. The quality of this gypsum varies as much as its color; the former from a compact crystalline mass, to a loose, powdery, and arenaceous soil, hardly to be termed rock; the latter from a pure white, slightly translucent at the edges, to a dirty grey, particularly in its passage into the limestone. The colors however are exceedingly various: a brilliant yellow variety was discovered in great abundance. The height of this deposit from the bed of the stream is about 1000 or 1200 feet. The mountain series decidedly calcareous.

#### *Gypsum at Salkot'h.*

The former gypsum I have explained as alternating to all appearance with argillaceous schist, and forming a series with rocks, the antiquity of which may be a matter of remark hereafter. This gypsum is apparently superficial, and entering into the series more as an independent formation, than as a feature expressive of the general structure of the mountain. It shows itself opposite that village, about four miles north of *Sansadhâra*, jutting from the face of the mountain in a bold and irregular outline, to the height of about 200 feet from

the bed of a tributary that joins the Nagul stream, opposite the village of *Salkot'h*. The whole mass is composed of gypsum, without the intervention of any alternating rocks; and a conclusion may naturally be drawn from the absence of the mineral in its vicinity, that this deposit is insulated, or simply an enormous nodule, resembling those of calcareous tufa so frequently met with, in detached and unconnected masses. The falling down of large masses of the upper part of the rock has caused such confusion and irregularity below, that it would be even doubtful whether the deposit actually extends to the bed of the stream, or whether its limits might not properly be curtailed to a depth of at least one-half, a circumstance moreover that precludes the possibility of discovering the rock on which it lies, or of satisfactorily describing the concomitant formations. The same difficulty generally occurs with these rocks; their decomposition is universally great, and the extreme variableness in texture so open to the attacks of weather, that externally, without the aid of slips and fractures, it is almost impossible to detect any regularity in stratification, or in fact any clue wherefrom to form an idea of their general character. The tendency that this rock has to form itself into peaks and protruding points is well preserved here, and deserves mention from a peculiarity for which it is distinguished in the Alps; resting solely however upon the decomposing character of the rock, and from no material *form* of composition. The mountain itself is formed entirely of the bluish limestone formerly mentioned, into which the gypsum decidedly passes, modifying itself into a bluish variety, effervescent, and differing only in appearance from the limestone itself, by its want of compactness, and loose and friable quality: a black fragmentary and argillaceous lime rock is also in abundant dissemination throughout the lower part of the deposit, and singularly attached to those parts where the gypsum appears to be of a purer quality than at others; indeed it generally appears that by the presence of the rock in question, the mineral acquires a purity both in color and texture, unobtainable in those parts in contact with the blue limestone or at a distance from the black rock. It would be endless to enumerate the colors that appear throughout this formation; from the purest white crystalline, it passes through dirty grey pink, until it arrives at the blue limestone, when it obtains a tinge of that color. The texture is also as variable, and I may say, that throughout the whole deposit a very small proportion is of that variety generally known by the name of alabaster; and

even those parts so fragmentary, and so interspersed with the coarser varieties, that any attempt at converting it into ornamental uses would, I fear, be out of the question. The specimens that I have seen in cups and small vases fully authorize this conclusion: their appearance being more of a white earth, or chalky limestone, than of a gypsum, or to speak in plain terms, of an alabaster. The varieties of Himalayan gypsum as yet discovered are certainly deficient both in beauty and value as an article of use, though interesting for comparison with other formations.

Selenite, in small tabular crystals, is disseminated throughout this gypsum, though in hardly sufficient abundance to give any peculiar character to the formation.

A question of considerable interest arises from the appearance and position of the above-mentioned deposits, which, as mentioned in a former part of this paper, from their position under rocks of the primary and secondary classes, acquire an appearance of antiquity, not borne out by the general history of the mineral; namely, that the gypsum throughout the globe is simply an infiltration analogous to the tufa and calcareous deposits, and depending on causes chemically similar; the sulphuric acid being the active generator instead of the carbonic. If in the proximity of sulphur an excess of oxygen would produce sulphuric acid, a difficulty is removed, and the contact with lime-rock or carbonate of lime would, it may be supposed, produce its sulphate, or gypsum; and I cannot perceive the improbability of such a process having been or being still in force; or that nature's laboratory might not have been as active in the dissemination of gypsum, as it is in the present day, of the calcareous tufa.

The argument obtains considerable weight from a most material circumstance, which almost makes it a matter of certainty that the origin of all gypsums is contemporaneous; this is, the exact resemblance both in texture and crystallisation that they all bear, whether Alpine, or those varieties found with the secondary rocks: a similarity that does not exist in any of the lime-stones formed at different periods, nor in other rocks: the primary and secondary varieties shewing the most decided dissimilitude both in texture, quality, and position.

The term infiltration must be received, as implying the simple power of a mineral in solution to insinuate itself into cracks and fissures, or to fill hollows and cavities, without any reference to a gradual process, as it is possible that the mineral in question might in many instances (parti-

cularly in those deposits where an appearance of stratification or alternation with other rocks is apparent) have undergone a change, more sudden, and more general, than what we understand by the term "infiltration," as applies to the formation of calcareous tufa. A question may be put, as to the absence of any impressions of vegetable remains,—as to the want of the cylindrical and radiated texture, which so peculiarly marks the tufa in formation? It must be confessed, that on comparing the minerals, and supposing the process under which they are found to be *similar*; difficulties, though not irreconcilable to the above supposition, present themselves. In the first place, the action of sulphuric acid would tend in a much more rapid degree to the formation of gypsum, than does the presence of carbonic acid and lime to produce tufa. The same rapid action would create a texture of a totally different quality, and the ingredients themselves would destroy any vegetable remains that might be enveloped in the mass: had the same gradual and slow process that forms the tufa been also exerted in forming gypsum, similar texture would have been the consequence; and the deposit of the latter would shew at least marks of stalactites, &c.; but though infiltration is granted as a solution of the problem, the action of time and other causes may have removed those outward and visible marks that might have tended at once to a direct conclusion. Age, pressure, and other causes, are well known as the means of producing most extraordinary changes in the system, and also in the texture and quality of the rocks themselves. The above causes, in a greater or less degree, may have equally exerted their effects on gypsum.

The obvious transition of the blue limestone into the gypsum at the deposit at *Salkot'h*; and the extreme purity of the gypsum when in contact with the black fragmentary rock, which scarcely effervesces with acids, leads me to the idea that all these varieties of lime-rock in the proximity of the mineral are simply modifications, caused by the action of the sulphuric acid in a greater or less degree. The springs and rivers in the vicinity of all these formations abound in carbonic acid, as is evident from innumerable deposits of tufa, and stalactitic formations;—while the rocks themselves are of limestone:—near *Sansadhára*, sulphur and sulphuretted hydrogen impregnate the waters, and it is at least plausible to suppose from the occurrence of gypsum, that the presence of sulphuric acid is one, if not the main cause of the superabundance of carbonic acid diffused through all the springs, and leading to the tufaceous and stalactitic deposits of lime that not only appear

in such magnificence at the caves of *Sansardhára*, but actually give a coating to the bed of the streams, and are the cause, I conclude, of the enormous excess of local conglomerate that appears throughout the whole of the ranges, of which *MasúriTiba* and *Bhadraj* form such prominent features; the latter mountain terminating the range towards the Jumna, whilst the eastern or opposite extremity, under the name of *Skanda Déhi*, is washed by the Ganges. The yellow color of some varieties of the gypsum may depend on the contact with sulphur\*, the abundance of which mineral may be concluded from the sulphuretted waters above alluded to:—that it was so in former times, is sufficiently shewn by the existence of the gypsum itself. Whether it is not daily forming may be a matter of doubt, at least in the above localities: we find independent masses of tufa apart from the proximity of springs and water, the course of the latter having changed or dried up; at least the argument would stand thus on the discovery of a mass of calcareous tufa similarly situated to the gypsum deposit of *Salkot'h*, or that of other countries, not forgetting the primary deposit of *Daubuisson* at *Cogne*!

If therefore where carbonate of lime, sulphur, and water are abundant, the chemical change above mentioned, is allowed, or is supposed from analogy to be a probable consequence, gypsum can no longer be entitled to a place in either primary transition or secondary classes; but must be considered as an adventitious formation common to all ages, and produced by causes analogous to the present rapid formation of calcareous tufa. Amongst our primary and transition rocks, none can be assimilated to the stalactitic carbonate of lime; amongst our secondary or latest class of general rocks, there is none like the gypsum, that is to say, we know of none actually forming at this day. Causes that led to the formations of such abundance of gypsum formerly, may from unassignable reasons, no longer exist; and those which produce the tufaceous carbonates, then at rest, may now be in full vigor.

The above reasoning is not affected by any account of a gypsum deposit that I have met with, and although the regular stratification or alternation of gypsum with clay slate, as above alluded to, may at first be a startling objection to the proposed theory, it will on examination be easily accounted for. The above discovered deposit of gypsum was assumed actually to consist of strata, but this is somewhat doubtful.

\* Is not the yellow color due to the presence of oxide of iron?—Ed.

To those who may differ with me on the subject, I must observe in conclusion, that gypsum has never been found in a country or district where the presence of the lime carbonate has been wanting; but mostly in a position surrounded by vast tracts of that mineral, rising in successive ranges in the vicinity of springs and running streams, whose courses are marked by their deposit of lime, in the presence of springs impregnated with sulphur and sulphuretted hydrogen. When the very ingredients are at active work at the present day in the manufactory of stalactite, may we not with circumstantial evidence at least, convict them of pursuing a different course, and under different times and circumstances of forming *gypsum*!

P. S. I may mention another deposit of the mineral on the *Masúri* range, on the descent from the ridge or spur upon which Capt. Brooke has fixed his residence, to the valley of the *Aglar* river. There are also appearances of it on the ascent from *Rajpúr* via *Jaraiáni* to *Masúri*, in the black fragmentary rock interspersed with minute threads of the gypsum, although, as far as my observation has been directed, the mineral at this point does not appear in mass: at the former deposit however, on the slope to the *Aglar* river, we find it in great abundance, though in quality by no means superior to the *Salkot* variety; the situation is partly to the right and left of the foot-path on the ascent, in large nodular masses, or independent rocks, whose outer surface exhibits the usual sharp angular and pointed features, and partly in irregular lumps imbedded in the debris of a huge slip of the mountain, which must have fallen within the last few years, as it bears every appearance of freshness. Unless we are to suppose that the mountain from which this slip has taken place was in itself formed of debris, and the rounded boulders of water-worn rock, which I may safely assume not to be the case, the appearance of these detached masses of gypsum is very unusual; they neither look like pieces broken off from a large mass in the fall of the mountain, nor have they the least resemblance to boulders; but from their uneven honey-combed surfaces, I could almost bring myself to imagine, that they had been formed by infiltration into holes and fissures in the rock or soil; the outer surface decidedly having the appearance of being formed in a mould which the irregular internal surface of a natural cavity would exhibit. These pieces vary in size, but do not exceed in dimensions a cubic foot or thereabouts.

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