VI. Observations on the Physical Structure of Devonshire and Cornwall.

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[Translated from the original French Manuscript.]

In venturing to lay before the Geological Society the following observations made in the course of a journey through Devonshire and Cornwall,* I do not presume to think that I have by any means comprehended all that is interesting in the physical structure of these counties; many observations, not only of detail, but of higher importance, have no doubt escaped me: all I pretend to do is, to give a general outline of what I have seen, and to connect those observations with such as I have made in the other countries of Europe which I have also visited.

Among the several formations † which the greater part of geologists recognize, (understanding by this term not only the...

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* I had the pleasure of making this tour in 1809, in company with Mr. Louis Albert Necker of Geneva, who has since presented to the Geological Society, of which he is an honorary member, a series of specimens, with a descriptive catalogue of the rocks he had collected.

† The word formation implies the idea of time or epoch.
nature of the rocks of a district, but likewise the general disposition of the strata, and their relation in point of position to the surrounding country) one of the most interesting undoubtedly is that of flint in chalk, which is subordinate to the secondary formation in the great and generally admitted division of rocks into *primitive*, *transition*, and *secondary*.

Whatever be the country, where the formation of flint in chalk or marl occurs, it is worthy of remark:

I. That it occupies a considerable extent.

II. That it belongs to flat countries stratiform or alluvial; and what appears to me a more striking circumstance is, that as far as I know, it is to be met with chiefly on the skirt of some great chain of mountains at *some* distance; as if it made one of the links of a complete system of formations. Thus, in France, it prevails on the skirt of the western boundary of Mount Jura, extending nearly in a direction from S. E. to N. W. and covering a space of at least two hundred and ten miles long, by about one hundred and fifty broad.* In Poland, on the borders of the chain of the Carpathian mountains, from the shores of the Baltic, comprehending the plains of the Pilica, of the Bug, and of the Vistula, as far as the first heights where these rivers have their source.† In England, to the east of the mountainous part of Devonshire and Cornwall, and stretching across to the German ocean. This formation is also found in Ireland, Saxony, Spain, Denmark, and Sweden; but I do not sufficiently know in what particular situations, to enable me to notice them in a less general manner.

From the nearly exact correspondence of the meridians under...
which this formation lies in France and in England, some persons have been led to consider it as one and the same, and consequently to conclude that the British channel, which separates these parts which are now opposed to each other, has been formed after the chalk had been deposited. I shall not however enter upon the discussion of the merits of that opinion, which if examined in detail, would offer several difficulties, as I do not think that it is necessary to adopt it, in order to account for the facts which present themselves.

One of the distinctive characters of this formation, is the disposition of the flint in beds or layers, nearly parallel to each other, though at unequal distances, so that whatever be the shape of the country at the surface, whether it be hilly or flat, the beds of flint preserve a nearly uniform parallelism with the surface of the ground; this is tolerably well seen in Dorsetshire, a county, the outline of which is very undulated. This kind of hilly ground is known in England by the name of downs. In Hampshire, in the western part of it especially, there are elevated plains, and occasional depressions, but these last are not sufficiently deep nor do they succeed to the former so rapidly as to entitle that district of country to the name of downs.

Flints near their original situation do not always appear in the form of pebbles, but often in masses of a more or less considerable size, and of a shape sometimes flatted and irregular. It is chiefly in alluvial ground formed of a slightly aggregated gravel, that flints are found in the state of pebbles, of different sizes, according to the friction they have undergone, and consequently, according to the distance from which they have been brought: hence, the individual pebbles of which gravel consists, become in general smaller and smaller as they approach the sea.
This cause has operated not only on flints, but also on every kind of rock, forming detached masses or entire mountains, which have been worn down either in whole or in part, and the fragments afterwards transported, and deposited in the plains by currents of water.* It is principally the same agent which has accumulated the heaps of quartz pebbles, which are found at the extremities of some primitive countries,† on elevated plains, to the nature of which they are quite foreign: it is however much more difficult to trace with any certainty the original locality of this quartz, than of flint gravel.‡

With regard to the formation of flints in chalk, if we adopt the explanation of Werner, that they have been produced by infiltration, I should be as much disposed to attribute the void spaces in the chalk to a natural contraction of its own substance, as to the disengagement of air. We know that chalk divides by drying, into compartments which are sometimes very regular, nearly in the same way as marl. According to this hypothesis we may suppose, either that the chalk and the flints are of contemporaneous formation, that the elements of the flint were mixed with those of the chalk, and that they separated from each other by elective affinity, or that the siliceous matter has been afterwards introduced, and has filled up the cavities left in the chalk.

But whichever of these opinions we may adopt, I do not see, how in any case we can possibly admit the conversion of chalk into flint,

* Saussure, Voyages aux Alpes, §§. 1315. 1327. 1329. 1334.
† For example, at the entrance of the great valley of the Rhone, in the neighbourhood of Lyons.
‡ Sir Henry Englefield has pointed out in the Isle of Wight, a very remarkable fact relative to the state of the flints imbedded in the chalk. Transact. of the Linnean Soc. vol. vi. p. 103 and 303. See also for a fact nearly similar to the preceding, Geographie Physique de Bergman. Journ. des Mines, No. xvi. p. 39.
or vice versa, that of flint into chalk. The following reflections of Saussure on this subject are strongly in point.—"These observations and these experiments appear to me to prove that the intermediate species which have been sometimes considered as forming the gradation from one genus to another, or as limestones partly transformed into flint, are very often merely mechanical mixtures of the two. In fact there is no mineral hitherto known which we might not assume as the commencement of a series, and thence proceed to establish by insensible shades a circuit comprehending the whole of those which have been already determined, and the more extensive our acquaintance with mineralogy the more will the truth of the observation become apparent, in consequence of the more numerous varieties and shades of difference which will be discovered."

It would appear however that the chalk in which flints occur, although subordinate to the carious rocks, must, according to Brongniart, belong to a formation anterior to that of the limestone which he denominates grossière. He asserts that the fossils found in chalk are almost all species of extinct genera, and that the situation of chalk is always inferior to that of the calcaire grossière.† It is probably this species of limestone of which the quarry of St. Europe, near Aix in Provence consists, where the Chevalier de Sades affirms, eleven beds have been formed since the existence of man in a civilized state?†

The western border of Dorsetshire is nearly the limit of the occurrence of flints in the chalk. This last, however, extends on the road to Axminster, to within four miles of Honiton in Devonshire, where

* Voyages aux Alpes, § 1537. Werner, without going so far as Saussure in strictness of language, is of the same opinion. Nouvelle Théorie de la Formation des Filons, § 91.
† Brongniart, Éléments de Minéralogie, tome i. p. 209.
It is totally lost, so that setting out from London, and going in a
direct line from east to west, this formation extends one hundred and
fifty miles between these two boundaries. The structure of the cliffs
on the sea-shore, it is true, changes several miles eastward of the
western boundary now stated. Thus the Island of Portland furnishes
a grit, having a calcareous cement; and Lyme Regis, a little farther
west, a shell limestone;* this last I did not see in situ, but from the
specimens I procured in that neighbourhood, it appeared to me rather
to deserve the name of a shelly-calcareous grit. It is of a bluish
colour, of a fine grain, and the particles distinct. It contains petri­
factions, particularly very beautiful ammonites, which are semi­
transparent. This rock, in many respects, very much resembles that
which forms the cliffs of Tracy on the coast of Bayeux in Nor­
mandy.†

Immediately upon quitting the chalk district, we enter upon a
transition country, of which Exeter may be considered the centre,
and as it is yet little known in a geological point of view, it deserves
a more particular examination.

The red sandstone, having an argillo-ferruginous cement, first suc­
cceeds the chalk and flint. Towards Honiton, it is in the state of a
coarse-grained gravel, almost entirely disintegrated. It contains
rounded pebbles, some of which are two or three inches in dia­
meter: it then approaches to a conglomerate puddingstone, but near
Exeter, it assumes the character of an arenaceous sandstone, and be­
comes more compact and uniform in its texture and composition.

* There is also along the coast of Dorsetshire, a range of argillaceous hills, belonging
to a kind which, according to M. Brongniart, are to be observed either on the bounda­
ries of primitive countries, or on the passage to the secondary countries. Traité Elé­
mentaire de Minéralogie, tom. i, p. 527.
† Journ. de Physique, Mars 1807.
This conglomerate is in nearly horizontal strata, which probably extend eastward below the chalk, while to the westward they lie upon rocks of a different nature, of which I shall afterwards speak.

The town of Exeter is situated in a sort of hollow encircled by hills not very elevated, nearly all of the same height, and which become gradually lower as they approach the coast. I found one of these hills, situated eight or nine miles N. N. W. of Exeter, near the village of Thorverton, to be seven hundred feet above the level of the sea. This basin opens to the S. S. E. and, as is frequently the case in England, a river, which at the distance of a few miles from its mouth would deserve rather the name of a brook, suddenly enlarges near the sea to a considerable width. The Ex at the place where it flows into the open sea, suddenly again contracts, and forms a very narrow strait.

There are several quarries opened in the neighbourhood of Exeter, deserving the attention of the geologist: some of these I shall now enumerate.

The quarry of Heavitree is situated about a mile and a half from Exeter, on the road to Honiton. It is worked to the extent of a quarter of a mile in length, and at present, to the depth of about ninety or a hundred feet, in a plane intersecting that of the strata. The rock worked in this quarry is a conglomerate evidently stratified; the strata are from six to eight feet in thickness, and dip S. E. at an angle of about 15°. As long as this rock preserves the character of conglomerate, it is compact and tenacious, and according to the workmen employed in the quarry, it hardens more and more by exposure to the air. But as soon as it passes to the state of an arenaceous sandstone, it becomes tender and friable. It is very common to see blocks of it in this last state, and sometimes of great size, included in the middle of the conglomerate. The cement of this
rock is argillo-ferruginous,* and by itself does not effervesce with acids, as it is easy to prove by making use of pieces of the pure sandstone for that purpose; but it produces so brisk an effervescence from the intimate mixture of calcareous particles, that it might be very easily mistaken for limestone. The substances which enter into the composition of this conglomerate are numerous; and it may first be remarked, that these pieces are of very different sizes and forms, sometimes rolled and rounded, sometimes pointed with sharp angles, from very minute grains to the size of several inches in diameter. There are found in it rhomboidal crystals of calcareous spar, and crystals of felspar, most frequently of an opaque white, and decomposed; pieces of flint; grauwacke; yellowish limestone; rolled masses of a species of porphyry somewhat resembling the antique, the base of which is of a reddish brown colour, not effervescing with acids, and containing numerous, small and well-defined crystals of felspar imbedded in it; pieces of a rock which is itself compounded, having the appearance of a porphyry, the base earthy, and including small grains of quartz, crystals of felspar, and pieces of bluish carbonate of lime; and a whitish tender steatite, in small angular fragments.

Poucham quarry is situated about two miles N. N. W. of Exeter. It is of much less extent than that in the parish of Heavitree. I was not able to determine either the direction or inclination of the

* May not the presence of iron in this conglomerate be owing to the disintegration of the granite of the low chain of Cornwall, the mica of which contains so great a proportion of it in the state of oxide?

The Count de Bournon appears even disposed to believe, that the primitive rocks have been the only source from which the iron has come, that is spread over the whole surface of the earth. Traité de Min. vol. I. p. 62.
strata. The rock itself is an amygdaloid, the nodules of which are chiefly calcareous; small and uniform; the base does not effervesce with acids, and when breathed upon, it has the smell peculiar to clay. It is much stained by oxide of iron, which tarnishes the lustre of the calcareous nodules and veins contained in it.

Thorverton quarry is seven or eight miles north of Exeter. In going to it by Cowley Bridge, on the summit of a hill which overlooks Exeter, and is almost close to the town, the grauwacke is met with in situ. It is of a greyish colour, with very distinct and separate grains, breaking spontaneously into rhomboidal fragments; it is harder in some places than in others; when tender, it splits in the manner of slate, and assumes quite the character of that species of rock. It occurs in strata, dipping N.W. at an angle of about 70°. The same grauwacke formation is met with to the N.N.E. of Exeter, on the road to Bickleigh, Silverton, Rew, and Cross-hill; at Cross-hill the direction and inclination of the strata are very distinctly seen. From Cowley Bridge the grauwacke extends as far as the neighbourhood of Upton Pyne, but in this district it can only be distinctly seen on the summits of the hills; it is lost in the bottom of the vallies, and is there succeeded by the red argillaceous sandstone. This is particularly the case at Upton Pyne, a village five miles north of Exeter on the right bank of the Ex. As there is a mine of black oxide of manganese worked in open day at this place, I had an opportunity of making pretty accurate observations on the strata, and on the nature of the rock. The red argillaceous sandstone, at the place where the mine is excavated, forms a stratum several feet in thickness from the surface; below this is a conglomerate puddingstone, the same that is found in the parish of Heavitree, but quite disintegrated: then, a reddish compact felspar in mass,
containing a few lamínæ of calcareous spar, and some crystals of quartz. This last rock forms the roof of the mine, the saalbände*. It consists of a calcareo-manganese amygdaloid. As to the floor of the mine, it is not known of what it consists, as the vein, which appears to be of considerable magnitude, has not been cut through. Its direction is from E. to W. dipping N. with an inclination of three feet in six. Of the black oxide of manganese, several varieties are met with, together with ferriferous carbonate of lime. The red argillaceous sandstone occupies the surface of the country from Upton Pyne to Thorverton.

There are three or four quarries at Thorverton, and these not far distant from each other. They are all in the same rock, viz. a calcareous amygdaloid, the nature of which, however, varies considerably in different places. In some places, the nodules are small, and very closely united in clusters in the base, forming nearly a homogeneous mass, with here and there nodules of a much larger size than the rest imbedded in it. In other places the nodules are about the bigness of a pea, all of the same size, and consist of rhomboidal sparry lamínæ. There are other places where the base of the amygdaloid has the appearance of a sand stone in which a small number of calcareous nodules are imbedded, externally coloured green by the steatite, and exactly resembling those which enter into the composition of some of the amygdaloids of Derbyshire, and of the Pentland hills near Edinburgh.

The country between Exeter and Plymouth by Chudleigh, Ashburton, and Ivy-bridge, is quite hilly, the whole being a continual

* The term saalbände, for which we have no corresponding scientific expression, is frequently denominated in some of the mining districts of this country, pasting or sticking. Tr.
ascent and descent as far as the neighbourhood of Ivy-bridge. The red argillaceous sandstone continues from Exeter for some miles on that road; it is succeeded near Chudleigh by a vast number of flint pebbles, which appear to be scattered over the surface of the ground: I was not able to stop to examine them more attentively; but between Chudleigh and Ashburton, there occurs a blue compact limestone, traversed by numerous veins of calcareous spar. At every step the extremities of the strata of this rock may be seen cropping out, and fragments of it are mixed with the soil. In the neighbourhood of Ivy-bridge a formation commences, which as will afterwards be shewn, occupies a prodigious extent in this part of England: I mean the slaty and compact grauwacke. At Plymouth, however, the cliffs on the shore are of limestone; which as I examined them leisurely, and as they appear to me to excite some degree of interest, I shall describe more minutely.

The range of tolerably high cliffs, which extends from Stonehouse Pool, between Plymouth and Plymouth Dock, and thence along Catwater, ascending the right bank of the Plym as far as the Flying bridge, together with Mount Batten, and probably also the Island of St. Nicholas, are formed of a compact limestone. It occurs in strata rising N.N.W. at an angle of about 65°; it breaks with a semi-conchoidal fracture into large flakes, is of a yellowish-white colour, and, when quarried, is blasted with gunpowder. I did not discover in it any impressions of organic bodies, and I did not hear that they have ever been found in it; at least, if any do exist, they are very scarce. It contains several cavities lined with calcareous spar, or with stalactites, and filled with an ochreous earth. It is frequently also traversed by veins of calcareous spar of a wedge shape, wider at the bottom than at the top, and which generally occupy the whole height of the cliffs. On the side of Catwater, this limestone
is of a bluish colour and a crystalline grain; it is here also frequently intersected by veins of calcareous spar. The cliffs near Stonehouse being much exposed to the action of the sea, afford very distinct proofs of its effect on the most tender parts of the rock. It has made in several places erosions or crevices of various extent, which have been afterwards filled by a gravelly sand thrown up by the sea, and which has, by drying, become so coherent, that one might be led into error, by conceiving that the sand alternates in beds with the limestone.

But it is at the eastern end of the Flying bridge, on the left bank of the Plym, that the transition limestone is found in its true character. I have nowhere seen it so well characterized, not even at Meillerie in Savoy, on the borders of the Lake of Geneva. The strata have the same direction and the same degree of inclination as those at Catwater. There is a quarry belonging to Lord Borringdon, which is an excellent spot for studying it. This limestone is blackish-brown, several rhomboidal plates of calcareous spar may be seen disseminated through the mass, and it suddenly assumes in the same stratum, all the characters of a shining slate; the rock in this last state effervesces less briskly with acids.

On quitting the coast, and advancing into the interior of the country, there is seen on the road from Saltram to Plymptom Earle a slaty amygdaloid, the base of which is of a purplish-brown colour, the nodules calcareous, and the greater part of them very minute. I found in the same neighbourhood, on the surface of the fields, in adventitious blocks and pebbles, another species of amygdaloid, the base of which is greenish-grey, and has the lustre of satin; several of the nodules being completely decomposed, had left corresponding empty spaces.

I cannot say what formation is found on the shore to the east of
Plymouth, by Dartmouth, Torbay, and Teignmouth. I am inclined to believe that it is the same limestone which I saw at Chudleigh and Ashburton, and which extends thus far into the interior of the country. The observations of Dr. Maton seem to support this conjecture,* as do those subsequently made by Lord Webb Seymour and Mr. Playfair.†

Nor do I know what rocks are found in situ, on the road from Exeter to Oakhampton. I can only say, that at a few miles to the east of that town, the extensive grauwacke formation commences.

Before proceeding further westward, where more constant and uniform formations will be found to exist, it may not be amiss to make here some general remarks, pointed out by the subject itself; on the nature and succession of the different formations which have been already noticed, and on what they seem to offer in the way of analogy with other countries.

It has been seen, that leaving on the borders of Dorsetshire the chalk and flint formation, and afterwards the shell limestone, a red sandstone succeeded, in strata slightly inclined, which as well as those of the conglomerate into which it passes, rest in some places on amygdaloid, in others on grauwacke, and finally on transition limestone. It is an object of inquiry which demanded more leisure than I was able to bestow upon it, to determine whether it is on one of these rocks in particular, that the argillaceous sandstone rests: but it is, I presume, a matter of secondary importance. There is another general fact of some consequence to observe, which is, the elevation of the strata the further they proceed to the westward, and the great angle of inclination they make with the horizon. Let us

† Illustrations of the Huttonian Theory, p. 55, 189.
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now compare these appearances with those met with in other countries, and we shall find, that upon a diminutive scale, they coincide for the most part with each other, and that they lead us very strongly to believe that we are approaching a primitive country, or rather, that we are upon the verge of it. Thus, upon the skirts of the primitive mountains, where the Rhine rises, and at the opening of the great valley through which that river flows, enormous masses of conglomerate breccia are found. I have followed them for the space of several miles, from the borders of the lake of Wallenstadt, on the road to Zurich. It is also upon the same line, but a little more to the eastward, and on the skirts of the chain of mountains of St. Gothard, that are found those masses of pudding-stone which form mountains of so great an elevation as the Rigiberg, the Ruffiberg, and the Albisberg; and turning W.N.W. extend into the Entlibuchthal, where I have seen mural precipices of it, of a considerable height between Schoepfheim and Hochstetten. I have also seen those mentioned by Saussure at Valorsine in the valley of Trient;† on the left bank of the Rhone, between Martigny and St. Maurice in the Valais;‡ as well as those which are found in the beautiful valley of Loch Ness in Scotland.

* Mr. Kirwan considers the Conglomerate of Rigiberg as a calcareo-argillaceous breccia, which he calls Farcilite. Geol. Essays, p. 252.

I believe he might have equally comprehended it under the same head as the aggregate which he has called Semi-Protolite (Geol. Ess. p. 256), for fragments of granite are included in it, though in small quantity. I have seen some at least in the detached blocks of breccia of the Ruffiberg, near the village of Steinen in the valley of Goldau; and what is remarkable, it is a granite, having the felspar of a brick-red colour, a variety very rare in the high Alps.

† Voyages dans les Alpes, §§ 687, 688, 689.

‡ Ibidem, § 1053.
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Ramond has likewise met with this breccia in the Pyrenees.* He describes it by the name of "bandes" formed of a heterogeneous mixture in irregular veins, occurring between the fundamental granite, and the secondary and tertiary mountains. Other travellers have observed it in similar geological situations, in the Palatinate, Saxony, Bohemia, and particularly in Siberia, where it is stratified, and where jasper constitutes one of the principal elements of it.†

An indefatigable artist, the beauty of whose descriptions is not inferior to the graphic charms of his pencil, has proved, that a traveller, without being a profound mineralogist, may, if guided by a spirit of observation, collect materials very useful to those who know how to employ them. Vivant Denon, in noticing the mountains on the road from Keneh to Cosseir on the red sea, says, "at day-break we found the appearance of the country changed; the mountains that we had passed the day before were rocks of freestone; these were of puddingstone, being a mixture of granite, porphyry, serpentine, and other primitive species, aggregated in green schistus. The vallies continued to grow narrower, and the rocks on every side more lofty. At noon we had reached the first half of our journey, in the midst of fine rocks of breccia, which would be very easy to work if it were not for the great distance from any supplies of provisions: the portions of this granite, of which this breccia is composed, shew, that the primitive mountains are not far distant."‡

With regard to the elevation, and abutting of the secondary and tertiary strata as they approach the primitive rocks, Saussure and

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* Voyages au Mont Perdue, p. 157, 359, 205, &c.
† Kirwan's Geological Essays, 229.
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Pfyffer are, I believe, the first, who paid attention to this circumstance: Saussure in the mountains of Meillerie and St. Gingouph, in Savoy, Pfyffer in the Alps bordering on Lucerne.* The neighbourhood of Plymouth affords an example of it in this part of England.

As the physical structure of the western part of England, from the banks of the Tamar as far as the Lands End, offers little variety in geology, and as the great masses consist of a small number of different rocks, it will, I think, be convenient, to give, at first, a sketch of the chain of mountains which traverses this part of the country, such at least as I conceive it to be. It will be an outline, which may afterwards be more easily filled up by future observations. Besides, as the grauwacke constitutes one of the most essential component parts of this chain of mountains, and as it is susceptible of numberless modifications, it will be better to give, in the first place, some details on the nature of this rock in the different states which it assumes.

General Observations on the low Mountain-chain of Cornwall.

The chain of low mountains, which forms the county of Cornwall, extends nearly into the centre of Devonshire, comprehending the elevated and irregular mountain plain, called Dartmoor Forest.

Like all primitive chains, it stretches from N.E. to S.W. or, more correctly, from E. N. E. to W. S. W. extending in this direction from 115 to 118 miles.

Its line of direction is pretty accurately represented by a line passing through the following places, viz. Two Bridges, Launceston,

* Voyages dans les Alpes, § 325.
Bodmin, Indian Queen, Redruth, Camborne, Tregonin-hill near Marazion, St. Burien, and Sennen.

The central and highest part of the chain is granite, which extends into a narrow mountain plain at the north eastern extremity, and as it approaches the south-west gradually contracts into a ridge, and is flanked on the right and left by grauwacke. The outline of the range is not altogether continuous, several of the rounded summits which compose it are separated by small vallies or ravines of various depths. Thus, the Tamar, which flows to the eastward of Dartmoor forest, seems quite to detach that mountain plain from the hilly country to the west of Launceston; but it is easy to see, that such a separation does not exist in reality, Brown-Willy, the most elevated point of the whole chain,* being in the parallel which passes directly through the middle of Dartmoor forest. The whole chain may be said to be formed of downs, and to be in some places interrupted, but no where entirely broken off. I have little doubt, that in the lower parts of the country, where the granite appears to be wanting, it would be found under the rocks, which I believe cover it, whatever these may be, if wells sufficiently deep were sunk in those places.

The water-shed of the chain is to the north and south, and both sides have nearly the same degree of inclination: the waters on the one side run into the British, and on the other into the Bristol Channel. The whole range has a gradual slope towards the west, but on the east the terminations are rather abrupt. The greatest breadth of the chain, is a little to the east of the middle point in its longitudinal extent. On the west it contracts into a narrow tongue of land, which is almost entirely granitic. The highest part of the

* According to the trigonometrical measurements of Lieut. Col. Mudge, this mountain is thirteen hundred and sixty-eight feet above the level of the sea.
chain is also very near its centre.* Brown-Willy, in the neighbour­
hood of Bodmin, is, as has been said, one thousand three hun­
dred and sixty-eight feet above the level of the sea, while the gra­
nitic cliffs at the Lands-end do not exceed sixty or one hundred
feet. It is however possible, that the neighbourhood of Craw­
Mere-Pool in Dartmoor forest, not far from the eastern extremity
of the chain, may be nearly as high as Brown-Willy. But it is
rare to find any general rule without some exceptions: thus, accord­
ing to André de Gy and Ramond, the highest points in the Vosges†
and in the Pyrenees are out of the central chain.

The low range of Cornwall presents a regularity in its compo­
sition, rarely found in great chains. Saussure has shewn the dis­
similarity between the two opposite sides of the Alps: on the
northern side, he informs us, the whole of the exterior range is com­
posed of mountains of limestone of considerable height and extent;
on the south side, on the contrary, the schistose rocks, and even the
granite reach the plains, and if limestone do exist on this side, it
is of very rare occurrence, and does not form broad and continuous
chains as on the northern side.‡

Pallas has also observed in Russia and in Siberia, essential differ­
ences between the opposite sides of the same chain of mountains.
Ramond remarked the great dissimilarity between the two sides of
the Pyrenean chain, the sandstones are rarely met with on the north­

* This appears also to be the case in North Wales. The county of Caernarvon, from
Bardsey island, in a north-easterly direction, to the promontory of Penmaen-bach in
Conway bay, is occupied by a range of mountains the highest of any in Wales. They
gradually ascend from each extremity of the chain towards the centre, which is occu­
pied by Snowdon, the loftiest of all." Arthur Aikin's Tour through North Wales,
p. 97.
† I have recognized in the Vosges, the truth of the observations of André de Gy.
‡ Voyages dans les Alpes, § 981.
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ern skirts, while they form a great part of the mountains to the south. The phenomenon of twisted and arched strata is much more common on the northern side, where the marine fossil remains are generally calcareous, as on the southern they are siliceous.

Among the small number of general facts, to which few exceptions have yet been found, in the structure of mountains, as stated by Sauvassure, the following appear very applicable to the mountains of Cornwall.

1. Mountain chains are generally directed from east to west, or from north-east to south-west.

2. The strata of mountains of newer formation generally incline towards, and rest upon the mass of those which are more ancient.

3. Great quantities of debris, in the form of detached blocks, of breccias, of pudding-stones, of sandstones, and of sand, are found either accumulated in the form of mountains, or scattered over the borders of the Alps, and even extend into the plains. This observation applies equally to all primitive countries.

General Observations on Grauwacke.

I give the name grauwacke to a rock composed of separate siliceous particles united by an argillaceous cement, with a little magnesia and iron. It might be called a sandstone, having a base so fine that the rock appears homogeneous; but the name grauwacke, made use of by the school of Werner, has been generally adopted.

Though formed by a mechanical precipitation, grauwacke is one of the oldest of the secondary rocks. I have never found in it any
impression of organic bodies, and I am not aware that it has ever been found to contain them. It is divided into two species, common grauwacke, and grauwacke slate.

The structure of the first is compact, dividing by natural joints into rhomboids or parallelepipeds: it is harder, not so fine in the grain and of a darker colour than the other variety. This last quality depends, no doubt, on its containing a greater proportion of iron. I believe that common grauwacke is a cornéenne trap of the French mineralogists. In Cornwall it is always found higher than the grauwacke slate: it may be supposed to have been precipitated more slowly, and under a less powerful pressure, whereby the mass has been allowed to contract, and assume a kind of crystallisation. It rests immediately upon the granite,* and, at its junction with that rock, it is very frequently accompanied by veins or beds of quartz, which is also often found in detached pieces or blocks.† It is much less rich in ores than the grauwacke slate.

The structure of grauwacke slate is schistose, and the laminæ become thinner, as they are further removed from the junction with the granite. The base is exceedingly fine, smooth to the touch without being unctuous; the colour of the mass varies from dark grey to white; its lustre is silvery, sometimes that of satin, especially when the fractures are fresh, but that fine lustre soon goes off when it is exposed to the air. It is to this variety exclusively that the Cornish

* The rock which Ramond calls Cornéenne, and describes as interposed between the fundamental granite of the chain, the primitive limestone and the porphyritic rocks, in the Pyrenees, is very likely grauwacke. Voyages au Mont Perdu, p. 4, 25, 206, 265, &c.

† It is probably also found in the mountains of Wales, according to the description given by Arthur Aikin—"All the mountains from Bala to Aberystwith are primitive "schistus, sometimes intersected by large veins of quartz, and of a coarse texture, some-"times forming slate." Journal of a Tour through North Wales, p. 42.
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miners give the name of Killas.* Here, as in the Hartz, it is very rich in ore, and for this reason, Klaproth proposed to call it Saxum Metalliferum Cornubiense.†

In low situations especially, grauwacke-slate has a very great resemblance to clay-slate;‡ in other places it decomposes, and passes into the state of marl.§

The grauwacke formation occupies a very considerable extent in Cornwall. Without having traced it step by step throughout, I believe I may safely say, that it prevails without interruption on the southern side of the chain from the mouth of the Hamoaze (the name given to the river Tamar after its junction with the Tavy) to that of the river Hel, thus occupying a space of about forty miles from east to west. It may possibly happen that in this course some other rock belonging to the same formation may be found in subordinate beds, but whatever it is, I do not think it can be of any great extent.||

* It is also this variety which has been analysed by Kirwan, and which he classes with the Hornstones. He found that 100 grains contained

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
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<tr>
<td>Silica</td>
<td>60</td>
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<tr>
<td>Alumina</td>
<td>25</td>
</tr>
<tr>
<td>Magnesia</td>
<td>9</td>
</tr>
<tr>
<td>Iron</td>
<td>6</td>
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† Klaproth's Mineralogical Observations on Cornwall, p. 7.
‡ La fermentation (qu'on me permette, dit M. de Trebra, de designer sous ce nom, cette force de la nature qui met tout en mouvement dans le regne minéral) peut transformer la grauwacke en un schiste argileux qui peut durcir et devenir un jaspe, si cette fermentation cesse ou diminue. Nouvelle Théorie de la formation des filons, par Werner, p. 54.
§ In some parts of Cornwall this marl mixed with sea sand and sea weed is used as a manure.
|| The Rev. Mr. Gregor of Creed, with whom I conversed on this subject, informed me, that going along the coast from Grampound to Fowey, a limestone is found, which
In Cornwall, as in the Hartz, the covering of grauwacke never rises very high, and we find that here, the more elevated points, although their absolute height be not very considerable, are left bare. Here also, as in other countries,* the two varieties of grauwacke are uniformly found connected with one another: they in general cover the transition limestone, whereas secondary greenstone and clay-slate occur in it in subordinate beds, and perhaps the formations of serpentine, of diallage with felspar, and of talcose slate, of which I shall afterwards speak, are similarly situated.

Though the cliffs at Stonehouse are of limestone, nevertheless Mount Edgecumbe, which is only separated from them by the Hameoaze, belongs to the grauwacke formation. We here find that rock passing from the state of a coarse argillaceous sandstone, of a reddish colour, not effervescing, and stained by oxide of iron, to that of a fine-grained grauwacke-slate, with red veins, giving it the appearance of ribbon jasper. It occurs in strata, dipping S.S.E. at an angle of about 65° or 70°, which is nearly the same as that of the limestone cliffs of Plymouth harbour. The stratification is best seen on the south side of Mount Edgecumbe about half way up; and especially from the great terrace to the arch, and beyond that on the way to the zig-zag walk. At the top of the hill the grauwacke becomes less distinctly stratified, and begins to separate into rhomboidal pieces. Maker Heights,† Rame Head, Higher Blarick in

append to him like that of Plymouth: he added, that it had been excavated in some places by the sea, and that the fissures had since been filled up with a gravelly conglomerate.

* Brochant, Traité de Minéralogie, tome ii. p. 588.

† The altitude of this place, computed from the Trigonometrical Survey, is four hundred and two feet above the level of the sea.
White-sand Bay, the point where my excursion to this part of the coast ended, and precisely in the meridian of the Eddystone lighthouse, all belong to the grauwacke formation. In White-sand Bay this rock, forming the cliffs, separates by very regular rhomboidal joints. It is of a whitish colour, of a friable texture, like that of the grès-molasse, and might pass for a corneous trap in a state of decomposition. It is accompanied by a rock, having a reddish argillaceous base, containing much oxyd of iron, and fragments of compact limestone, and which effervesces with acids.

There is at Peter Point in St. John's Creek, very near Torr Point, a bed of greenstone, in the composition of which there is a good deal of steatite, completely included in the grauwacke. Though of small extent, it is quarried for building. Not far from this place, on the banks of Lyhner Creek, and on the estate of Sir Henry Carew, there is another bed of greenstone: it is immediately adjoining the ferry. This bed extends from one bank to the other; and on the right or south side of the creek there is a large quarry of it. Very remarkable differences may be observed in the texture of the greenstone, though the specimens be taken from the same bed. The base is sometimes so close, so homogeneous, that single unconnected specimens of it might pass for corneous trap,* with pyrites dispersed through it: other specimens, however, taken quite close to the preceding, are of a composition and grain, between that of corneous trap and greenstone: these are in my opinion sufficient reasons for comprehending all the varieties of this substance, under the common denomination of greenstone.

* It is, more properly speaking, what the German mineralogists call grauistein (greystone) which they describe as having nearly a homogeneous base, of an ash-grey colour, and of a dry aspect. Brochant, Traité de Minéralogie, tom. ii. p. 608.
It is difficult to account for these differences in the same rock, but though they certainly do exist, I do not think they are sufficient to constitute distinct species. I conceive that in the nomenclature of rocks especially, we ought strictly to adhere to the principle laid down by Saussure—"To determine genera and species from those individuals in which the characters are most distinct, and to qualify by the name of transitions, those which are doubtful or indistinct."

From Lynher Creek, directing our course northward towards Callington, by Saltash and St. Mellion, the grauwacke continues uninterrupted, but as the country rises, and we approach Kitt-hill, situated about a mile N.E. of Callington, the quantity of quartz met with on the road in blocks and pebbles becomes very remarkable: this indicates our being near the termination of the grauwacke, and we accordingly find it cropping out to-day on the side of Kitt-hill, at about two-thirds of the ascent. Kitt-hill is the nearest place to the sea from the mouth of the Hamoaze, where granite is found in situ. This little hill, though insulated, must be considered as a dependance of the mountains of Dartmoor: it is situated on the southern skirt of the granitic mountain-plain of the low range of Cornwall.

The sides of Kitt-hill are gently inclined; that on the east is the most abrupt. The north and south sides are the most extended, and may be considered as the water-sheds. The upper part of the hill is a true granite, composed of crystals of white felspar, quartz and mica. Mr. Necker found in the neighbourhood of Kitt-hill an adventitious mass of tourmaline of a cylindrical form, and of a brownish-green colour, which the Comte de Bournon, to whom I shewed it, considers a new variety of form. From Callington to Plymouth, by Beer Alston, Beer Ferris, and Tamerton Folliet, as far

*Voyages dans les Alpes, §, 1945.*
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As the point where the high road to Tavistock joins, the grauwacke-slate continues. Its stratification is very distinctly seen at the passage of the Tamar near Calstock, and of the Tavy near Beer Ferris.

At Calstock, the strata are cut more abruptly on the left bank, and at Beer Ferris on the right bank, from which we may infer, that the depth of the Tamar and the Tavy is not the same at both banks, the depth of a river being in general increased as its banks become more precipitous.

The grauwacke-slate also continues in the road from Plymouth to Ivy-bridge. On approaching the latter place we find pebbles and even adventitious blocks of granite, which being brought down into the plains, by the rivers which flow from the high land of Dartmoor, shew that that district is formed of primitive rocks.

Of the Mountain-plain of Dartmoor Forest.

When we trace up the courses of the rivers which flow through Devonshire, we find they all rise in an elevated and extensive plain situated nearly in the middle of the county, and upon which the adjacent rocks, gradually rising as they approach it, are found to rest. The south and north sides are the water-sheds of the mountain-plain. The Tavy, the Plym, the Yealme, the Erme, the Avon, and the Dart, flow down the southern side; the two Oakments and the Taw run to the north: there is only the Bovey on the south-east, and the Lyd on the west, and these are both very small streams.

I entered Dartmoor forest, by the valley of the Erme, which opens at Ivy-Bridge. This little valley is at first contracted and deep, with a rapid ascent. The general direction is nearly from
IIS Dr. BERGER on the physical Structure

N. to S. which is the same with the course of the river flowing through it. Thus it appears that these vallies, which are all similar to each other, are perpendicular to the mountain plain.*

Leaving the bed of the river Erme to the left, about five minutes walk from Ivy-Bridge, we pass some farm houses at the bottom of a small detached hill, the name of which I did not learn, nor do I find it laid down in the common maps of the county: it is situated N.N.E. of Ivy-Bridge, and from thence to the top of the hill is about two miles and a half by the nearest road. This small hill, the only abrupt face of which is towards the south, is situated on the exterior line of the mountains of Dartmoor, on the first plain they form from the sea coast. The upper half is composed of a rock which I call a porphyritic granite,† and the lower part as well as the base is of grauwacke. I found the summit to be one thousand one hundred and thirty feet above the level of the sea, and the greatest height to which the grauwacke rises on its sides is six hundred and thirty-one feet.

There is on the right bank of the Erme another small hill, facing the latter, equally rounded in its outline: both have that appearance which Saussure calls moutonnée,‡ an expression in my opinion peculiarly applicable to the low granite mountains of the ci-devant Forez.

* In the Alps, the vallies are longitudinal and transverse; in Jura, they are almost all longitudinal; in the Vosges, the greater part are oblique; in the Pyrenees, they are nearly at right angles. Journal des Mines, No. 126.

† The base of this porphyritic granite is a beautiful kind of felspar of a brick-red colour, confusedly crystallized, in which are imbedded crystals of vitreous quartz, hornblende and tender steatite of a greenish yellow. I found on the summit several adventitious blocks of amethystine quartz.

‡ The mountains which Saussure designates by this expression (moutonnée) are composed of an assemblage of rounded tops, covered sometimes with wood, but more fre-
Kit-hill is situated farther in the interior of the country than the small hill above Ivy-Bridge. The distance of the latter from the coast is, in a direct line, scarcely nine miles, whereas Kit-hill is at least thirteen.

In proportion as the valley of the Erme rises, it continues to open, insomuch, that at three miles and some furlongs from Ivy-Bridge northward, the river is no longer confined in a narrow channel, but flows over a plain gently inclined towards the south.

This mountain plain, at Harford church, which is six hundred and fifty-eight feet above the sea, is entirely granitic. We leave the grauwacke behind, about half a mile nearer the sea, and in ascending the valley of the Erme, the point of termination is very distinctly seen, particularly on the left bank. At the junction, there are veins or shoots of granite of different lengths and breadth, and they appear to penetrate into the grauwacke. The two rocks are certainly contiguous, and in immediate contact the one with the other.

The grauwacke near its termination loses its slaty character, as may be seen on the sides of the hill above Ivy-Bridge, where it attains nearly the same height as in the last mentioned place.

The primitive rock of this district is a true granite, composed of felspar, quartz, and mica, and the crystals of felspar are sometimes two or three inches long.

From Harford church the country assumes quite a bare and alpine appearance, presenting a vast plain extending beyond the...
visible horizon. The face of the country is formed by swellings and undulations gradually overtopping each other without ever forming very distinct mountains. There is neither vegetation nor any human dwelling; we tread upon a boggy soil of very little depth, and scarcely furnishing sufficient food to support some dwarf colts, wild as the country they inhabit.

The Erme rises about nine miles north of Ivy-Bridge, and one thousand one hundred and thirty-one feet above the level of the sea; the land gradually rising as we approach its source. This however is not the most elevated point of this part of Dartmoor forest; as far as I can judge, that point is near a place three miles south-east of Two-Bridges, where some tin mines are worked, and where that metal is found disseminated in the granite, as one of its integrant parts.

Two Bridges is fourteen miles to the north of Ivy-Bridge. There is but one house, and that an inn, which stands nearly in the middle of this vast mountain plain, which contains, I believe, nearly three hundred and fifty square miles of surface. Two Bridges is one thousand one hundred and forty-eight feet above the level of the sea. To the north of this place, the granitic country appears to extend as far as the neighbourhood of Oakhampton, but I cannot speak of that with certainty, as I did not trace it myself over the whole of that extent; I can only say, that according to the course of the rivers, the only mountain of any consequence

* There has been lately erected in the neighbourhood, a vast stone building, where it is intended to convey the greatest part of the French prisoners now confined in Mill prison at Plymouth. There are also at some distance from the inn at Two Bridges some houses on the high road from Tavistock to Ashburton, and Moreton Hampstead, which crosses this part of Dartmoor forest.

† It contains about 80,000 acres. Maton's Survey of the Western Counties, vol. I. p. 299.
which appears to me to rise above this mountain plain, and which is, without doubt, the highest point of all that part of the country, is Craw-Mere rock, where the two rivers Oakment and Dart have their source.

I bent my course from Two Bridges to Launceston, by St. Mary Tavy, Brentor, and Lifton, making a circuit of the exterior boundary of that part of Dartmoor forest. As long as the mountain plain continues, the country preserves the same appearance, and all along the road between Two Bridges and Tavistock, for the first six or seven miles, we find on the surface of the ground great numbers of granite-blocks; these probably come either from the tors, or are produced by the rock on the surface splitting in that manner, in consequence of the continued action of external agents. Several of these blocks are so firmly fixed in the ground from which they project, and are besides so uniformly spread over the surface in every direction, that they cannot be supposed to have been transported by a current to the place which they now occupy.

At the distance of three miles and a quarter from Tavistock the grauwacke begins to reappear in a very distinct manner, and at the height of one thousand one hundred and twenty-nine feet above the level of the sea, which is rather considerable for this formation.

From this place, the country lowers with a pretty quick descent towards Tavistock, and this change of rock is accompanied by so complete a change in the vegetation, that it is impossible not to be struck by it. Nothing can be more remarkable than to see on the skirt of this mountain plain, towards St. Mary Tavy and Brentor, highly cultivated valleys, succeeded by rich pastures, which rise as high as the line of superposition of the secondary rocks, above which there is nothing but bare and naked rock.
About a mile from St. Mary Tavy, near the place where the roads join which lead from Plymouth to Oakhampton, and from Tavistock to Two Bridges, there is a bed of greenstone of some feet in thickness, in the grauwacke slate; it decomposes into a green earth. With regard to the grauwacke itself, the direction and inclination of its strata continue the same, it only contains more quartz as we approach St. Mary Tavy, and becomes at the same time less slaty.

St. Mary Tavy is six hundred and forty-eight feet above the level of the sea. A copper mine is worked here at a great depth, and amongst the rubbish I found grauwacke and schistose limestone,* heaped one above the other; which shews that the epochs of formation of these two rocks are nearly coeval, since we find beds of the one included in those of the other.

From St. Mary Tavy to Launceston by Brentor and Lifton, we cross successively the Lyd and the Tamar, continuing in the grauwacke slate formation to within a mile of Launceston. The strata of the grauwacke slate are very distinctly seen at the ferries of these two rivers. It is succeeded by a schistose limestone having a very fine paste of a dark blue colour and dull lustre, dividing into large flags, which are put to the same use as slate, and which I should have taken for such, if I had not found that it effervesced with acid.† Besides, it is here only in subordinate beds, and I do not believe that it extends very far.

I saw at the house of the Rev. William Gregor of Creed, two rolled pieces, one of which appeared to me to be idocrase (vesu-
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vian) and the other actinolite. Both had been given to him as having been found on Dartmoor.

From Launceston to Bodmin the distance is twenty miles, and between these towns, the highest part of the county of Cornwall intervenes. In the course of this tract of country, we quit, and again enter upon the grauwacke formation. It is exactly at the distance of seven miles and a quarter from Launceston, that it is lost at a height of nearly eight hundred feet above the level of the sea: the nearest village to this place is called Five Lanes. Here the grauwacke is succeeded by a granitic plain, where several rivers, flowing to the right and left, have their source: the Inny, the Fowey, the Camel or Alan, &c.

Brown Willy and Rough Tor do not rise much above their base, not more than other hills of much less absolute height, which are seen in the horizon. The grauwacke is again found exactly at the fourth mile stone from Bodmin, very near New London Inn, at a height, which upon that side of the chain appeared to me considerably greater than upon the northern side, but I was not able to determine the point more accurately. The land afterwards falls with a rapid descent to Bodmin, which is only one hundred and eighty-eight feet above the level of the sea. The soil of that granitic ridge is boggy, and quite like that of Dartmoor Forest.

From Bodmin to Truro, by the Indian Queen and St. Michael, is twenty-two miles: the grauwacke formation continues the whole way, becoming more slaty as we approach Truro, that is to say, as we get lower down. It then very nearly resembles clay-slate. The most elevated point on this road, and from which the whole of the Bristol Channel may be seen, is in the neighbourhood of St. Michael. From that place to Truro, the vegetation is very luxuriant, but from St. Michael to the Indian Queen, and from thence to within three
miles of Bodmin, the soil is composed of peat and produces absolutely nothing. It is almost entirely a country of mines, especially in the neighbourhood of St. Austle. The inn called the Indian Queen is four hundred and ninety-one feet above the level of the sea: the most considerable branch of the river Fal rises in this neighbourhood. From the Indian Queen to Grampound, we continue for nine miles in grauwacke-slate, without its offering anything remarkable. It is however very far otherwise, if from Grampound we direct our course N.N.E. towards the parish of St. Stephens.*

On quitting Grampound, the road leads for a short way towards the north, until we reach a small valley, which at its opening runs nearly east and west; it afterwards turns towards the north, and very soon takes a direction due north and south. A branch of the Fal flows through it, and the water, which on the heights near its source has been employed in washing porcelain earth, retaining the white colour of the earth, has at a distance the appearance of milk, which produces a very singular effect.

In proportion as we ascend, the grauwacke slate disappears, and in the neighbourhood of St. Stephen’s church, it passes into the state of cornéenne, or of common grauwacke. It is stained with oxide of iron, and accompanied by numerous veins and pebbles of quartz. All these appearances indicate that we are approaching towards its limit. And although we cannot exactly point out the very spot of the transition itself, we may, without any material error, fix that point at Step-aside, a hamlet situated two or three furlongs from St.

* The pleasure and instruction I derived from this excursion, were particularly augmented by my having the advantage of the company of the Rev. Wm. Gregor, a gentleman equally modest as well informed, and whose name I have already had frequent occasion to mention.
Stephen's Church, and which is about six hundred and thirty-five feet above the level of the sea.

From Step-aside, we enter upon a mountain-plain of decomposed granite in the state of kaolin, which is famous for the porcelain earth it affords, and which is sent to Worcestershire. This plain is some miles in extent, and belongs to the southern boundary of the chain. One of the most elevated points of it, and which is in the neighbourhood of the principal quarry of the porcelain earth (China pit) is eight hundred and thirty feet above the level of the sea. This granite, the felspar of which forms two-thirds of the mass, appeared to me to be less decomposed near the borders of the plain, than in the central part. In this last place it has rather the appearance of a porphyry with a pulverulent base, of a whitish colour, in which crystals of quartz, and some plates of mica, are loosely included. It is used in this rough state in the manufacture of porcelain, in the same manner as the Chinese make use of petuntze, by mixing it in certain proportions with the porcelain earth that is obtained by washing and frequent precipitations. Crystals of a compact and earthy felspar are occasionally met with in this decomposed granite, of a much larger size than usual. We also find here another rock, the geological position of which is very interesting; I mean the *schorl rock,* a binary compound of schorl and quartz, in which the first considerably predominates. We find masses of it of all sizes, generally of a rounded shape, and coated on the surface with the porcelain earth. There are also large blocks of it in the bed of the Fal.

*"The schorl rock of Cornwall is probably very intimately connected with topaz. rock." Jameson's Elements of Geognosy,

The same author adds in a note—"The geognostic relations and characters of schorl-rock are not well ascertained, therefore I have declined saying anything regarding it in the text."
near St. Stephen's Church. This is not the only place in Cornwall where I found that scarce rock, of which I shall speak more particularly hereafter.

It is difficult to decide, whether the formation of this kaolin clay, (the feld-spath argiliforme, of Haüy) is connected with a particular texture of the felspar, dependent on some principle which is inherent in it in the places where this earth is met with; or whether, as I should be more inclined to believe, we are to attribute it solely to the action of external agents, particularly of the water retained in the crevices of the native rock of the place, which produces a decomposition in one portion of the rock, then acts upon the adjacent parts, and so by degrees, in time extends its effects to a considerable distance.* Whatever be the cause, we know that kaolin is never found but in a primitive country, and forming beds or veins in granite, particularly in that species called graphic granite.

To the already pretty extensive enumeration of the places where kaolin is met with, such as China, Japan, different parts of Germany, of France, &c. I shall add another, which as far as I know has not yet been mentioned, viz. the Culma d'Orta in the Milanese, a granitic mountain, elevated one thousand four hundred and fifty-eight

* Ramond found granites in the high chain of the Pyrenees, corroded both externally and internally: not detached blocks alone, he informs us, but whole regions are attacked with this cariousness, the cause of which is still unknown. This corrosion is frequently met with on the northern confines of the chain, where beds of cornèenne, of porphyries, of hornblende in mass, and of serpentiue spontaneously resolve into clays, fullers earth and marls: these still preserve the appearance and grain of the rock which has produced them, though they now only form an earth easily cut by the knife. Voyages au Mont Perdu, p. 17.

It is the carbonic acid according to Werner, which has changed the felspar into kaolin in granite and gneiss, as well upon the walls of veins as upon the surface of mountains. Nouvelle Théorie de la formation des filons. Journal des Mines. No. xvii. p. 84.
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feet above the level of the sea, six miles east of Varallo, at the entrance of the valleys of Sesia Grande and Piccola.

From Grampound to Falmouth, by Creed, Tregony, Tregear, and St. Mawes, grauwacke slate continues the whole way, and the fertility of the country sufficiently indicates it, as that kind of rock is very abundant in springs. The granite ridge begins sensibly to lower, and consequently the grauwacke formation occupies less extent. It is found on the sea-shore, traversed by quartz veins, although it is stratified. I observed this, among other things, in crossing from St. Mawes to Falmouth, near a strong fort on the right, facing Pendennis Castle.

There is something very romantic in the view of the port of Falmouth from the heights of St. Just: it resembles very much the situation of Loch Long and Loch Fine in Argyleshire. There is at first some difficulty in believing that all those creeks which penetrate so far into the interior of the country, are basins of salt water.

I observed on this road, that near Pennare Point, a small promontory a few miles E. N. E. of Falmouth, the cliffs were high and precipitous.

The grauwacke slate still prevails from Falmouth to Menaccan: there is a fine quarry of it from Falmouth to Penryn, which skirts the bottom of the hill on one side, and the King's Road on the other. The beautiful river called the Hel flows over the same rock, at the ferry, near its mouth, from Mawnan to Helford. It is intersected there by a great number of quartz veins, and blocks of it of different sizes are found on the road from Penryn to Mawnan Smith. This very extensive formation at length terminates near a small sea-port called Port-hallo, or as the inhabitants pronounce it, Pralo, which is three miles S. S. E. of Menaccan, across the Dinnis. This river runs in the bottom of a valley, where the substance named
menachanite by the the Rev. Wm. Gregor (the Titane oxydé fer-
isère of Haiiy) is found in a stream work.

Before arriving at Port-hallo, I observed in the village of Tregollis, in the parish of St. Kevern, a bed of greenstone of small extent, and this is the last place in Cornwall where I observed that subordinate rock of the grauwacke formation. According to the geological rather than specific characters, this greenstone ought to be considered as belonging to the transition rocks.*

The next formation in importance, which succeeds the grauwacke, is the serpentine. But although it may be seen for some miles before, in the form of large blocks scattered here and there in the fields, and forming part of the materials of the walls of the inclosures, it is not upon this rock that the grauwacke immediately rests, but on a kind of talcose slate, of a greenish grey colour at the surface, tender and shining, soft to the touch, and evidently stratified: it forms a bed of small thickness, the boundaries of which it is difficult to determine. The junction may be seen in the cliffs to the S.S.E. of Port-hallo, immediately upon crossing the brook which runs through that village in its passage to the sea.

A few paces beyond this bed of talcose slate, the serpentine appears in the form of large blocks of an irregular shape, detached one from another and projecting above the surface of the ground: these soon disappear, and on the way to St. Kevern's Church, on the S.S.W. we enter again, for a short time, upon the grauwacke, which shews that these rocks are included in an irregular manner one within the other; and in a cultivated country it is not easy to trace the line of demarcation. It is quite clear, however, that to the S.

* Secondary as well as primitive greenstone is composed of hornblende and felspar, but the grains of it are less crystalline, and less intimately blended. Brochant, Traité de Minéralogie, tome ii. p. 60.
of St. Kevern, there is no more grauwacke. Before coming to the serpentine in situ, a rock intervenes, composed of felspar and diallage which I traced very distinctly as far as Treleever, a hamlet about four miles S.S.E. of St. Kevern. The felspar of this rock is compact and opaque, with a tendency to crystallization: the diallage belongs to the variety called diallage metalloïde by Hartig: its colour varies from bronze green to a brilliant grey, and it presents very smooth rhomboidal joints; sometimes the felspar prevails in the mass, but most frequently the diallage. This rock is extremely tough, when struck it makes the hammer rebound. There is a quarry of it in the village of St. Kevern, where it is blasted with gunpowder. From what I have seen of the serpentine district, I believe that it is confined to that portion of the country, which lies to the south of a line stretching east and west, from the neighbourhood of Treleever, by Ruan Major, as far as Lower Pradanack; thus including the promontory, the extremity of which is called the Lizard Point. It is possible, however, that the serpentine may extend beyond these limits, or that it may be irregular, as we have found the grauwacke to be; but it is not an object of much importance whether it is so or not. I must not omit to mention, that in the space which the serpentine occupies, there are two formations of rocks in subordinate beds, and of different natures: the one mica slate, which is met with to the S.S.W. of the village of the Lizard, on the way to the light houses, where it forms the cliffs, and appears to extend into the sea, forming those dangerous reefs and sunken rocks, which are seen beyond the Lizard Point: the other is the soap-rock to the north of Kinance Cove.

The serpentine of the Lizard Point is not homogeneous in its composition; the colour of the base is usually leek green, and the
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fracture often conchoidal, breaking into large broad flakes with sharp edges; it is also frequently striped with red, which appears to be owing to the oxide of iron it contains; small threads of tender yellow steatite are seen running through it, and it is often traversed by veins of whitish asbestos. The course of these veins is very straight, and by their intersections they form nearly regular rectangular pieces, thus disposing the rock to break in those directions.* Sometimes this serpentine passes into a hard steatite, disposed in curved laminae, and having at the same time a fibrous fracture.

The mica slate of the most southern part of the Lizard has a very brilliant lustre, is of a fawn colour, includes veins of quartz, and is evidently stratified. I was not able to discover any garnets in its composition.

By soap-rock is meant a kind of steatite, so tender that it may be cut as easily as new cheese. It is imbedded in the serpentine. Its colour is a pearly white or grey with red and blue veins, and when pure it has a sort of semi-transparence. On coming out of the quarry, it may be kneaded like a lump of dough, but after having been exposed to the air for some time, it becomes friable, owing, no doubt, to the evaporation of the great quantity of water it contains; it possesses the soapy feel in the highest degree, and pieces of hard stone are included in it, in pretty large quantity. It is used in the manufacture of porcelain for the same purpose as the kaolin, and on.

* On the summit of the mountain de la Garde near Genoa, Saussure observed a granular serpentine, which divided naturally into polyhedral fragments, most frequently of a rhomboidal form. Voyages dans les Alpes, § 1342.

On the road from Nice to Fréjus, the same geologist found another kind of serpentine, which divided into irregular polyhedral masses. Ibidem. § 1434.
of Devonshire and Cornwall.

many accounts it might be said that soap-rock is to serpentine what kaolin is to granite.*

Kinance Cove, situated a mile and a half N.N.W. of the Lizard Point, is a kind of small valley (combe) in the serpentine formation, opening towards the sea, and exhibiting pillars or detached rocks of very rude forms and appearance, which recalled to my mind those of the high Alps. One of these obelisks projects into the sea; others have been so much excavated by the action of the sea, that fissures, or complete arches have been formed, under which you may walk at low water. When the sea, at the flowing of the tide, begins to rush through these excavations, the whiteness of the foam, contrasted with the brown colour of the rocks upon which it breaks, produces a very striking effect.

From the soap-rocks to Mulryan Church-town, where we re-enter the grauwacke slate, on the west side of the promontory, we walk over a common covered with turf, which prevents us from knowing what the nature of the rock is in that district, it was besides, almost dark when I passed over it.

Remarks on the serpentine formation, and on some rocks which usually accompany it.

Before I proceed to inquire to what formation the serpentine of the Lizard belongs, I shall briefly notice the geological position of

* Are we to refer to a species of kaolin or soap-rock, the white and unctuous clay which the ancients called terra cimolitia, and which was employed by the inhabitants of the island of Argentiera, formerly Cimolis, instead of soap, for the purpose of cleansing cloth. Lettres sur la Grèce pour servir de suite a celles sur l'Egypte, par M. Savary, p. 370.
one or two rocks in different countries, which almost always accompany serpentine.

It is not in Cornwall alone, that diallage is found in the immediate vicinity of serpentine. It is found on Mount Musinet, two leagues west of Turin, a mountain almost entirely composed of a hard greenish serpentine. The mineral named after Saussure, which he himself calls smaragdite, is the green variety of diallage united with jade. The semiopal or hydrophane is found in a subordinate bed in the same mountain.* I am sorry to say that this last mineral becomes daily more rare: I was not able to procure on the spot a single well characterised specimen, after employing several hours in searching for it.

I found on Monte Baldissero, in the Circle of Ivrea, the metalloidal diallage, accompanied also with semiopal, nearly in the same geological position as on Mount Musinet; the only difference is, that the rock which forms the mass of the mountain approaches more to the nature of steatite than of serpentine. I also found in a vein on Monte Baldissero a white earth in rounded mamillated masses, which used to be taken for pure alumine, but which Giobert has shewn to be magnesia.† It is used in the manufacture of porcelain.

* Voyages dans des Alpes, § 1313.

† It contains according to this chemist,

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesia</td>
<td>68</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>12</td>
</tr>
<tr>
<td>Silica</td>
<td>15.60</td>
</tr>
<tr>
<td>Sulphate of lime</td>
<td>1.60</td>
</tr>
<tr>
<td>Water</td>
<td>3</td>
</tr>
</tbody>
</table>

100.20

Journ. des Mines, No. 118.
of Devonshire and Cornwall.

Viviani relates, that the lamellar metalloidal diallage, as well as the jade of Saussure, are found in the serpentine mountains of the Apennines between La Rochetta and Sassello, in eastern Liguria.* It appears to form a subordinate bed in the composition of those small insulated hills, which are for the most part of serpentine, and which are scattered here and there in the great valley which separates the southern extremity of the Alps from the Apennine chain.

I was very desirous of discovering from whence came the vast quantity of blocks, consisting of diallage united with the jade of Saussure, which are met with, not only in the great valley of the Rhone, but also in that distinguished by the name of the Bassin de Genève, and I had the good fortune to discover it in 1806, in company with Mr. William Maclure, in the Visp-Klein-Tbal in the Haut Valais on the skirts of Mount Rosa, which is an assemblage of mountains of serpentine. The smaragdite, or green diallage, extends here for the space of several miles, from the village of Saass (eight hundred and eleven toises above the level of the sea) ascending the Vispach, as far as the neighbourhood of Mount Moro at Macugnaga, and very near Meigeren, the most elevated village in Switzerland and the Valais which is inhabited during the whole year. This rock is found in the form of enormous rounded blocks, adhering to the ground, and heaped close together; it is sometimes only a mixture of green diallage, jade, and a little red oxide of titanium; in other places it is green diallage mixed with primitive marble; but I did not find the metalloidal variety there. Serpentine is also the matrix of the schillerspar of the Tyrol, and of that found at Baste or Paste, near Harzburg, at Mezzebergen in Moravia, &c.†

* Journal de Physique, Octobre 1807.
† I am disposed to consider the hornblende of Labrador, the variety called schillerspar, and the smaragdite of Saussure, as one and the same species, as well as the
If we now compare the analyses of these different rocks in order to ascertain, if in their chemical composition, there is the same analogy which their geological situations seem to indicate, the result of that examination will prove by no means so conclusive.

Although serpentine is in itself a simple rock, we find it so often mixed with foreign substances, that it is impossible to obtain by chemical analysis any uniform results. Thus Kirwan has found in one experiment, 0.18 of alumina, while Klaproth found none. Kirwan gives 0.23 as the proportion of magnesia, Bayen 0.33: but there are even greater differences in these analyses.*

With regard to the analyses we have of diallage, by Vauquelin, Drappier, Heyer and Gmelin, they all state a greater or less proportion of lime, a substance never found in serpentine. The smaragdite contains besides, according to Vauquelin, as much as 0.08 of oxide of chromium, and a little oxide of copper. There are also great differences in the proportions of the same principles in the green and metalloidal varieties. Vauquelin found in the first, 0.06 of magnesia, 0.21 of alumina; and Drappier found in the second, 0.29 of magnesia, and only, 0.03 of alumina.† Lime is also, according to Hœpfner and Theodore de Saussure, one of the component parts of jade, but the first finds in it as much as 0.38 of magnesia, while Saussure makes no mention of it. On the other hand, Saussure found soda and potash in jade, but Hœpfner does not seem even to have suspected their existence.‡

* Brochant, Traité de Minéralogie, tome i. p. 423.
† Brochant, Traité de Minéralogie, tome i. p. 483.
‡ Brongniart, Traité Élémentaire de Minéralogie, tome i. p. 442.

Brochant, Traité de Minéralogie, tome i. p. 492.

Journal de Physique, Mars, 1807, Analyse de la Saussurite appelée lehmanite par De la Metheric.
Thus we find, that all those rocks which are geologically arranged with serpentine, contain in greater or less proportion, several substances quite foreign to it, and what is still less satisfactory, we find that the same rocks analysed by different chemists, frequently give very different results. I believe that upon full examination, we shall agree with the observation of Saussure, that substances of very dissimilar natures are often included in rocks which do not at all, or very slightly resemble them, although both may have been formed simultaneously; but that, in consequence of certain principles of affinity, the similar particles of the different materials suspended in the fluid, united and formed distinct rocks.*

In considering the steatite, a mineral which still more frequently than the diallage and jade accompanies the serpentine, I shall adopt the same method I have pursued in treating of these last substances.

Steatite is found not only intimately combined with serpentine, but frequently in masses forming subordinate beds in that rock; such are the soap-rocks at the Lizard.

There is in the valley of Sesia Grande, about half a league to the north of Alagna, and consequently, at the foot of Mount Rosa, a bed of true potstone in the serpentine. It is so soft as to be worked upon the lathe, and dishes are made of it which are known in the country by the name of lavezzi.† But I learned upon the spot, in 1806, that they had given over working the quarry, since it had been encumbered by the fall of an enormous block of serpentine. In the mountains of Chiavenna, and also in the valley of Chamouni, steatite, in scattered blocks is often met with, though, according to the observation of Saussure, less frequently on the side of the Alps than on the side of Italy.‡

Estner suspects, that the beilstein (a variety of steatite) must form

* Voyages dans les Alpes, § 1312. † Voyages dans les Alpes, § 2151. ‡Ibid. § 716.
distinct beds in primitive mountains, included in rocks of serpentine with which it is closely connected, but he does not give any example.*

Of all the rocks allied to the serpentine formation, steatite is that, without doubt, which approaches nearest to it in chemical composition. The only analyses of these two rocks which I know, are, that of serpentine by Kirwan, and of the soap-rock of Cornwall by Klaproth, who calls it seifenstein. The coincidence of these two able chemists in the proportions of the component parts of these substances, renders the idea I had formed, relative to their common origin, more probable. I subjoin a comparative statement of the results of these two analyses. It is possible, that hereafter, when such experiments are multiplied, we may discover too many anomalies to allow us longer to consider these two rocks as nearly allied to each other, and that we shall be obliged to arrange soap-rock as a distinct species of steatite.

<table>
<thead>
<tr>
<th>Serpentine analysed by Kirwan</th>
<th>Soap-rock analysed by Klaproth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>0, 45</td>
</tr>
<tr>
<td>Magnesia</td>
<td>0, 23</td>
</tr>
<tr>
<td>Alumina</td>
<td>0, 18</td>
</tr>
<tr>
<td>Iron</td>
<td>0, 03</td>
</tr>
<tr>
<td>Water</td>
<td>0, 12</td>
</tr>
<tr>
<td></td>
<td>101</td>
</tr>
</tbody>
</table>

We see that with the exception of the silica and the water, which are most abundant in the soap-rock, there is in this last substance a diminution of about 0,03, or 0,04 of all the other component parts.

* Brochant, Traité de Minéralogie, tome i. p. 471
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of the serpentine, as if they had been destroyed in consequence of the disintegration of the rock, and carried off by the waters.

In what formation then, ought we to place the serpentine of the Lizard? does it belong to the older formation of Werner, or to that which is more recent? the distinctions are in my opinion so vague, that I am almost led to suspect, that the terms are designedly obscure, in order to avoid being more explicit in the definition. Notwithstanding that obscurity, I think I can understand so far, as to discover that the characters by which it is endeavoured to distinguish these two formations, are erroneous, or imply a contradiction, and that if they are followed literally, we shall not in the present instance be able to refer the serpentine of the Lizard, either to the one formation or to the other.

The oldest formation according to Brochant, is found in the vicinity of gneiss and of mica slate, is mixed with granular limestone,* and sometimes this last even predominates. It appears from what Brochant adds respecting the great extent of the newest serpentine formation, that the oldest is of least extent.† Brongniart says, that the oldest formation seldom rises to a very great height, and in noticing the potstones and the beds of iron ore (Fer oxidulé) found in the newest formation, he gives us sufficiently to understand that they are not found in the oldest; he also states, that the newest serpentine occurs in masses or balls, but does not say, whether this is the form in which the oldest is found.‡ Kirwan says, that although the oldest serpentine is not metalliferous, yet it contains magnetic iron, and veins of copper.§

* He does not say whether chemically or mechanically.
† Brochant, Traité de Minéralogie, tome ii. p. 577.
‡ Brongniart, Traité Elémentaire de Minéralogie, tome i. p. 487.
§ Geological Essays, p. 204.
It is easier to shew, that these characters are for the most part erroneous, than to substitute others more precise, and consequently better, in their stead: a negative truth is however in my opinion always of some value.

Monte Rosa is we know, next to Mont Blanc, the highest mountain in Europe; there being a difference of only ninety-six feet between them. All mineralogists and geologists agree that it is an assemblage of primitive mountains.* Brochant does not state the extent of that vast deposit of newer serpentine which he tells us exists at Zoeblitz in Saxony; I think however, that a circuit of mountains of serpentine, the internal diameter of which is thirty thousand feet, and which is bounded by walls, if I may so express myself, fourteen thousand five hundred and eighty feet high, cannot be considered as a deposit of very limited extent.†

As a cap of eternal snow completely covers the upper part of the mountain, it is only by analogy we can say that the serpentine reaches to the top, it can however be traced to a very considerable height. I have observed it myself at ten thousand four hundred and sixteen feet above the level of the sea, at the fort of St. Theodule, in the passage of Mont Cervin. This may serve as a reply to the assertion of Brongniart, that the serpentine of oldest formation does not rise very high. He does not omit, it is true, to mention Monte Rosa as an exception, but he has forgot to produce a single example in support of his opinion. The potstone which is found at Alagna at the foot of Monte Rosa, at the height of three thousand eight hundred feet above the level of the sea, may be considered, I think, by all

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* Saussure compares the assemblage of mountains which form Monte Rosa to a tennis court.

† Voyage dans les Alpes, § 2140.
mineralogists, as occurring in the oldest serpentine, as much as that at Chiavenna and elsewhere.

There is a little way below the Pass-d'Olen, a ridge connected with the main body of Monte Rosa itself, a bed of magnetic iron* which is worked, though situated at the height of eight thousand eight hundred and fourteen feet above the level of the sea, so that without going out of the boundary of this mountain we find arguments supported by certain facts, proving that the characters which have been pointed out as distinguishing the two kinds of formation, are not well founded. Cornwall furnishes an example no less conclusive, as we find at the most southern point of the Lizard, the serpentine resting on mica slate, though it appears as if occurring there in mass.

Of all the characters which have been considered, I see only one, upon which we can rely in establishing a division in the serpentine formation, if such a division be at all necessary, viz. that the serpentine is found either stratified; or in mass, in balls, and forming subordinate beds. All the other circumstances which have been hitherto thought to characterize the one or the other of these formations, appear to me to belong to both indifferently. It is probable that there may be some reason for admitting a difference of age in the serpentine formation, but on what ground this distinction is to be admitted, does not appear. It is a subject which among a great many others ought to excite the attention of those who are interested in the study of the physical structure of our globe. Let us imitate the example of the most skilful geologists, of Pallas, and of Saussure, who without ever losing

* Brochant also mentions this mine; he calls the Pass-d'Olen the Col d'Olingue. Traité de Minéralogie, tom. ii. p. 278.
Dr. Berger on the physical Structure

sight for an instant of general views, did not cease to collect in the most patient and judicious manner, observations of detail, which if not in sufficient number to enable us to explain all appearances, have nevertheless the immense value of serving as a compass, and thus preventing us from making retrograde steps in our researches after truth.

Though Mullyan is situated completely in the grauwacke slate, we find here and there in the neighbourhood loose blocks of serpentine, which indicate a transition country, and similar to that on the east side of the Lizard Point between St. Kevern and Menaccan. The cliffs from Mullyan to the neighbourhood of Loe Pool are the highest I have seen on the coast of Cornwall, especially near Pengwinian Point: they form a semicircular line, the regularity of which is broken by angular portions of the rock projecting in some places, and by fissures and indentations in others, exhibiting fine sections of the grauwacke. The continuity of the line is interrupted at Gunwalloe by the mouth of a small river; through this creek the sea-sand is carried at some distance into the interior of the country, covering the soil, and heaped together in some places so as to form little sand hills.

The cliffs become gradually lower as they approach Loe Pool, and the shore is covered with a very fine siliceous sand. At the mouth of the river Loe there is rather a curious fact, and worthy of some remark: the river forms a kind of reservoir at a little distance from the sea, which I found to be one hundred and sixty paces at low water, from which the water runs into the sea by a subterranean passage. The water in the pool is fresh, though the bar of sand between it and the sea is not more than twenty feet high. This shews that the tides do not rise very high, and the inhabitants assured me,
that at no time of the year did they find the water in Loe Pool become salt. I tasted it repeatedly and found it quite fresh.*

The coast beyond Portlever rises abruptly, at the distance of a mile and a half from the sea, and at the height of three hundred and sixty feet, we leave the grauwacke and enter the granite, just before we reach the road leading from Helston to Marazion.

It will be recollected that the mountain chain of Cornwall dips to the west, that the land is contracted very much on that side by Mount's Bay, thus cutting off a great portion of the grauwacke formation, for although the road from Helston to Marazion runs nearly the whole way along the shore, it lies directly on the line of transition. The grauwacke rises to the height of three hundred and sixty feet on the side of Tregonning-hill,† from thence the granite continues as far as the sixth mile stone from Helston to Marazion. There, the land gradually lowering to the sea, we enter again on the grauwacke, near the village of Kennegy, but at what height I did not ascertain.

Antiquarians, after very laborious researches, have conceived, that they have found sufficient proofs in the testimony of ancient his-

* This was in the beginning of May.—We find in the History of New Holland, by the Right Honourable William Eden, a fact of this sort, which is nearly similar. "Part of the Batavia's people were sent to look for water on one of the islands near the spot where she was wrecked, and having landed there, had subsisted for near three weeks upon rain water, and what lodged in the cliffs of the rocks, not imagining that the water of two wells which were on the island could be of any use, as they saw them constantly rise and fall with the tide; for they concluded from this circumstance that, having a communication with the sea, the water must consequently be brackish; however, upon trial, it was found to be very good, and the ship's company were thenceforward plentifully supplied." p. 12.

† The top of this hill at the signal house is five hundred and eighty-four feet above the sea. Both channels may be seen from this station, which is the most elevated in this part of the country.
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torians, that St. Michael's Mount, situated in Mount's Bay, at the
distance of a quarter of a mile from the nearest land, (Marazion) had
been separated from it at a period, apparently not very remote, since
some carry their pretensions so far as to state the quantity of
land and the number of churches, that were swallowed up. Dr.
Maton has taken the trouble to collect together the different ac-
counts of this matter.*

I do not presume to reject, or even to lessen, the degree of confi-
dence which ought to be placed in historical records of very remote
date, notwithstanding the general tendency of the human mind to
receive with eagerness every thing that is at all extraordinary, espe-
cially if presented in a plausible shape. All that I can say is, that
upon an examination of the place, I am satisfied, that if a separa-
tion did ever take place (an event certainly possible and even pro-
bable) it must have been previous to the deposition of the grauwacke
formation, consequently at a period, which I presume is extremely
remote from that of any historical record whatsoever. The strata
of grauwacke, which all along the south slope of the mountain-chain
of Cornwall, invariably dip S.S.E. have here, a direction exactly the
reverse, viz. they dip N.N.W. This may be seen near the bottom
of the northern side of the mount, which is the least abrupt, exactly
in the meridian of Ludgvan Church-town, near a well of fresh water,
the only water fit for drinking which the inhabitants have when they
are surrounded by the tide.

The grauwacke extends westward, facing Penzance, and seldom
rises above the eighth part of the absolute height of the mount;†

† I found by the barometer, the height of St. Michael's Mount to be two hun-
dred and thirty-one feet from the level of the sea to the platform of the tower of the
chapel.
it is common grauwacke, with quartz,* and at its junction with the granite, it is traversed by veins of this rock, similar to those I have already mentioned in the valley of the Erme in Dartmoor.† The southern side of the mount is nearly precipitous, and is composed from top to bottom of a granite split into irregular masses; at the bottom is a heap of large blocks, among which, I thought I observed some indications of copper ore, on their surface. Sometimes the felspar and sometimes the quartz predominates in this granite; when it is the quartz, it gives the rock a vitreous appearance: it contains also black tourmaline, and pinite is also said to have been found in it.

Admitting however, that the mass of granite of St. Michael’s Mount was detached from the land, before the grauwacke was deposited upon it, and conformable with it, the grauwacke could only have rested on the northern face, or that which is the least abrupt, as the southern face is almost perpendicular, which is shewn by the great depth of the sea at the bottom of the mount on that side. But without having recourse to this hypothesis, to explain so partial a fact, it would perhaps be more reasonable to admit, that the epoch of the separation and transportation of St. Michael’s Mount has been posterior to the deposition of the grauwacke which has remained adhering to the detached mass of granite; and that in settling it has taken such a degree of inclination, that the strata of grauwacke on the south have been completely concealed, and only exposed to view on the northern side. I should not have dwelt so long upon

* The large rocks lying on the bar between Marazion and the Mount, are also common grauwacke.
† Mr. Playfair has described this appearance, with a degree of precision proportionate to the importance he attaches to facts of this sort. Illustrations of the Huttonian Theory, p. 318.
an individual fact, and one of so little extent, were it not that it offers an exception to what I consider as a general law in Cornwall, I mean, the direction and inclination of the gruwacke strata.

A semi-circular beach, covered with fine sand, in front of which stands, in a magnificent bay, St. Michael's Mount, topped by its gothic castle, affords a delightful walk the whole way from Marazion to Penzance. The land rising on both sides, breaks the uniform though imposing grandeur of a horizon bounded by the vault of heaven, and the picture taken in its whole extent, forms one of the most beautiful landscapes that the human eye can contemplate.

At the entrance of Penzance, I remarked some rocks of common gruwacke, which were not I believe in situ. We find in the neighbourhood, indications of this rock, but only close by the sea, showing, that its geological situation is the same throughout the whole extent of Cornwall. Thus, on leaving the village of Newlyn, on the road from St. Paul, it is seen distinctly in situ, but one hundred and fifty paces farther, the land rising, though but a little, the gruwacke is lost, and we enter upon the granite. From St. Paul to Mouse-hole, by the sea side, the land again falls, and we re-enter the gruwacke about two or three hundred paces from the churchyard of St. Paul. It is remarkable that the gruwacke, although in so low a situation, is no longer slaty, but compact; it is here, however, near the point of its junction with the granite, a circumstance which, more than its absolute height above the level of the sea, determines its particular structure. At the south end of the village of Mouse-hole, the granite lowers so much, that the gruwacke can only be seen at low water. It contains much quartz, and even felspar, and at the place of junction, there are several veins of granite seen shooting through it.
The last place in Cornwall where I met with veins or shoots of granite in the grauwacke, was at Mousehole near Penzance. As the attention of geologists, particularly the supporters of the Huttonian Theory, has been strongly directed to facts of this sort, I shall briefly state the observations I have made on this subject, confining myself to what I saw in Devonshire and Cornwall: not that I am unacquainted with some of those places on the continent where similar facts have been pointed out, but because I found them exhibited in this part of England in a manner much more striking and less difficult of apprehension.

1. We never find these veins or shoots of granite but at the point of junction of that rock with the grauwacke, whether that junction be in high situations or on the sea shore.

2. These veins are not independent or insulated, but by following their course we can always trace them to a main body of granite, without any interruption of continuity intervening between them.

* There is a remarkable example of this occurrence of granite veins at the junction with the grauwacke, in New Galloway in Dumfries-shire, on one of the estates of Sir James Hall. Vide third vol. of the Transactions of the Royal Society of Edin. Sir James Hall had a very interesting model of the place made on a pretty large scale, which he has deposited in the collection of the Geological Society.

Mr. Playfair also mentions some other facts of this sort, which he has observed in the course of his travels in England and Scotland. Illustrations of the Huttonian Theory, from p. 307 to 320.

† Voyages dans les Alpes, § 598, 599, 601.
3. In those places which have been thought to prove that granite veins were formed in the same way as metallic veins, they have always been at a considerable depth, such at least, as might reasonably induce us to suppose, that they were very near the main body of the granite. *

4. These granite veins, whether they are found at the surface or at a greater or less depth, are in Devonshire and Cornwall, invariably directed from north to south, which is a direction opposite to that of the metallic veins, but quite conformable with the mode of deposition of the grauwacke on the mass of granite which forms the low mountain chain of Cornwall.

5. These subterraneous granite veins are rarely metalliferous, but when they do contain a metal, it is always tin, which is known to belong to the oldest formation, and which sometimes forms one of the component parts of the granite.

* Granite veins have been found at a great depth in some of the mines in Cornwall, such as Dolcoath, Huel Providence, Huel Gorland, &c.—It is worthy of remark, that the prefix Huel, which is given to the greater number of mines in Cornwall, is the same as that by which they are distinguished on the opposite coast of the continent, in Brittany. These veins are called lodes by the miners, and divided into two classes, those of granite being called grazan, and those of porphyry elvan. The following are examples of these two kinds:

a. Vein of granite, found at the depth of one hundred and sixty-one fathoms in the mine of Dolcoath. This granite ought to be called porphyritic, as the particles which compose it are so far separated from each other, that they may be said to be imbedded in a base of common felspar, which is in a state of decomposition. The quartz is of a bluish appearance, and opalescent; the plates of mica are few, as well as the crystals of felspar; these last are very well defined.

b. Vein of porphyry in the mine of Huel Providence. This rock is more compact, or more sound than the preceding; the base is a felspar, of a dirty grey colour, in which are imbedded small crystals of quartz, mica, and felspar of an opaque white colour.

In the Journal des Mines, No. xviii. p. 84, there are some observations on the causes which may have produced these alterations in the texture of granite.
6. The width of these veins does not always diminish as they recede from the main body of granite. Sometimes after a very slender beginning, they swell out, or divide into ramifications.

7. I did not find the veins extend very far, nor rise perpendicularly, on the contrary, I always observed those at the surface to be conformable with the planes of inclination of the ground.

8. At the point of contact of these two rocks I never found the one disseminated in small quantities through the other, the granite never mixes with the grauwacke, but both retain their distinct characters.*

9. In breaking a part of these veins with the hammer it generally happens that the grauwacke separates from the granite, which proves that there was no penetration, but only juxta-position, as if the one had been moulded in the crevices of the other.

Several of these facts appear to me not very easily reconcilable with the following assertion in the work of Mr. Playfair: I quote it in his own words, "It remains certain therefore, that the whole mass of granite and the veins proceeding from it are coeval, and both of later formation than the strata."†

To the latter part of the above quotation, I cannot assent; I conceive, that at the time the grauwacke was deposited upon the granite, the water in which its particles were suspended, meeting with portions of the granite, a little more elevated than the general plane of the surface, left them exposed, and filled up the spaces between

* At least, if any thing of the kind has been observed, it has never been at such a distance as we might expect it to be, if produced by so considerable a force as that which the Huttonians suppose, but only at the edges; and in this case, it may have happened that the granite was softened by the grauwacke acting upon it as a solvent, so far as to permit pieces of that rock to amalgamate with it.

† Illustrations of the Huttonian Theory, § 82.
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them.—If we are to attribute the origin of these veins, according to the Huttonian Theory, to the action of a force from below, and which has caused them to intersect the grauwacke posterior to its formation, how comes it that along the whole line of the superposition of the grauwacke on the granite, they occur in so few places? and how comes it that the grauwacke, without any exception, forms a covering upon the granite, which, as it approaches the junction between it and the primitive rock, continues diminishing in thickness?

From Mousehole to St. Burien, the road continues to ascend, and is now completely in the granite formation. Several projections or hillocks may be seen in the horizon as we advance into the interior of the country; they are all of little height, and to their partial disintegration may be attributed the great number of blocks which are spread over the surface of this plain; it extends to the west, and has that uneven rugged appearance peculiar to a low primitive country.

St. Burien stands, I believe, on the highest point in that part of the country; its height is four hundred and sixty-seven feet above the level of the sea. There is a very extensive view from the top of the church tower, commanding the whole range of the surrounding country, and it is even said, that in clear weather, the Scilly Islands may be seen in the horizon.* The soil in the neighbourhood of St. Burien is mossy, and characterized by that sterility which usually accompanies a granitic country, but it becomes more fertile in approaching the sea. There are two or three druidical barrows, in very good preservation, at a short distance from the town.

The plain on which St. Burien is situated preserves its height

* I did not see them however, the weather, though very fine, being rather hazy.
pretty far to the west, for Sennen, the most western village in England, which is three miles distant from it in a straight line, and only half a mile from the Land’s-end, is, according to my observations, but seventy-six feet lower than St. Burien, that is, three hundred and ninety-one feet above the level of the sea.

The cliffs which bound this western shore of England, are nevertheless of small elevation. They are rather more abrupt and more lofty towards the north than towards the south. Mean Cliff and Cape Cornwall are higher than the Land’s-end and the Logan rock.

The Logan rocks, or rocking stones, are a heap of blocks of granite on the sea-coast, beyond the village of Traen or Trereen, a little to the south of the road from St. Burien to Sennen, forming a kind of cliff more inclined than abrupt towards the sea. Though there may be to the south of these rocks, near the ancient castle of Trereen, some remains of fortifications, I am satisfied that the logan stones formed at one time only one complete mass of granite, which by the action of the atmosphere and other external agents, has split into irregular blocks: the greater part of these, though separated on all sides from each other, have remained in their original position, but now appear as if they had been placed one above another. It appears to me, that it is in this way granite disintegrates in low primitive countries, and this appearance has, I believe, been often mistaken for strata, and has given rise to the idea that true granite is stratified, an opinion which I cannot adopt, even after having visited those places where Saussure thought he had discovered the strongest proofs in favour of the fact. * Among these logan rocks, there is one which rests upon another by only one

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point, and it is so nicely balanced, that a child may move it with the greatest ease, although it is of a very considerable size. The interesting observations of Mr. Playfair on this subject, render it unnecessary for me to say any thing further concerning it.*

With regard to the nature of the granite itself, the crystals of felspar in it are numerous, very large, and often in an earthy state: the rock is crossed in many places by felspar veins of considerable length: black tourmaline, in large and small crystals, is also very common in the mass: taken in its whole extent, this granite is rough and uneven, furrowed on the surface, and may be said to bear very marked proofs of the hand of time.

At the point which may properly be called the Land's-end, the cliff is abrupt, but not more than fifty or sixty feet high. It is composed of granite, presenting very remarkable appearances, and which might be taken for the work of art, as well as the logan stones. In some places there are shafts which look as if they had been cut with the chisel, in others, regular equidistant fissures divide the rock into horizontal masses, and give it the appearance of a collection of basaltic columns:† in other places again, there are complete arches under which the waves of the sea roll—physical and undeniable proofs of the combined action of time and external agents.

* Sic igitur mundi naturam tolius aetas
Mutat, & ex alio terram status excipit alter.
Lucret. de Nat. Rerum. lib. v.

The Islands of Scilly, nine leagues distant from the Land's-end, are said to be granitic, as well as the Islands of Jersey, Guernsey and

* Illustrations of the Huttonian Theory, § 354.
† What Ramond calls crystalline forms of granite, and which he describes and represents in a plate, in his "Voyages au Mont Perdu," are, in my opinion, only accidental splittings of the rock, though perhaps of a regular form. Page 312, plate i, fig. 1. c.
of Devonshire and Cornwall.

Alderney, and the adjoining coasts of France. If it were attempted to determine the epoch when the land of Cornwall was separated from the opposite coast of the Continent, and consequently the epoch of the formation of the British Channel, we must, in order to diminish the resemblance as little as possible, fix the date of that great event, immediately posterior to the deposition of the granite, a period lost in the darkness of ages.

Mean Cliff, situated a little to the E. N. E. of the Land's-end, is also entirely composed of granite, and is one hundred and eighty-eight feet high: at the bottom of it is a rock curiously shaped, called by the inhabitants, the Irish Lady.*

In descending from Mean Cliff to White-sand Bay, we passed a small village called Escales, at the north end of which we found the rocks laid bare by the sea at low water, to be compact grauwacke: that rock may be traced for some distance under the sea. The same common grauwacke again occurs on the sea-shore a little further to the north. The point of land called Cape Cornwall, stretching out to the west, and which may be considered as the western limit of the northern portion of the mountain chain, is entirely composed of grauwacke, although it is two hundred and twenty-nine feet high, while, at the cliffs east of the cape, the same rock does not rise higher than ninety-three feet.

Advancing from Cape Cornwall into the interior of the country by St. Just, many blocks of schorl rock are found scattered on this part of the granitic plain, particularly amongst the rubbish of some old tin mines, which are now scarcely worked. Though quartz be disseminated in small crystals through the mass, it sometimes also

* In the road from Two Bridges to Tavistock, in Dartmoor Forest, Mr. Necker remarked a rock of granite, of which he took a sketch, very much like an Egyptian sphinx in a mutilated state; the same resemblance occurred to us both at the same instant.
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appears in the form of rounded nodules, giving the rock a porphyritic appearance. It is very common to find cavities in it, lined with crystallized tourmaline. I did not see this rock in situ, but it is so abundant in this district, that I suspect it forms a subordinate bed in the granite, perhaps as the matrix of an ore: in the vicinity of the Land's-end, the granite is often accompanied with masses of black schorl, both amorphous and crystallized.

From St. Just, which is four hundred and four feet above the level of the sea, the granite continues as far as the neighbourhood of St. Ives by Botallach, Morvah, and Zennor, though only at a short distance from the sea. It must however be observed, that the height of the granitic plain continues, and even increases as we advance. Thus, the highest point of that part of the road, in the neighbourhood of Mean Screefs, is six hundred and twenty-three feet above the level of the sea. The tors in that part of the country rise in succession, and form an almost uninterrupted boundary to the south of the road. Near St. Ives, the country suddenly lowers, and we enter the grauwacke, but at what place, or at what height, I cannot say.

Leaving St. Ives for Redruth, the road crosses a hill, the top of which lies to the right: it is granitic, but the common grauwacke having a very fine and close texture, appears on its side. The termination of this rock is pretty near the highest point of the road. Being in a hurry to pass the river Heyl, which can only be forded at low water, I had not time to determine the exact height.

The mouth of the Heyl lies in a small inclosed bay between St. Ives and Godrevy, situated N.N.E. of Mount's Bay. By these two bays this part of Cornwall is formed into a kind of isthmus. A great deal of sand is heaped up in St. Ives' Bay, particularly on the east side, forming small sand hills between Gwithian and Phillack.
The grauwacke slate appears on the right or eastern bank of the Heyl, and continues without interruption as far as Redruth. Nevertheless, we are upon its boundary near Camborne, and I should not be surprised if that place, which lies a little to the right of the road, were on granite, for the ground rises in that direction, and at a small distance the Tors make their appearance. I had already observed the grauwacke at several places on the Bristol Channel, but it was of so small extent, that I found it impossible to judge, whether, according to my expectations, the strata dipped N.W. on the northern slope of the chain. There was every reason to expect that this would be the case, as the strata on the opposite side of the chain, have, as I have shewn, the contrary slope; I was therefore much gratified when I found my expectation realized in the course of an excursion I made from Redruth to Portreth, the nearest seaport, and three miles to the N.N.W. I had at the same time a very agreeable walk, and it is the only place where, in this part of the country one could forget for an instant, being in the midst of a mining country, and I may also say in the midst of ruins, for between Camborne and Scorrier House, there is hardly any vegetation to be seen. The ground is on all sides torn up and covered with rubbish and excavations.

In order to go to Portreth, we follow the course of a brook, along the sides of which there are some stream works: the country gradually lowers, and the verdure of the meadows foretold the approach of the sea, which we very soon discovered, and as we went through a narrow and woody pass, it had quite the appearance of a lake. When we reached the bottom of the bay, we found the grauwacke fully displayed; the angle which its strata make with the horizon is nearly the same as that which was formerly mentioned.
A little to the south-west of Redruth is a Tor,* called Carn-brea or Karn-breb, with an old castle on the top. This hill forms a ridge extending from E.N.E. to W.S.W. and the highest point of it is six hundred and ninety-seven feet above the level of the sea. The northern side is covered with heaps of granite blocks, which are probably the debris of a part of the ridge. The rock appears to be of a very tender texture, and the water retained at the surface by the mould which covers it, contributes, no doubt, very powerfully to its decomposition.†

Carn Marth, another small hill, the summit of which is elevated eight hundred and forty-nine feet above the level of the sea, is distant two miles S.S.E. from Redruth. It is the highest point in the neighbourhood, and from it may be seen the two channels and the port of Falmouth, which is about seven miles distant in a straight line. The upper part of Carn Marth (about one-third) is granite; large blocks are strewed over this part of the mountain; and they appear to have been rolled from the summit. In general, all these

* The small round hills in this part of Cornwall seem to be better known by the name of Karn or Carn, than that of Tor.

† We are so apt to form our opinions on those of others, and to see things only as they have been seen before, that to speak of Carn-brea without immediately recognizing it to have formerly been a place consecrated to the worship of the Druids, is almost an insult offered to the greater number of those who have visited the place. Nevertheless, I must freely confess, that the Druidical barrows which are said to be here so distinctly marked, did not appear to me as such, and in my opinion are by no means to be compared to those in other parts of Cornwall, as well as in the north of Scotland. And I can never believe that those rocks which are distinguished by the pompous names of Judicising, Sirloin, and Sacrificing stones, were ever excavated by the hand of men: indeed I never saw any thing which could more reasonably be attributed to the operation of time. If the Druids had ever made the Alps their habitation, there is no doubt that homage would have been paid to the Table au Chantre, the Pierre ronde, &c.
tors seem to have undergone great changes by the lapse of time, and they were probably higher at a former period than they now are.

The grauwacke covers the lower part of Carn Marth, and rises exactly to the height of five hundred and forty-three feet, which is about two-thirds of that of the mountain.

According to the mean of nine barometrical observations, the height of Redruth at Gray's Hotel, in the middle of the town, is four hundred and fourteen feet above the level of the sea; about two hundred paces beyond the first milestone from Redruth to Truro, the grauwacke disappears, and is superseded by a ridge of granite which continues exactly to the end of the first mile; there the land lowers, and we re-enter the grauwacke, on which formation Scorrier House stands.*

Porth Towan is another place on the Bristol Channel, four miles from Scorrier House, where the direction and inclination of the strata of grauwacke may be well observed. The cliffs are high and rather abrupt, and the rock has been very much excavated at the bottom by the action of the waters. Quartz abounds in it.

I observed that the grauwacke assumed a more slaty structure as it approached the sea from Scorrier House. The sands at Porth Towan extend pretty far into the interior of the country.

St. Agnes's Beacon is an insulated eminence of a pyramidal form, situated N.E. of Porth Towan, a short way in the interior; it has nearly the same degree of inclination on all sides, and is quite covered with debris. It is entirely composed of grauwacke, though six hundred and sixty-four feet above the level of the sea, and in

* Scorrier House, on the road from Redruth to Truro, is three hundred and seventy-seven feet above the level of the sea: it is a house, which mineralogists who visit Cornwall, and who seek instruction as well as good company, ought not to fail to visit.
the upper part this rock is compact. From this eminence there is a very extensive view of the coast, which presents a very irregular broken line.

In going from Redruth to Truro, by Carron which is at the farthest extremity of Restronget Creek, we follow for some time the road to Falmouth, and for the first three miles at least there is only granite; a little before coming to the road from Penryn to Truro, and just before leaving the parish of Gwennap, the grauwacke formation begins and continues without interruption as far as Truro, its positions to the east of which town I have already described.

General Observations on the Mines of Cornwall.

I passed too short a time in Cornwall, and I am not sufficiently familiar with the practical part of mining to enable me to treat of this interesting subject in detail; I must leave it to those who are more capable. I shall confine myself to a few geological observations alone, and I shall, as may be expected, follow with most other mineralogists the opinions of Werner on the formation of veins.

All mineral beds or deposits whatsoever may, I believe, be referred to one of the three following divisions.

A. Mineral beds.
B. Mineral veins.
C. Alluvial depositions.*

* This denomination, which conveys a very good idea of what is meant here, was suggested by two friends, instead of the less correct French word "minérais de lavage," (stream-works),
Devonshire and Cornwall.

A. Of Mineral Beds.

A bed is the mass of a substance different from the rock or rocks of which the mountain is formed in which it occurs, but the direction and position of which are conformable with the strata of the mountain.

Mineral beds are of less extent and of rarer occurrence on the surface of the globe than mineral veins.

We seldom find mineral beds and mineral veins in the same district.

I know of no ores having been found in the form of beds in Cornwall.

There is at Torneo in Lapland, a mountain entirely composed of iron ore, and at Luleo in the same country, the mountain Gelliware is one mass of rich iron ore of a blackish blue colour, which extends like an irregular vein for more than a mile, and is three or four hundred toises in breadth. *

I saw in the valley of Brozzo in Piedmont, five leagues west of Ivrea, at the height of four hundred and fifty-five toises above the level of the sea, a mountain almost entirely composed of very rich iron ore, (the fer oxydulé of Haüy) covered only at the surface with a cap of gneiss or mica slate. Every inhabitant of the valley having the right of working this mine, by paying a very small sum of money to the Commune, it cannot be expected that the mining operations are conducted with that method which is the result of theoretical and practical knowledge combined. Every one endeavours to dig out the greatest possible quantity of ore with the least possible trouble and expense to himself. Nothing can be more curious than the appearance of those galleries, if galleries they can.

be called; on entering them with a torch we discover vast chambers or excavations placed one above another, very much resembling the different stories of a house, with a common entrance.

The mine worked at Rammelsberg, and which is of so great an extent, does not appear to be a vein, but an immense mass of ore deposited in that place in the same manner as mountains are formed. Werner is also of opinion that the vein (spitaler hauptang) at Schemnitz, mentioned by Born, as well as two others of equally great thickness, worked in the same place, are rather banks of ore than true veins, judging from the uniformity of their direction and inclination, from their nearly horizontal position, and from what is said of their thickness.

B. Of Mineral Veins.

Veins have originally been fissures in mountains, and intersect the strata or beds of which the mountain is composed. These fissures have been filled from above by substances differing more or less from those of which the mass of the mountain that they intersect is composed, and those substances have been precipitated from a liquid solution.

Werner has brought forward so many facts in support of these two fundamental positions, that his theory scarcely receives a greater degree of stability by any of the farther proofs which are daily discovered.

Two particular cases have come to my knowledge, which I shall, notwithstanding, briefly mention. The one proving that veins have

Journal des Mines, No. xviii. p. 79.
been empty spaces, and the other, that they have been filled from above.

I observed the first in the mine of Dolcoath, between Camborne and Redruth, where, at the depth of seventy fathoms below the adit level,* that is to say, according to my observations, one hundred and eighty-four feet below the level of the sea, there was found an empty space in the vein of some fathoms in length, and broad in proportion. The walls of it are smooth, which is seldom the case, as these cavities, called by the miners, *druses, creaks, or pouches,* are almost always lined with crystallisations; Werner observes, that we find these druses in places where the vein is of greatest thickness. It often very distinctly appears that they have been much longer and wider, but that they have been partly filled up by a new substance having been deposited in them.†

The second fact, I have alluded to, I observed in a coal-pit at Littry in Normandy, two leagues S.W. of Bayeux. In sinking the pit St. George, there was found in a vein at the depth of two hundred and fifty feet from the surface, a conglomerate formed of rounded pebbles, the greatest part of them flints, although the *saalbande* and the rock are of stratified limestone. A branch of a tree was also found, with the ligneous structure preserved.‡ Werner mentions

* The adit level is twenty-seven fathoms below the surface of the ground, where the entrance to the mine is situated, and which is, according to my observations, two hundred and thirty-six feet above the level of the sea.

† Nouvelle Theorie de la formation des filons, p. 80. One of the most singular caverns of this sort, is that which exists at Joachimstal, at the depth of two hundred and fifty toises. This cavern, from which a vast quantity of water ran out, is said to be eleven toises in length and nine in breadth. Its height, which is not yet known, considerably exceeds twelve toises. Ibidem p. 115.

‡ Journal de Physique, Mars 1807, p. 225.
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a fact nearly similar, observed in the coal strata near Hainchen. He also saw a vein at Joachimsthal, entirely filled with pebbles.* Now, how is it possible that these stones could find their way into the interior of the veins, if these had not been originally open at the top?

Of the comparative Age of Beds and Veins.

Though according to the theory of Werner, the spaces of veins were immediately filled up by precipitations from the same solutions which, by previous precipitations, had formed the mountains, it does not, I think, follow as a necessary consequence that beds and veins are exactly of the same age. The difference which I conceive exists between them is in the mode of their formation.

Beds of ore being now covered by strata of rocks, in a manner conformable with those on which they have been deposited, it follows, that the elements of both were all held in solution at the same time, but that by a play of affinities, which tended to unite together similar particles, sometimes precipitates of the one, and sometimes of the other, took place, by causes which are yet unknown to us; but since they are deposited alternately we may safely say that they are coeval. Veins on the contrary, having been originally fissures, which could not be formed until after the retreat of the waters, when the mass of the mountain was in a soft or semi-indurated state, we may conclude, that at that time, the solutions from which the veins were filled up, were no longer mixed with those from which the mountains were formed, and consequently, that a vein is of posterior formation to a bed.†

* Nouvelle Theorie de la formation des filons, p. 74 and 81.
† It is said, that in the Bannat of Temeswar, the same formation is found in beds, which occurs in veins in Voightland, in Bayreuth, in the Hartz near Lauterbach, and in
C. Of Alluvial Depositions of Ores.

I agree with many mineralogists* in the opinion that these accumulations of ore have been originally true veins, worn down and removed by some cause or other from the place where they were formed; that they have been water-worn, and carried to a greater or less distance, where they have been covered by alluvial soil. These washed ores occur everywhere in similar situations, either in a plain, or in open and very low-lying valleys, in beds or strata, which are generally at a small depth below the surface of the ground, and often

Westerwalde. This formation consists of copper pyrites, red oxide of copper, malachite, brown compact testaceous iron ore, with quartz. Nouvelle Théorie de la formation des filons, p. 168.

Werner endeavours to prove by this, that an analogy exists between the age of veins and beds. But admitting the example just quoted (Werner does not give it as undoubted), does it follow that this formation of beds and veins in different countries is coeval? has not Werner himself told us, that veins of the same nature may be of different ages?

* Klaproth's Mineralogical Observations on Cornwall, p. 11.

Mr. Jars believes these fragments to be remains of heaps of refuse from the ancient unskilful working of the mines, which by inundations have been washed down from the mountains, and formed beds in the valleys. Ibidem, p. 11.

Pryce, who was a practical miner, divided the alluvial ores of tin into different kinds. "The shode is disjunct, and scattered to some declined distance from its parent lode, and it is pebbly or smooth angular of various sizes, from half an ounce to some pounds weight." Stream tin ore is the same as shode, but smaller sized, or arenaceous.

"It is the smaller loose particles of the mineral, detached from the bryle or back of sundry lodes, which are situated on hilly ground, and carried down from thence by the retiring waters, being collected in large bodies or heaps in the valleys. In the solid rock of the valley there is no tin ore, but immediately upon it is deposited a layer of stream tin of various thickness; perhaps over that a layer of earth, clay, gravel, &c. upon that again another stratum of tin ore, and so on successively, stratum super stratum according to their gravity, and the different periods of their coming thither," Pryce Mineralogia Cornubiensis.
accompanied with remains of marine animals or other organized bodies. At Poth stream-works, about four miles from Fowey, on the shores of Trewardreth Bay, tin in the form of round pebbles is found imbedded in a bluish marl, containing the remains of marine animals at the depth of twenty feet. The tin pebbles vary in size, from a grain to that of a small egg.*

At the head of Restronget Creek, not far from Falmouth, the tinstone of Carnon is found under fifty feet of soil. I saw in the collection of Mr. John Williams, of Scorrier-house, deer's horns which were found in the same soil, and which were in no way mineralized. I was told that trunks of trees and small grains of gold had also been found in it.

The other places in Cornwall where stream tin has been met with, are at Perran Porth in the parish of Perranzabuloe, below the sea-sand in the form of large blackish grains, at Hallibesack in the parish of Wendron, at Frogmoor in the parish of Probus, at St. Dennis and St. Roach in larger, but angular fragments, at Swanpool in the parish of Ladock, often mixed with cubic galena;† at St. Austle Moor, at the average depth of eighteen feet, and at St. Blazey Moor at the depth of twenty-eight feet.‡

The menachanite, which is found in the form of sand in the small valley of Menaccan, at a short distance from the sea, and the iserine, which is also found in the state of sand in the beds of different rivers, as well as in the neighbourhood of volcanoes,§ belong probably to the formation of alluvial ores.

† Klaproth's Mineralogical Observations on Cornwall, p. 13.
‡ Pryce's Miner. Cornub.
§ The iserine is a metallic sand, composed almost entirely of titanium and oxide of iron, and appears to differ very little from the menachanite. Dr. Thomson has analysed
D. Of the Course of the Veins in Cornwall.

Almost all the veins in this country, as well as those in Devonshire, belong to the class of oblique or inclined veins. Their degree of inclination varies, but according to the information I received on the spot, and from what I saw myself, I believe, that taking an average, they may be said to dip a foot and a half in each fathom. The point of the compass to which they dip varies. Some mineralogists think that the veins of copper generally dip to the north, and those of tin to the south; but we must look to practical miners for the most accurate information on this head.*

The position or direction of the productive veins is from east to west, or more correctly from E.S.E. to W.N.W. forming what used to be called in France filons du matin.† It is remarkable that in England, and also in Scotland, all veins of whatsoever age, or of whatsoever ore they may be composed, have nearly the same position, which would seem to indicate, that the cause to which they owe their existence, had acted in the same direction, though at different periods. It appears then that the veins run parallel to each other. The tin veins are not so long as those of copper, and they

that which is found in the bed of the river Dee in Aberdeenshire, and M. Cordier has analysed a great variety of different kinds gathered in volcanic countries. Journal des Mines, No. 124.

* Metallic veins in Derbyshire near Castleton, run from east to west, and are traced or discovered from the surface. They incline about one foot in ten, sometimes to the north, sometimes to the south. Mawe's Mineralogy of Derbyshire, p. 2.

† In Brittany, on the contrary, they consider as barren, all the veins which have a direction from east to west; the best run nearly from north to south, or at least do not vary much from that direction. Journal des Mines, No. xvi.
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are even shorter than those which contain a mixture of copper and tin. This appears, at least, by comparing the number of the workings with the number of the veins. The respective length of the three species of veins may, I believe, be pretty accurately represented by the relative value of the following numbers.

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<tr>
<td>Tin</td>
<td>58</td>
</tr>
</tbody>
</table>

In the parish of St. Agnes, and at other places along the coast, but particularly at St. Agnes’ Beacon, the distortion and irregularity in the course of the veins is very remarkable.* The width of the veins varies with the form they assume; when they divide into small ramifications they become poor; when, on the contrary, several small veins converge, and form a belly, then they become rich. I do not believe that there is any vein in Cornwall more than a fathom in thickness, at least if there are any of greater width, they are very rare. Some of the veins in Cornwall penetrate to a very great depth, to one hundred and forty fathoms in Huel Alfred, and one hundred and eighty-eight in Dolcoath, Cook’s Kitchen, and Huel Virgin. The copper veins go deeper than those of tin.* There is another fact pretty well known to the Cornish miners, viz. that a change of the rock in which a vein runs, produces a change in the

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† It is very seldom that tin continues rich and worth the working beyond fifty fathoms deep; and it is absolutely certain, that copper is not often wrought in great abundance, till past that depth, to an hundred fathoms or more. It is also a fact, that most mines with us, both of tin and copper, are richer in quality near the surface. The richest state for copper is between forty and eighty fathoms deep, and for tin, between twenty and sixty. Pryce’s Miner. Cornub.
degree of richness, for instance, if a vein was in grauwacke, it would be impoverished by entering the granite, and vice versa.

It was formerly conceived, that the veins of copper belonged exclusively to the grauwacke, and that those of tin were chiefly confined to the granite; but there are now several copper veins worked in the primitive rock: it is however true, that they are near its junction with the grauwacke.*

* Mr. Kirwan has endeavoured to explain, why ores are found less frequently in granite than in all other rock formations. He says, "Hence we see why metallic veins seldom occur in granitic mountains or those of jasper, and the harder stones, as their texture is too close to permit the percolation of water, at least in sufficient plenty, and because their rifts were previously occupied and filled with stony masses, as being more soluble, and therefore soonest conveyed into them; thus silex sufficiently comminuted is soluble in about one thousand times its weight of water, or even less, whereas metallic substances require much more; but if the granitic stones are in a state of decomposition, as in the lower mountains they often are in Cornwall, &c. there they may be metalliferous. On the other hand, gneiss and schistose mica, argillaceous porphyry, and argillites being much softer, are the principal abodes of metallic ores." Geological Essays, p. 412.

Cross courses are veins of marl or clay which intersect the true veins in Cornwall nearly at right angles to their direction, that is to say, which run from north to south. The most considerable of these cross courses extends from sea to sea; it passes directly through the meridian of St. Agnes, leaves in the middle of its course the parish of Stythians, three quarters of a mile to the west, and terminates on the south in the neighbourhood of Pedn-Boar-Point: it varies from a few inches to some feet in thickness: the depth to which it penetrates is still undetermined. It not only intersects all the true veins, but it has thrown the western portion of those veins some fathoms to the north of the corresponding portion on the east side of it. These cross courses are evidently of posterior formation.
to the metallic veins, since they cross them, as I had an opportunity of observing at different places in the mine of Dolcoath.

I do not know if there are any other true veins posterior to the cross courses, that is to say which cross them, and the direction of which would in that case be from east to west. Did these occur, it would point out three distinct periods at least, in the formation of veins in Cornwall. Ought the small metalliferous veins which run in the same direction with the cross courses, i.e. from north to south, to be considered of contemporaneous formation with them? It is in a vein of this sort that the arseniate of lead is found. This mineral has been lately discovered in the mine of Huel Unity, and has been analysed by the Rev. Wm. Gregor.*

Although the cross courses are barren veins,† they are nevertheless, always dug into on each side, to ascertain whether they contain any ore left behind by the older vein in the act of its being rent asunder. A metallic vein interrupted by a cross course is more generally impoverished than enriched.‡

* Philosophical Transactions, part ii. 1809.

† Cross lodes, cross courses, cross flookans, cross gossans, and contre or caunters, are generally quite barren for tin and copper, but we have some few instances of cross gossans being wrought for lead, though not to any great profit. Some antimonial veins run also north and south. Pryce's Miner. Cornub.

‡ Charpentier thinks on the contrary, that a vein is sometimes enriched by meeting with another which is poor or even absolutely barren, or by meeting a vein that is slightly filled up, and sometimes quite empty. He gives as an example, the mining district, called Le Prince Electoral Frederic Auguste, at Gross-Schirma, where a large vein suddenly increases in richness, by meeting a very narrow vein, containing only a grey clay, and without any metallic substance whatever. Journal des Mines, No. xviii. p. 96.
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E. Estimate of the number of Mines in Cornwall, of the different kinds of ore they contain, and of their relative ages.

Most of the data on which the facts comprehended in this paragraph are founded, I obtained from a MS map of the mines of Cornwall, executed by Mr. William Phillips in the year 1800. This map is very interesting, and ably executed in all respects, but there are several omissions in it, which may be easily accounted for, as the state of the mines varies from year to year. Old workings are given up, and new mines are daily opening; what follows therefore is to be understood in a relative and not in an absolute sense.

Without taking into account the tin stream-works already mentioned, and the mines of soap-stone, which is a particular object of itself, there were about the year 1800, ninety-nine mines worked in Cornwall.*

Of these, there were forty-five of copper, twenty-eight of tin, eighteen of copper and tin, two of lead, one of lead and silver, one of copper and silver, one of silver, one of copper and cobalt, one of tin and cobalt, and one of antimony. To which we may now add, some mines of manganese which were not worked at that time.

Of the copper mines, eleven are in the parish of Gwennap alone, six in that of St. Agnes, five in Camborne, four in Gwinear, the same number in St. Hillary, three in Germoe, Crowan and Illogan, and two in St. Neot. The other mines are scattered singly in parishes more or less distant from each other.

Of the tin mines, seven are in the parish of St. Agnes, four in Wendron, three in Gulval, two in Lelant, Redruth, and Perranzabuloe, and only one in the parish of Gwennap, where most of the copper veins are found.

* According to Mr. Phillips's map.
Of the mines of copper and tin, there are four in each of the parishes of Redruth and Gwennap, three in St. Agnes, and two in St. Neot.

The two mines of lead marked in the above-mentioned map, occur in the parish of Sithney, in a situation which is nearly of the same elevation, as the lead mines of Beer-alston in Devonshire.

The mine of lead and silver is found in the parish of Wendron, and that of silver in the parish of Cubert.

The mine of copper and silver is in the parish of Gwinear; the antimony at St. Austle and Endellyon; copper and cobalt in Camborne; tin and cobalt in Madron; manganese near Launceston and the Indian Queen.

If we examine these localities it will appear, that the copper and tin which either singly or combined form four-fifths at least of the mines in Cornwall, are met with near the junction of the granite and gruwacke:* but it also appears, that tin may, contrary to the opinion of Werner,† be sometimes found in secondary stratified mountains. It is true that at Kithill, and in the islands of Scilly,‡ it is found in the true granite.

When the tin is not combined with copper, it usually forms a constituent part of the granite, and in this case it is often accompanied by wolfram in the matrix of the vein.§

* Baron Born and Ferber have made the same observations, the former in the Bannat, the latter in the mountains of the Veronese and of the Vicentine. Ferber's Letters on Italy, to Baron Born, p. 36.


‡ "The vestigia of any tin lodes, mines or workings, in the islands of Scilly, are scarcely discernible; for there is but one place that exhibits even an imperfect appearance of a mine." Pryce's Miner. Cornub.

§ At Kithill near Callington.
A very singular and very anomalous combination of tin with sulphuret of lead is found in the mine of Heavas in the parish of St. Mewan. There is also a vein at Marienberg in Saxony, in one part of which ores of tin are found, and in another, ores of silver.* Are we to infer, that in some cases the tin veins already formed have been rent, and the new fissures filled with ore of a later formation; or are we to admit, that there are tin formations of different ages?

The cobalt united with tin, found in Wherry mine in the parish of Madron, belongs very probably to the oldest formation of cobalt, the same as that of Gieren in Silesia, which is in a mountain of mica-slate;† for the veins of cobalt in secondary mountains are of very recent formation.

The tin is accompanied with arsenical pyrites, copper pyrites, and even blende, as in the mine of Trevascis. Arsenical pyrites, according to Werner, is of very old formation, although produced at different ages; for we find it (he says) with tin, with galena, sometimes, though rarely, with copper pyrites, and also with arsenical silver ore.‡ It is not usual, he adds, to find copper pyrites with blende, but very frequently this last accompanies galena.

Copper occurs in various forms in Cornwall, independently of its combinations with tin, with cobalt, and with silver: viz. in the native state,§ in the states of red oxide, blue carbonate, green carbonate, sulphuret, grey antimoniated ore, and arseniate. The sub-

* Nouvelle Théorie de la formation des filons, p. 106.
† Ibidem, p. 179.
‡ Nouvelle Théorie de la formation des filons.
§ "Native copper is frequently found in our mines near the clay or surface, or commonly but a few fathoms deep; though there are some few instances of its being found very deep, particularly in the mine of Cook's Kitchen." Pryce's Miner. Corn.
stances that have been found to accompany the veins are, arseniate of iron in the mines of Carrarack and Huel Gorland, oxide of uranium in the state of ochre, in Tin Croft mine; bismuth and nickel at Dolcoath, spathose iron at Cook's-Kitchen, and native silver united with decomposed galena in the mine of copper and silver at Herland. Judging of this formation of copper from its being accompanied by bismuth and uranium, we should be led to consider it as very old. Uranium and bismuth being found in this district proves, that those metals may, contrary to the opinion of Werner, be met with in secondary mountains. The nickel, cobalt, silver, and especially the spathose iron, would lead us on the contrary to refer that formation to a much more recent epoch, insomuch, that we must perhaps admit, that in the deposits of copper in Cornwall, there are veins of different ages.

It may be possible also, and this idea seems to me the most probable, that the accompanying substances which contradict the uniformity of age in veins of copper, are met with in rents formed at a later period, or in the veins called cross-courses, of a still more recent date. It is only however from practical miners, that we can hope to obtain information on this head.

"Native copper is found in very considerable quantity at Cape Lizard, between the rocks near the sea shore, in filiform branches, and veins of some thickness, contained in blackish serpentine, in Huel Virgin, Carrarach, at Poldory in the clefts of mountains composed of killas." Klaproth's Miner. Observ.

* "At Huel Trugo also, a copper mine near St. Columb, some of the purest Cobalt has been worked. Very good cobalt has been also discovered in Dudnap's mine in Illogan parish." Pryce's Miner. Cornub.

† Ramond has also found in the Pyrenees indications of nickel and cobalt, at the junction of the veined granites with the cornéennes, i.e. in a geological situation very analogous to that of Cornwall. Voyages au Mont Perdu, p. 206 and 239.

‡ It is said, however, that bismuth never accompanies cobalt and nickel in deposits of new formation. Journal des Mines, No. xviii. p. 94.
The relative age of the different formations of silver, according to Werner, is not yet determined.* The vein which was formerly worked at Huel Mexico in Cornwall, was in grauwacke slate. The ore appeared to be mixed in it in the form of insulated masses or nests; besides the native silver, congeous ore (muriate of silver) was also met with. This last ore, of all the combinations of silver, is that which is most frequently found at the surface of veins.†

Silver united with lead in the state of galena is found in the mine of Huel Pool, and filiform native silver, with vitreous silver and decomposed galena, has been met with at Herland; we know that these two metals combine very readily, so much so, that we rarely find a mine of lead which does not contain more or less silver. The mines of Beer-alston in Devonshire, contain a pretty large proportion of it. The most important mineral deposit at Freyberg is of silver and lead.

Grey antimony ore (sulphuret) is sometimes found in primitive, and sometimes in secondary mountains. According to most geologists it belongs to the middle ages of our globe. It was formerly worked in different parts of Cornwall; among others at Padstow Harbour and Camelford near St. Teath, and more lately at Huel.

Bismuth unaccompanied by any other metal does not form veins, but kidney-form masses. Thomson’s System of Chemistry.

I do not know exactly under what form the bismuth has been found at Dolcoath, I believe in the kidney form.

* At Freyberg and in Norway, silver is found in gneiss, at Johanngeorgenstadt in clay slate, mica slate and hornblende. Nouvelle Théorie de la formation des filons.

According to Bergman, silver is found in quartz, limestone, and sometimes in petrósilex. It is often accompanied with blende, pyrites of different metals, among which may be particularly noticed, antimony, zinc, cobalt and lead. Journal des Mines, No. xvi. p. 25.

† At Frankenberg in Hesse, leaves of native silver have been found upon petrifactions. Nouvelle Théorie de la formation des filons, p. 185.
Dr. Berger on the physical Structure

Buoys in the parish of Endellyon. All these workings are now given up.*

Manganese has only lately been worked in Cornwall, and it appears to afford considerable profit to the proprietors of those mines. The ore is shipped direct for Lancashire, where for some years it has been employed in the bleaching of cotton. I was informed of two mines of this metal, the one near the Indian Queen, on the road from Bodmin to Truro, the other at St. Mary Magdalene, a mile to the south of Launceston; both are consequently situated in the grauwacke formation. It is the pink siliciferous oxide of manganese, which is worked at St. Mary Magdalene, the same variety that is found in the mines of Nagyag in Transilvania. I have already given a detailed account of the mine of brown oxide of manganese at Upton Pyne in Devonshire, accompanied with ferriferous carbonate of lime, &c. Dr. Maton, at the time of his last visit to Exeter, was informed that the working of this last mine was abandoned, and that others had been opened at Newton St. Cyres, four miles N.W. of Exeter.†

Manganese usually accompanies iron stone mines.‡ The soil at Upton Pyne evidently contains a considerable quantity of iron in the state of red oxide; but whether it is found in the situations just

* There exists a small deposit of grey antimony accompanied with quartz, in the circle of Freyberg; it is considered as subordinate to an older deposit of antimoniated sulphuret of silver. Nouvelle Théorie de la formation des filons, p. 303.

According to Bergman, antimony is found in kidney-shaped masses, and in threads, in veins of galena and hematites. It is also found native at Carlson, and in the mine of Sala. Journal des Mines, No. xvi. p. 34.

† Observations on the Western Counties, vol. II. p. 74.

‡ Penzilly in Breage parish affords hematite of a liver brown colour, mixed with Manganese. This fossil is found in a vein of yellow friable iron ore, through which it runs in veins of different thickness and position. Klaproth's Miner. Obser. p. 31.
mentioned, I cannot say. Manganese as well as antimony occurs in primitive and in secondary mountains, and the different formations of it appear to belong to a middle age.

The lead formation is of very small extent in Cornwall, it is confined to the low parts of the county. This metal is known to occur particularly in calcareous countries, rarely in primitive rocks; it is one of those metals most universally spread over the surface of the globe, especially in the state of galena. Werner conceives that the numerous formations of this metal are of very different ages.*

The ferriferous oxide of titanium belongs almost exclusively to primitive countries. The locality of the menachanite proves nevertheless, that it may also be met with in secondary countries. The naturalist, to whose accurate researches we are indebted for the discovery of the menachanite, has also observed it in a kind of sonorous petrosilex, which I consider as the clinkstone of Werner, and which had been picked up in the neighbourhood of south Brentor in Devonshire, where it is found in blocks on the surface of the fields. We know in fact, that the oxide of titanium exists in a great number of rocks, even in granite.

With the exception of platina, mercury, molybdena, tellurium, tantalium, columbium and cerium, Cornwall affords indications of all the other known metals, in one shape or other, in mass, forming deposits, or as adventitious substances in the veins.†

* Galena in large cubes is found at Treseavan, with copper pyrites: at Poldice mixed at the same time with cupreous and arsenical pyrites in quartz and killas: and at Penrose there is a rich vein of it which opens upon the surface. Klaproth's Miner. Obser. p. 30.

† Becher in his remarkable dedicatory epistle to the famous Boyle of his mineralogical alphabet which he wrote at Truro, says, The earth is here so abundant in different kinds of fossils that I believe there is no place in the world which excels Cornwall in the quantity and variety of them. Klaproth's Miner. Obser. Introd. p. 3.
It will have been remarked, that calamine or carbonate of zinc, so common in stratified limestone, is found in no part of Cornwall that I am aware of, although blende, or sulphuret of zinc, occurs pretty abundantly in the veins.

Those who know the geological situations of coal will not expect to find it in Cornwall. There is at Bovey in the eastern part of Devonshire, a kind of brown coal or bituminized wood (braunkohle) which contains some very remarkable substances. I refer however for a full account of this substance to the interesting memoir of Mr. Hatchett.*

According to Klaproth, asphaltum or indurated bitumen has been found somewhere in Cornwall in granite, at the depth of ninety yards.† I am not acquainted with the locality, but I should suppose that the presence of this inflammable principle in that situation must be owing to some local and accidental cause.

Among the substances that are combined with the different metals of which the mineral deposits of Cornwall are composed, there are two which merit particular notice, both on account of their very general occurrence, and also because they appear in certain circumstances to act considerably upon the rocks with which they are in contact, altering their texture, and distintegrating them, as if they had been exposed to acid vapours. These two substances are sulphur and arsenic.

This change of appearance in the rock in contact with the veins, and which sometimes extends pretty far, takes place principally where the ore is strongly combined with sulphur. It is found to continue for some distance from the actual contact of the ore, so much so, that in following a barren vein, if we come to a place where the

* Philosophical Transactions, 1804, part 2. † Miner. Obser. p. 32.
of Devonshire and Cornwall.

rock is decomposed, it may be concluded that ore will very soon be found.* The arsenic acid, according to Werner, produces a similar alteration upon rocks, and the carbonic acid also appears sometimes to contribute to this decomposition. It is in porphyritic rocks, sienite, gneiss, mica-slate, and clay-slate, that this alteration principally occurs, but it is still more distinctly seen, where felspar is found, as has been said above in noticing the veins of granite, which have been found at a great depth in some of the mines of Cornwall.†

F. Of the different Matrices accompanying the mineral Deposits in Cornwall and Devonshire.

By saalbande is understood a slip or band interposed between the vein and the rock which forms the body of the mountain. The

* Théorie des filons, 151. 156.
† The action of these substances is not confined to rocks alone; their effects seem to me to extend even to the workmen. The miners are affected in a somewhat similar manner as the unfortunate criminals who are employed in roasting the ore in the arsenic and cobalt mines of Saxony, where they live almost continually in an atmosphere of arsenical vapours, and are seen to languish at the end of a few years. This poison is, no doubt, infinitely less powerful in Cornwall, but there are many other circumstances which combine with it to destroy the health of the workmen. I was nevertheless very much struck with the pungent smell of garlic in the galleries after a blast, or when a vein has been worked for a long time with the pick-axe. A blow of the hammer alone, upon some parts of the ore, produces a very powerful smell. It is possible, however, that this smell of garlic may in part be produced by antimony, for we know that this metal, even in a pure state, when strongly heated, gives out a vapour, the smell of which is very similar to that of arsenic.

Whatever may be the respective effects of these various causes, it is certain that the miners never live to an advanced age: fifty-five is a very long life for them. I was anxious to consult the parish register of Redruth, in order to ascertain the average life of the miners compared with the husbandmen, but was prevented by want of time.
saalbande is in general of a different nature from the substances to which it is contiguous: it is sometimes composed of clay, sometimes of amianthus, of mica in layers, &c. It is not found in all veins, and those from which it is absent are said to be adherent. This is, I believe, generally the case in Cornwall.

Vein-stones are the different stony substances with which the ore is intermixed, and which as a whole constitute the vein. It is these vein-stones which I now propose more particularly to consider.

Werner is of opinion that in the same vein the parts of the veinstone nearest to the saalbande are the oldest, those in the middle the most modern, and the intermediate parts of a middle age. But whatever may be the age of these different parts of the vein, they are all necessarily posterior to the rock of the mountain in which the vein occurs, and in the present case, to the granite and the grauwacke, the only two formations of any extent that are met with in Cornwall and Devonshire.

As the same vein-stones are found in different formations of veins, we must therefore admit, that the same rocks have been held in solution at different periods.

Massive quartz sometimes forms alone the greatest part of the vein-stone of certain veins. This is the case at Kithill near Callington: I believe that here the quartz is united to the granite without any saalbande intervening.

In the tin mines between St. Just and Cape Cornwall, quartz is united with black, massive, and radiated tourmaline. The quartz exists not only in the form of veins, but also in blocks. According to Bergman, there is in the mountain of Nasa, a block of quartz several hundred yards broad, and double that dimension in length.*

* Journal des Mines, No. xvi. p. 41.
Dodecahedral hyaline quartz is frequently found among the vein-stones of the lead mines at Beer-alston in Devonshire.

Swimming quartz is met with in the copper mine of Huel Gorland, and in that of Suit and Cloak, or Pednandrae, united with tin and calcedony. The same quartz is said to be met with at Nancothan.

Compact quartz, passing to quartz-agate and calcedony, is very common in the old mines of Beer-alston. It may be said to form the principal part of the vein-stones. It is combined with fluor, galena, and blende, which are disseminated through it in small masses.

Calcedony, in the form of stalactites, is found at Huel Sparnan and Trevascus. In the former place, it is combined with chlorophane, a variety of fluor, which was thought to be peculiar to Siberia.*

In the copper and tin mine of Tol-carn in the parish of Gwennap, a kind of flint, commonly known in England by the name of chert, has been found with semi-opal in a decomposed granite; and jasper-agate has been found in the tin mine called Ding-dong in the parish of Gulvall.

Pitchstone has been met with in the copper mine of Carrarach, one of the consolidated mines.†

* Fluate of lime does not usually enter into the composition of primitive rocks; it is said however, that the violet variety called chlorophane is found disseminated in a granitic rock, in eastern Siberia; and Dandrada mentions having seen in Sweden, in the district of Norberg, extensive strata of mica-slate mixed with fluate of lime in compact masses, and with nodules of quartz. Brongniart, Traité Elem. de Minér. tome i. p. 246.

† In the island of Arran, there are appearances of pitch-stone in the form of veins traversing the granite, but as all veins are of posterior formation to the rocks which they traverse, this cannot be equally old with the granite or other rocks reckoned primitive.
From these several facts we may conclude, that although quartz is
the oldest vein-stone, it has nevertheless been produced at different
periods under various forms.

Spathose iron, though scarce, is however one of the vein-stones at
Beer-alston.

But fluor appears to be by far the most common vein-stone in
both Devonshire and Cornwall. It is more generally disseminated in
particles, than occurring massive: it belongs almost entirely to the
green variety, and differs in intensity of colour from a greenish-white
to a bluish-green with a dull aspect. It is of a brittle texture,
and slightly coherent: it is found, I believe, in the middle parts of
the vein, and is therefore of the most recent formation. It chiefly
occurs in the copper mines.

Perhaps the different colours of the fluor may, to a certain extent,
have some connection with the different periods of its formation.
Red or pink fluor, as far as I know, has never been found but in
primitive countries: it has been met with in the valley of Chamouni,
near the glacier of Talcul, in the valley of Urseren, not far from
Mont St. Gothard, &c. The violet or blackish-green fluor is
chiefly peculiar to the stratified limestone of Derbyshire, and the
green variety would seem to characterize that of Devonshire and
Cornwall.

Dr. Kidd mentions a bivalve shell in the mineralogical cabinet of
Oxford, the interior of which is lined with imperfect crystals of
transparent fluor,* shewing undeniably, that fluor is in some cases

These veins (of pitch-stone) traverse the common argillaceous sandstone in Morven,
and are often of a great magnitude. In the island of Mull, it seems to lie between sand-
stone and basalt, but in Eigg it forms considerable veins traversing basalt. Jameson's
Mineralogy of the Scottish Isles, vol. 1.

* Kidd's Outlines of Mineralogy, part i. p. 74.
of very recent formation. This fact, which Dr. Kidd conceives to be unique in its kind, appears less extraordinary, since the discovery by Morichini of fluate of lime in the enamel of some fossil elephants' teeth, where it was mixed with phosphate of lime and gelatine.*

In the mine called Stony Gwynn, in the parish of St. Stephens, violet fluor is found combined with vitreous quartz, phosphate of lime, and yellowish foliated talc, forming a very hard and compact rock, which constitutes the saalbande. This rock is certainly not the same with that forming the mass of the mountain, although it resembles it, thus demonstrating its antiquity. The middle parts of the vein, in the same mine, although more recent, are however, in my opinion, of much earlier formation than the greater number of the other mines in Cornwall. It is a rock which has some resemblance to the topaz-rock of Werner; and is composed of a fine quartz, more or less granular, with yellowish or white foliated talc. In the middle part of the vein, there are frequent cavities, lined with rock crystal, and crystallized apatite. This assigns a pretty remote age to the last-mentioned substance as well as to the talc, which is conformable with the ideas of Werner. The schorl rock may perhaps be considered as a vein-stone, or rather as forming a saalbande.

Carbonate of lime is of very rare occurrence in Cornwall; I saw a very fine specimen of schiefer-sparth, (slate-spar, or chaux carbonatée sacrée of Haiüy) in the collection of Mr. John Williams, which had been found, I believe, in the tin mine of Polgooth.

Such are the few observations I had to make on the ores and

* Brongniart, Traité Elem. de Minér. tome i. p. 246.
their matrices. Before closing this memoir, I shall venture to offer some conjectures on the causes to which some of the great phenomena in the physical structure of Cornwall may be attributed, and on the epochs of their occurrence, more particularly with respect to the formation of the veins and the cross-courses.

It appears to me, that the force which produced the fissures that now contain the veins must have acted upon the northern and southern slope of the chain: that at the time when the waters fell into the British Channel on the one side, and into the Bristol Channel on the other, the granite ridge, as well as the upper part of the strata of grauwacke, being left exposed and in a state of softness, must, when left to their own weight, have yielded on the sides where they were no longer supported, and that owing to this cause, fissures, or empty places, were formed on each slope, parallel to the length and to the direction of the chain, that is to say, from east to west; and that these spaces, being afterwards filled up with different materials held in solution, formed the veins such as we now see them.

But the body of water still serving as a support to the strata at the base, while they were deprived of it in the upper parts, it necessarily followed that the fissures were confined to the parts of the chain which were first left exposed; and we find, in fact, that the greater number of the mines are situated on a line which is a little below that of the junction of the granite and the grauwacke.

Further, there must have been at an after period some great convulsion, which produced the falling down or hanging of the chain towards the west; the formation of the cross-courses, and consequently the breaking across of the true veins; and lastly, the dislocation of some portion of the chain, the fragments of which carried
of Devonshire and Cornwall.

down into the plain on the eastern side,* were accumulated there, and again consolidated by the waters, thus affording those beds of conglomerate which have been already noticed in the course of this memoir.

* Does not the weight of the substances included in the conglomerate, described p. 98, seem to give some weight to this conjecture?
Dr. Berger on the Physical Structure

Table of the different heights which indicate the line of superposition of the secondary on the primitive rocks in the low mountain chain of Cornwall.

<table>
<thead>
<tr>
<th>Names of Places</th>
<th>Heights in feet above the level of the sea</th>
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<tbody>
<tr>
<td><strong>Devonshire.</strong></td>
<td></td>
</tr>
<tr>
<td>Kithill, near Callington (on the slope)</td>
<td>700 by approx°</td>
</tr>
<tr>
<td>Ivy-bridge Hill (on the slope)</td>
<td>631</td>
</tr>
<tr>
<td>Harford Church, Dartmoor Forest (neighbourhood of)</td>
<td>658</td>
</tr>
<tr>
<td>Dartmoor Forest, three miles and a quarter from Tavistock on the road to Two Bridges</td>
<td>1129</td>
</tr>
<tr>
<td>St. Mary Tavy (neighbourhood of)</td>
<td>648</td>
</tr>
<tr>
<td><strong>Cornwall.</strong></td>
<td></td>
</tr>
<tr>
<td>Bodmin Downs, seven miles and a quarter from Launceston</td>
<td>800</td>
</tr>
<tr>
<td>Step Aside, a hamlet two or three furlongs from St. Stephen's Church</td>
<td>635</td>
</tr>
<tr>
<td>Carn Marth (slope of) one or two miles S.E. of Redruth</td>
<td>543</td>
</tr>
<tr>
<td>Tregoning Hill (slope of) about five miles E.S.E. of Marazion</td>
<td>360</td>
</tr>
<tr>
<td>St. Michael's Mount</td>
<td>It is at a very small elevation, but not having determined it accurately, I prefer omitting it.</td>
</tr>
<tr>
<td>Newlyn, a village about a mile S.S.W. of Penzance.</td>
<td>0</td>
</tr>
<tr>
<td>Mousehole</td>
<td>9</td>
</tr>
<tr>
<td>White Sand Bay, parish of Sennen</td>
<td></td>
</tr>
<tr>
<td>Cape Cornwall (cliff)</td>
<td>93</td>
</tr>
</tbody>
</table>

I ought to mention that I only mark the junctions of the grauwacke with the granite, which I observed myself; if it were desired to have the list complete, a great many other localities ought to be added.
Table of the heights of different places in Devonshire and Cornwall, determined by the barometer.*

<table>
<thead>
<tr>
<th>Names of Places</th>
<th>Heights in feet, above the level of the sea.</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>By the Barometer.</td>
<td>By the trigonometrical measurement of Lt. Col. Mudge.</td>
</tr>
<tr>
<td>Devonshire.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exeter</td>
<td>123</td>
<td>Mean of four observations.</td>
</tr>
<tr>
<td>A hill, one or two miles north of the village of Thorverton</td>
<td>703</td>
<td>Mean of four observations.</td>
</tr>
<tr>
<td>Oakhampton</td>
<td>423</td>
<td></td>
</tr>
<tr>
<td>Ivy-bridge</td>
<td>310</td>
<td></td>
</tr>
<tr>
<td>Summit of a hill to the N.N.E. of Ivy-bridge</td>
<td>1130</td>
<td></td>
</tr>
<tr>
<td>Harford Church in Dartmoor Forest</td>
<td>668</td>
<td></td>
</tr>
<tr>
<td>Source of the river Erme in Dartmoor Forest</td>
<td>1131</td>
<td></td>
</tr>
<tr>
<td>Two Bridges in Dartmoor Forest</td>
<td>1148</td>
<td></td>
</tr>
<tr>
<td>St. Mary Tavy</td>
<td>648</td>
<td></td>
</tr>
<tr>
<td>Brentor Inn</td>
<td>802</td>
<td></td>
</tr>
<tr>
<td>Cornwall.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whitesand Bay Cliff to the S. of Saint Germains</td>
<td>338</td>
<td></td>
</tr>
<tr>
<td>Saltash</td>
<td>173</td>
<td></td>
</tr>
<tr>
<td>Hill on this side Saint Mellion, on the road to Callington</td>
<td>436</td>
<td></td>
</tr>
<tr>
<td>Hill beyond St. Mellion, on the common: the highest point in the road between Saltash and Callington</td>
<td>675</td>
<td></td>
</tr>
<tr>
<td>Callington</td>
<td>428</td>
<td></td>
</tr>
</tbody>
</table>

* I made use of the portable barometer of Sir Henry Englefield, Bart. which seems particularly suited for the geological traveller. The heights have been calculated according to the formula of Sir George Shuckburg, which Sir H. Englefield recommends in the paper where he describes this instrument. Phil. Mag. Feb. 1808.
184 Dr. BERGER on the physical Structure

<table>
<thead>
<tr>
<th>Names of Places</th>
<th>Heights in feet above the level of the sea.</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>By the Barometer.</td>
<td>By the trigonometrical measurement of Lt. Col. Mudge.</td>
</tr>
<tr>
<td>Kithill Top</td>
<td>942</td>
<td>1067</td>
</tr>
<tr>
<td>Launceston</td>
<td>591</td>
<td></td>
</tr>
<tr>
<td>The Jamaica Inn, Bodmin Downs</td>
<td>825</td>
<td></td>
</tr>
<tr>
<td>Bodmin</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>Indian Queen</td>
<td>494</td>
<td></td>
</tr>
<tr>
<td>St. Stephen's Church</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granitic Mountain-plain, near the China pits</td>
<td>830</td>
<td>605</td>
</tr>
<tr>
<td>Menachan</td>
<td>153</td>
<td></td>
</tr>
<tr>
<td>St. Kevern's Church</td>
<td>213</td>
<td></td>
</tr>
<tr>
<td>Mullyon Church Town</td>
<td>280</td>
<td></td>
</tr>
<tr>
<td>Tregoned-hill, Signal-house</td>
<td>548</td>
<td></td>
</tr>
<tr>
<td>St. Michael's Mount</td>
<td>231</td>
<td></td>
</tr>
<tr>
<td>Buryan</td>
<td>467</td>
<td>519</td>
</tr>
<tr>
<td>Sennen</td>
<td>391</td>
<td>387</td>
</tr>
<tr>
<td>Mean Cliff, parish of Sennen</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>Cape Cornwall</td>
<td>229</td>
<td></td>
</tr>
<tr>
<td>St. Just Church Town</td>
<td>404</td>
<td></td>
</tr>
<tr>
<td>Highest point in the road between St. Just and Zennor, near Mean Screens</td>
<td>623</td>
<td></td>
</tr>
<tr>
<td>Redruth, Gray's hotel</td>
<td>414</td>
<td></td>
</tr>
<tr>
<td>Carn Brea</td>
<td>697</td>
<td></td>
</tr>
<tr>
<td>Counting house at Dolcoath</td>
<td>372</td>
<td></td>
</tr>
<tr>
<td>Redruth Church Parsonage</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td>Carn Marth</td>
<td>849</td>
<td></td>
</tr>
<tr>
<td>Scorrier House</td>
<td>377</td>
<td></td>
</tr>
<tr>
<td>St. Agnes' Beacon</td>
<td>664</td>
<td>621</td>
</tr>
</tbody>
</table>

240 Maton's Observ. on the Western Counties, vol. i. p. 195. I do not know whether it was by the plumb-line, or by what other process, that this result was obtained.

<table>
<thead>
<tr>
<th></th>
<th>Mean of nine Observations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redruth, Gray's hotel</td>
<td>Mean of two Observations.</td>
</tr>
<tr>
<td>Carn Brea</td>
<td>360 Klaproth's Min. Observ. p. 27.</td>
</tr>
<tr>
<td>Counting house at Dolcoath</td>
<td>Mean of two Observations.</td>
</tr>
<tr>
<td>Redruth Church Parsonage</td>
<td>In this instance, the simple method,</td>
</tr>
<tr>
<td>Carn Marth</td>
<td>that is to say, the difference alone of the</td>
</tr>
<tr>
<td>Scorrier House</td>
<td>logarithms of numbers which express</td>
</tr>
<tr>
<td>St. Agnes' Beacon</td>
<td>the heights of the barometer at each station</td>
</tr>
<tr>
<td></td>
<td>(six hundred and sixteen feet), is</td>
</tr>
<tr>
<td></td>
<td>more correct, or at least comes nearer to</td>
</tr>
<tr>
<td></td>
<td>the trigonometrical measurement, than</td>
</tr>
<tr>
<td></td>
<td>the method with the corrections.</td>
</tr>
</tbody>
</table>

N. B. The comparative experiment on the sea shore, and on St. Agnes' Beacon, were carefully made, there was a very short interval between each, and the observations were made in a line nearly vertical, between two and three o'clock, in the afternoon.