



## XXXIII. On the serpentinite of Lizard—its original rock-condition, methyloitic phenomena, and structural simulations of organisms

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XXXIII. *On the Serpentinite of the Lizard—its Original Rock-condition, Methylotic Phenomena, and Structural Simulations of Organisms.* By Professors WILLIAM KING, D.Sc. &c., and T. H. ROWNEY, Ph.D. &c.\*

[Plate II.]

*Its Original Rock-condition.*

DE LA BECHE, referring to the “*apparent passage*” of hornblende slate into serpentine rock at Poltreath and other places, remarks that the phenomenon is “somewhat embarrassing, inasmuch as there is reason to conclude, from the grauwacke conglomerate at the Nare Point in the north part of the Lizard district, that hornblende slates were in existence, forming a surface from which large portions were abraded by the action of water, while the serpentine and diallage rocks of the Lizard were not formed; for rounded pieces of the hornblende slate, though rare, are found in the conglomerate, while no trace has yet been discovered of either serpentine or diallage rock, though the latter especially is of great hardness, and therefore quite as likely as the hornblende rock to resist comminution into fine sand, and the two former are nearer to the conglomerate than the latter.” He also observes, “in contradiction to this apparent passage, we find a mass of serpentine amid the hornblende slate between Dranna Point and Port-halla, on the north of the principal mass of serpentine, which has every appearance of having been thrust up among the hornblende slate, twisting and contorting the laminae adjoining it in directions which we should consider consistent with the passage of the serpentine in a state of igneous fusion through them. As a whole, however, the hornblende slate and rock seem to have formed a basin into which the serpentine and diallage rock have been poured in a state of fusion” †.

From observations which one of us made during a few days’ examination of the Lizard in the summer of 1873, kindly aided by Mr. W. V. Symons, manager of the Poltesco Marble Works, we are ready to admit that the serpentine rock of that district occurs both as interstratified and intersecting masses.

On the east side of Poltesco Cove there is a **hard heavy** rock in well-marked thick beds, composed of darkish green and greyish alternating laminae lying strictly parallel with the planes of bedding, and porphyritic through the presence of innumerable disformed crystals of a kind hereafter to be described. The green laminae consist of impure serpentine, apparently highly aluminous; and the grey ones are seemingly an

\* Communicated by the Authors.

† Geological Report on Cornwall, Devon, and West Somersetshire, p. 30 (1839).

intimate mixture of felspathic and quartz matter. The laminæ are regular, even, and widely continuous, so that they have quite the appearance of having resulted from sedimentation. On the other hand, there are places in the neighbourhood, especially on the shore between Poltesco and Kenwick Cove, where a rock, essentially serpentine, encloses separated masses, in beds, of semimetamorphosed sandstones and argillites, the latter possessing the character of imperfect hornblende schists.

These no doubt would be "embarrassing" cases to De la Beche; but now that important discoveries connected with serpentine have of late years been made, they cease to be such any longer. Hence we shall adopt the opinion (fully confirmed by our own researches in ophite) entertained by some of the leading mineralogists and mineralogical chemists (Bischof, Dana, G. Rose, Blum, Haidinger, and others), and disputed by only one authority of eminence\*, that serpentine is in all cases the product of chemical changes or methylosis, effected in a preexisting mineral or rock of another kind, and analogous to pseudomorphism in crystalline solids. Obviously changes of the kind may take place in igneous as well as metamorphic rocks, meaning by the latter term aqueous deposits that have undergone a superinduced crystalline or structural transformation.

As regards the intersecting masses above noticed, it seems almost certain that they were originally igneous injections; and with respect to the bedded masses, such as the one occurring at the mouth of Poltesco Cove, it would seem probable that they have been in their origin argillaceous and arenaceous sediments, which became converted into hornblende schists, gneiss, and other metamorphics.

There are various kinds of igneous rocks in the Lizard: some are hornblendic or dioritic; others, in the form of intersecting dykes and intercalary beds, are pyroxenic or doleritic. We have little to say respecting the former, as time would not admit of their being properly examined on the occasion already notified. We shall therefore offer no decided opinion as to whether any of the Lizard serpentinite is a methylosed form of an igneous hornblendic rock; but it may be remarked that the hypersthene variety of the latter, occurring at Crouza and other places, seems, if itself is not a changed product†, to have been converted into the so-called diallage, common in some of the serpentinites. We have, however, to notice a fact which goes far to prove that much of the latter rock around Poltesco Cove was originally a dolerite.

\* Dr. Sterry Hunt maintains that serpentine is an original chemical precipitate.

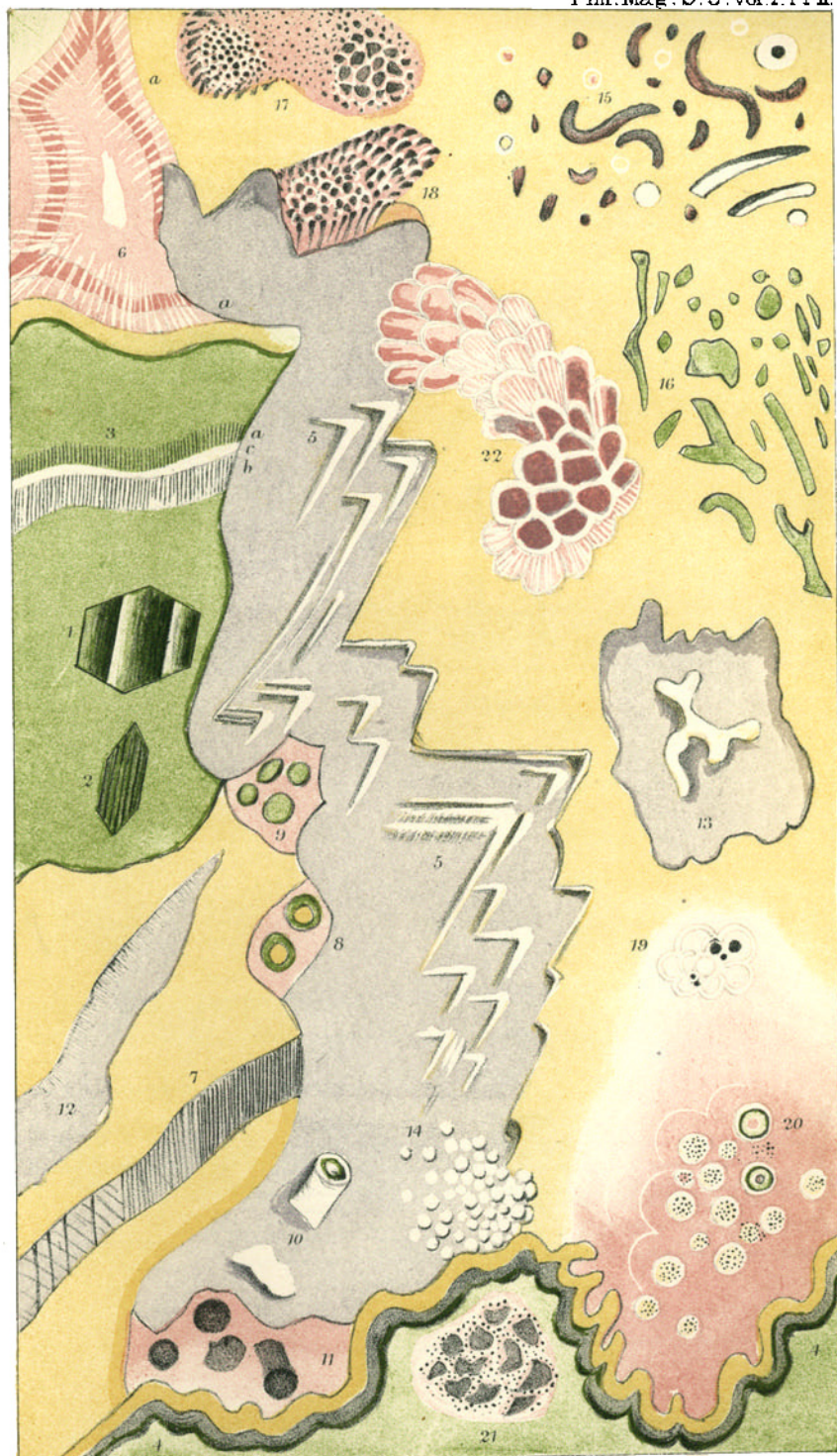
† The Crouza stone has much the appearance of having undergone a change; so that it may have been originally like the hypersthene of Volpersdorf, Moravia.

Dr. Haughton has appropriately called the rocks we are engaged with porphyritic serpentine, on account of the abundance of rude crystalline forms imbedded in its amorphous base. When large and coarsely laminated, these bodies have much the appearance of altered diallage; but in very many cases we have no doubt of their representing another mineral.

Fig. 1, Plate II., gives the outline of one of the rude crystalline forms, which are usually so crushed out of shape as to be rendered undefinable. In this example, however, we have succeeded in determining the usually modified crystal of pyroxene—a short oblique rhombic prism: the observed three faces correspond with those belonging to its front (or back)\*. The crystal does not now consist of pyroxene; on the contrary, its substance has quite the appearance of chlorite, in colour, lustre, and cleavage. Fig. 2 represents a transverse section of another crystal, showing its form and chlorite-like cleavage. In many cases the latter character is rather coarse, which, with a metallic lustre, reminds one of bronzite. At first we imagined the crystals to consist of a lamellar allomorph of serpentine; but, whatever their substance may be, there can be no doubt that they are pseudomorphs after pyroxene.

The Lizard serpentine rock has its counterpart in the north of Italy—the latter being porphyritic, and charged with crushed crystals apparently similar to those just described. In the east and south-east of Europe there are igneous rocks strongly suggestive as to the original character of our home rock, viz. the wackite of Schima, Bohemia, which contains both py-

\* The three faces might be mistaken for *laterals*. What gives rise to this false appearance is, that the two faces forming the bottom, also the top, (if we may be excused using such non-technical terms, applicable, however, to an *oblique* solid) of an ordinary crystal of pyroxene are generally unequally truncated, one (say, belonging to the top) being deeper or lower and consequently larger than the other. In fig. 1 the largest and deepest face forms the left slope of the top, and the corresponding one the right slope of the bottom, which peculiarity, it will be observed, causes the solid to appear inclined in this aspect. The front and back of a crystal of pyroxene are often similarly modified (that is, unequally), so that the *vertical edges* bounding the central face of the front, instead of being opposite to their analogues of the back, are usually opposite to the *faces* of this part. It is this peculiarity which has produced the vertical ridges and furrows commonly seen on the crystalline forms in the Lizard serpentine; for it will be understood that edges when opposite to each other must offer more resistance to pressure than when they are not opposite; hence it is that a face belonging to the front of these forms is *crushed in* against an edge belonging to the corresponding or opposite part, the one making a furrow and the other a ridge. These forms cannot have been originally hornblende, or the observed central face would have been less acutely rhomboidal, and it would have been *lateral*: in the usual crystal of hornblende the *front* and *back* consist each of two faces; as may be gathered from the above, each of these parts in pyroxene consists of three faces.



roxene and hornblende. But we entertain a suspicion that the porphyritic pyroxenic rock (a hard wackite) of Bufaure in the Val di Fassa, Tyrol, which contains crystals of pyroxene of the average size of the Cornish pseudomorphs, is a still nearer counterpart. It must also be borne in mind that at Monzoni, in the same region, porphyritic pyroxenite passes into serpentine rocks, some of which contain crystals in various stages of pseudomorphism, ending in perfect serpentine.

The Lizard serpentine is not characterized with many structural varieties or allomorphs. Chrysotile, which is the only one we are acquainted with, does not occur to any extent. Thin veins of it, variously intersecting the serpentines, are to be seen passing from amorphousness, through the incipient, into the fully developed or normal condition. Fig. 3 represents a vein subdivided into three layers in different states: *a*, layer of incipient chrysotile, whose substance, in being simply marked at distances (as in stylolitic structure) with faint dark parallel lines, is still manifestly serpentine; *b*, layer of normal chrysotile, which is a mass of white glistening parallel fibres, so *infinitely divisible* that it is impossible to determine their form, any more than that of the fibres of asbestos, with the highest magnifying-power\*.

As yet we have failed to detect any varietal examples of chrysotile with a definite acicular structure, such as occurs in many ophites, and more or less separated by films of calcite. In one instance calcite is present in the layer *c*, but dividing it in two halves.

#### *Its Methyloitic Phenomena.*

Not only may it be assumed that the serpentinite of the Lizard was originally a different rock which became methylosed, but we have every reason to believe that its essential mineral constituent, in itself, has undergone further changes of the kind.

Many of our specimens, notably from Kynance Cove, in addition to their various shades of green (from pale to nearly black), show the serpentine gradually changing into brown, pale yellow, and cream-colour. Often the change is manifested by the serpentine becoming sinuously banded like chalcedony in agates, the bands of different colours and various degrees of lustre blending, or abruptly meeting, with the most beautiful effect (fig. 4). This is heightened by the substance of the bands occasionally appearing as if it had been in a gelatinous

\* Although the incipient and normal kinds of chrysotile may be distinguished from each other, as in the text, yet the one is occasionally convertible into the other by mechanical appliances, as rubbing; which reminds us of double-refracting calcite, whose cleavage, to all appearance *nil*, is developed by a blow of the hammer.

condition. Very frequently green serpentine occurs in isolated pieces of various forms (often angular), and of all sizes down to that of a pin's head, separated by a paler-coloured variety: the latter has the appearance in many cases as if it had run into the separations.

In most cases the pale-coloured mineral is saponite, which differs from serpentine simply and essentially in containing a multiple more of water; nevertheless saponite is generally taken by mineralogists to be a chemically changed product. We may therefore safely look upon the Cornish examples under notice, considering their associations and mode of occurrence, as having originated from serpentine through the latter becoming charged with additional water\*.

Assuming the conversion of serpentine into saponite, are we to consider that the change is never carried further than the production of a mineral silicate? that this latter cannot be replaced by some other mineral with a different acid? This would be in opposition to the teaching of the numerous instances known as pseudomorphs, and contrary to the opinion we have expressed on former occasions. The evidences hitherto adduced by ourselves are with difficulty appreciated, on account of their requiring the most careful microscopic observations. We are now, however, enabled to bring forward evidences which require no more than a hand magnifier to be observed with their full meaning.

One most distinctive peculiarity which separates the Lizard serpentinite from a number of other rocks of the kind, occurring in other places, is the absence in it of the variety called ophite: consequently the intimate association of calcite and dolomite with serpentine, as in the latter rock, is exceedingly rare in the Lizard. The few exceptions we are acquainted with were only obtained after considerable delay and difficulty.

In a few of our specimens showing the serpentine passing into saponite, the latter mineral is occasionally affected with a double divisional structure—an imperfectly developed form of cleavage, its two directions intersecting each other obliquely and at an acute angle†. In certain places a mass of saponite is defined on one side by a zigzag edge; next to which there is a mass of calcite containing a number of ridges, in the shape of the figure 7, formed of saponite, separated from the zigzag edge, and having their two limbs strictly parallel to the two directions of the latter (see fig. 5). Besides, the two direc-

\* Serpentine consists of Silica 43, Magnesia 44, Water 13. According to Haughton, Cornish saponite contains Silica 42·28, Magnesia 29·70, Alumina 7·21, Water 18·92. Serpentine, it must be noted, often contains Alumina.

† Serpentine is occasionally affected with a similar cleavage. See Proc. Roy. Irish Acad. vol. x. pl. 43. fig. 8.

tions of the zigzag edge and the two limbs of the ridges strictly correspond with the two cleavages above mentioned. Obviously, then, there is an intimate connexion between these three formations; and no one can observe the ridges without feeling convinced that they were once integral portions of the adjacent mass of saponite, also that the presence of calcite in the intermediate spaces is an interpolated phenomenon. Moreover, on further consideration another conclusion irresistibly forces itself into notice—that the intermediate spaces were once occupied with saponite, which, having been removed, has undergone replacement by the calcite now occupying them. As in the case of an outlying reef of rock that has been separated from the mainland by the gradual removal of an intermediate mass of rock, and the latter replaced by the sand now occupying the denuded space, so it must have been with the outlying ridges of saponite and the calcitic interspaces.

It may be suggested with regard to the latter interspaces, that they are the result of cracks, widened by some cause or other, and subsequently filled up with a deposition of calcite; but this is completely disproved by their being shaped like the ridges. The portion corresponding with, say, the downward limb of the ridges might be produced by a widened crack; but in such a case the origin of the other or transverse portion must be the same. Again, the slightest reflection on the integrity, relative position, and uninterrupted connexion of the two limbs of the ridges must deprive the suggestion of every probability.

Guided by what we have very frequently observed in ophite (clearly leading to the conclusion that serpentine has been gradually replaced by calcite), we have no hesitation in offering, in general terms, the same explanation for the case under notice\*.

\* We would suggest the following as the particular way in which it may have been produced. As the saponite is *intermittently cleaved*, it is consequently liable to be disintegrated or decomposed here and there where the cleavage is present, and to retain its compact condition where there is no such divisional structure developed. Let it be conceived that a mass of saponite was intermittently cleaved, as in the annexed woodcut (which it will be seen is a *fac simile* in outline of fig. 5); the *cleaved* portions will thus be rendered easily affected by dissolving agencies (*e. g.* a carbonated solution), so that while their saponite is removed and replaced by calcite, the same substance will remain untouched in the *uncleaved* portions.

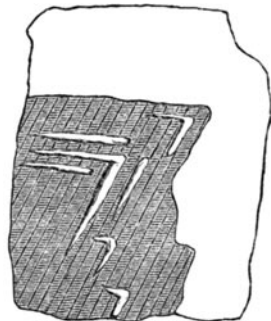


Diagram showing a mass of saponite with cleavage intermittently developed. The non-lineated portions consist of uncleaved saponite.



Similarly demonstrative is another fact to be mentioned. The mineral coloured red in our Plate, which we provisionally consider to be a variety of tremolite\*, consists, in the specimen represented in fig. 6, of a mass of divergent fibres that originated in the outer layer, *a*; the mass is closed in by serpentine, saponite, and calcite, the latter being in immediate contact with its right side. It will be observed that there is an absence of the outer layer on *this side* of the tremolite, and yet the characteristic fibres are present in the adjacent portion of the mass. What have these fibres originated from? Clearly from the same layer as all the others. Then can we do otherwise than amplify our answer by stating that the layer in which they had their origin has disappeared? And are we not equally warranted in unreservedly maintaining that the layer has been simultaneously replaced by the calcite occupying its place?

Serpentine rocks occurring in other places have furnished us with numerous evidences of the same kind resulting from chemical changes, but in other minerals, as serpentine and malacolite. Examples of chrysotile (an allomorph of serpentine) changing into calcite have also occurred to us in ophites from Connemara and Italy†: in the latter instances the change had not destroyed the *fibrous structure* of the replaced mineral. Veins of fibrous dolomite are not uncommon in the Cornish serpentine; but we have not succeeded in procuring any which we can affirm to be pseudomorphic after chrysotile, though a strong suspicion may be entertained that the veins referred to are of this nature. As somewhat countenancing such a suspicion, we have the fact that these veins occur intersecting saponite, and that, while some of them are indefinitely fibrous like chrysotile here, they are decidedly columnar or prismatic there, and without any structure of either kind in another part: in the latter case the mineral is more or less affected with rhombohedral cleavage. Fig. 7 represents a thin vein in these three conditions, as displayed in specimens collected near Kenwick Cove.

But though admitting that the last cases are not directly to the purpose in hand, we must take a different view of some yet to be briefly noticed. Fig. 8 represents two cylindrical rods composed of saponite; fig. 9, other four of serpentine: both

\* This mineral is usually of a reddish colour, white where it is granular. Amorphous green serpentine is occasionally intermixed with it. A qualitative analysis (the only one we have succeeded in obtaining) afforded silica, alumina, magnesia, and lime, which, with a divergent fibrous structure and the absence of water, leads us to suggest the identification given in the text.

† Proceedings of the Royal Irish Academy, vol. x. pl. 42. fig. 6; pl. 44. fig. 9.

cases are imbedded in tremolite. We have represented in fig. 10 two more rods of serpentine, but imbedded in calcite; and in fig. 11, other four composed of calcite (dissolved out by decalcification) and imbedded in tremolite. Evidently in all these cases we have different results from chemical changes; while one of them, just like those represented in figs. 5 and 6, unmistakably makes it known that calcite is one of the products of these changes.

Dr. Sterry Hunt has pronounced that we are transmutationists holding "extravagant views." Nevertheless this is no proof that we are wrong. Without going into the various evidences which have been adduced in our former papers, we would simply submit that the cases adduced in the present communication are a sufficient answer to the vivacious utterances of our esteemed fellow labourer, and that they alone are of more weight in a scientific discussion than all the ingenious elaborations, devoid as they are of any reliable and tangible evidences, which he has brought forward in support of his dogma that serpentine and other mineral silicates (steatite, hornblende, pyroxene), also the calcite associated with them, characterizing the Laurentian ophites of Canada, were "directly deposited as chemical precipitates,"—"formed by a crystallization and molecular rearrangement of silicates generated by chemical processes in waters at the earth's surface," and "not by subsequent metamorphism in deeply buried sediments" \*.

\* Chemical and Geological Essays, p. 300; Geology of Canada, 1866, p. 577; Quart. Journ. Geol. Society, vol. xxi. p. 70, &c. If Gumbel advocates this dogma, he lays himself open to adverse criticism in his letter, quoted by Sterry Hunt (C. G. E. p. 305, footnote):—"I do not maintain a metamorphic origin for the primitive rocks; for, although these are certainly much altered, there are no firm and consolidated rocks which are not so." [Is it to be understood, "altered like those forming the Laurentians"?] "They were formed like, for example, the limestones of more recent periods" [what limestones?]: these were once pastes, magmas, or muds; and so were the primitive rocks at the time of their origin; but during these first ages of the earth the consolidating and crystallizing forces (differing in degree only from those of the present time, and aided by a higher temperature) allowed the magma to assume the form of mineral species, more or less distinct. If we choose to call this change metamorphism, then the rocks thus formed are metamorphic; but so are the limestones of later periods." This is a strangely inconsistent way of reasoning. The "much altered" condition of a large group of rocks (diorites, gneisses, serpentinites, dolomites, &c.) is illustrated by the formation of "limestones of more recent periods." Why is there no reference to any contemporaneous argillaceous and arenaceous rocks containing substances convertible into mineral species with forms "more or less distinct"? Again, excluding such as Carrara marble, Permian and other dolomites (whose metamorphism or methylosis we have always contended for), what other recent limestones have assumed the altered or crystalline condition corresponding to that of "the primitive rocks"? Surely encrinal and other fossiliferous "limestones of more recent

*Its Structural Simulations of Organisms.*

In some other specimens collected at Kynance Cove the saponite encloses calcite on a small scale. It is only by immersing the specimens in a weak solution of hydrochloric acid and examining them with a magnifier that they can be seen to contain here and there patches and strings of this mineral. The vacant spaces resulting from decalcification are often crowded with projecting configurations of saponite, presenting every variety of form, including regular-shaped aciculæ, and no end in shape of arborescences.

The aciculæ, pretty uniform in length and thickness, occasionally form a regular layer investing the wall of saponite bounding a piece of calcite; and they may be in immediate contact, or separated by thin interspaces filled with calcite. In the latter condition they line one side of a fissure in the case represented in fig. 12. In their parallelism, as well as every feature, these aciculæ of saponite, it will be seen, differ in nothing except their substance from those which characterize the acicular modification of chrysotile occurring in certain ophites, and forming the so-called "nummuline layer of *Eozoon canadense*"\*.

The arborescences may be simple, or highly complex—large, or small. Fig. 13 represents a medium example—which, it will be observed, closely agrees with typical examples of another eozoal feature, called "canal system," and common

periods" are not regarded as such! It is not to be disputed that the crystalline condition of the primitive rocks has been produced by a crystallization of their *mineral* components; but any geologist must be aware that fossiliferous limestones are essentially crystalline through the organic remains they contain having become converted into calcite, and the interstitial infiltration of calcareous matter. What any sound geologist will maintain respecting the present condition of undisputed metamorphic rocks is, that it is a superinduced phenomenon, matterless what the temperature may have been that developed it; and he will reject as such the limestones just referred to. Carbonate of lime, it is well known, crystallizes with the greatest facility. Oyster-shells, with the animal still living, are often found with their valves consisting of calcite, or Arragonite. So it happens that, besides the *fossils* in the "limestones" particularized being converted into calcite, the interstices in these rocks contain the same mineral, which, in the form of a calcareous solution, had infiltrated itself into them. But obviously neither the crystallized fossils, nor the calcitic infiltrations, have any analogy with the "pastes, magmas, or muds" from which the Laurentian metamorphics have originated. Sterry Hunt and Gumbel take very little note of what may be assumed as a fact, that the Laurentians have been deeply buried in the earth's crust. Could they in this condition, aided by solutions and a high temperature, remain without undergoing transformation and transmutation?

\* See 'Annals and Magazine of Natural History,' S. 4. vol. xiv. pl. 19. fig. 4; also figures of the same kind in our previous memoirs.

not only in ophite, but in chondroitic, malacolithic, and other rocks in different regions of the globe (United States, Norway, and Ceylon).

Occasionally the saponite assumes an oolitic structure, presenting spherical grains which closely resemble the ova of a fish. Fig. 14 represents a cluster of them, nestling as it were in a recess, as if they had been purposely or instinctively placed there, and had afterwards got covered up with a calcareous deposit. Many of the grains are in contact; others are isolatedly imbedded in the transparent calcite remaining undissolved after partial decalcification.

The saponite *in the mass* also presents appearances as if it contained organisms, entire and in fragments, distinguished by their comparative opacity in some cases and translucency in others, as in fig. 15. These are vermicular bodies—straight, curving, or tortuous—resembling wormcasts and shell-bearing annelids: one of the latter, represented by the circular body in the corner of the Plate, appears like a transverse section of a shell tube, having its interior filled with infiltrated matter. Examined by themselves these bodies are extremely puzzling as to their origin, and it must be admitted that they have much the appearance of the kind of organisms they resemble; but examined in connexion with the various forms assumed by serpentine or its varieties, their purely mineral origin becomes obvious. The group of pieces of serpentine shown in fig. 16 includes a great diversity of forms, such as it is conceivable would give rise to simulations of the kind; while the sinuous bands, some translucent and others opaque (fig. 4), would yield an abundant family of tortuous annelid-like bodies.

But if the foregoing configurations bear a striking resemblance to organic structures and organisms, what may we not say of those next to be described?

Imbedded in the saponite there are occasionally irregularly shaped aggregations of two kinds of bodies, which for the present may be conveniently termed ovoids and spheres. The ovoids, besides forming good-sized complex aggregations, occur often sparsely aggregated, and even sometimes isolated. They consist, partly or wholly, of slender attenuated diverging rods with a more or less definite form, being in many instances marked out by white opaque bounding planes which enclose a dark amorphous translucent interior. A transverse section of the ovoids, by cutting the rods across, presents a singularly reticulated appearance under a magnifying power of 37 diameters. When the rods are large the reticulations are decidedly angular; small rods give rise to a circular reticulation (fig. 17). The ovoids consequently appear as if their compo-

ment rods were white-walled tubules that have become filled with a translucent material. This is particularly the case in those ovoids composed of slender rods: indeed it often requires more than the eye to determine that the rods are solid; for in many instances they appear like actual tubules in an empty condition!

In short, looking at the ovoids, whether a transverse or longitudinal section (fig. 18) be under examination, they might be readily taken for fossil corals of the genus *Stenopora*; and some resemble certain Carboniferous and Permian species so closely that a consideration of structural characters alone does not enable one to differentiate them from the organisms they simulate.

The spheres have also a strikingly organic appearance. Some specimens resemble, when a few are clustered together, certain foraminifers—notably *Rotalia* and *Globigerina* (fig. 19\*); while others in an isolated state have the resemblance of *Orbulinas*. Nay, have we not an appearance of actualities of the latter represented in fig. 20? As shown in this figure, two examples appear to be perfect casts in serpentine†; and all the others have what appears to be their shell-case not only beautifully preserved, but riddled with pseudopodial pores!

Besides the ovoids and spheres, the saponite contains patches consisting of what may be taken for closed-cell structure; and in a few cases, as in fig. 21, we have detected another structural form, resembling, in being canaliculated, sponge-tissue, with its walls appearing as if distinctly perforated.

It may be that the explanation we have to offer to account for the origin of the coral-like bodies is not strictly correct; and it is possible that we are as far from the mark regarding the foraminifer-like spheres: we also confess our inability to offer any solution of the sponge-like structure free from grave objections. Unlike the simulations in saponite, those last described do not appear to have resulted from chemical changes, but rather, to some extent, from structural modifications of the mineral we have provisionally assumed to be tremolite. Observe in fig. 22 a specimen of this mineral in its fully developed condition, consisting of prismatic and fibrous fasciculi, roughly speaking, ovoidal in shape. In some fasciculi their internal structure is well marked; while in others it is scarcely to be

\* The specimen figured appears as if it were a section of a *Globigerina* with its chambers containing two or three embryos (black spots)!

† The centre of these two spheres is in the condition of saponite. The other spheres are greenish white in colour; evidently due to the serpentine passing into the flocculent condition. All the spheres are imbedded in the tremolite.

observed, so that their interior is amorphous and translucent. Again, where the prismatic structure is well defined, the prisms, especially if they are large, have their interior in the same condition\*. These differences are clearly assignable to different degrees of fibrous and prismatic development.

Why some fasciculi are unlimitedly divided by which they are made eminently fibrous—why some are formed of well-defined prisms, and others, instead of being fibrous or prismatic, are entirely amorphous—we shall make no attempt to explain; but it may be remarked, with some confidence, that the ovoids resembling *Stenopora* are each a fasciculus of prisms with their interior in the amorphous condition. The remarkable appearance of empty tubules in the ovoids that are finely prismatic we assume to be caused by the interior of the prisms being imperfectly illuminated: opaque walls would necessarily intercept the light in its passage into the interior of such small prisms.

With respect to the spheres, we would suggest that they are each the nucleus, in amorphous serpentine, of a mass of radiating prismatic tremolite; that the prisms radiated from and originated on the surface of the nuclei, and were characterized by opaque walls and a translucent interior; that on the surface of a nucleus, at their point of attachment, the internal translucency of the prisms produced the perforated appearances, and their opaque walls the partitions which define the apparent perforations.

We cannot conclude without remarking that, organic-like as the foregoing cases in tremolite appear to be in our specimens, they are even more so than the figures we have given convey an idea of; indeed, although our best has been done to give a faithful representation of them, our efforts have fallen far short of depicting with sufficient exactness their wonderful resemblance to the organisms which they simulate.

## EXPLANATION OF PLATE II.

\*\*\* It will be understood that the figures represent things exhibited in a number of specimens. Although this is the case, they are always represented in their own matrix; whether it be serpentine, saponite, calcite, or tremolite. The calcite having been slightly dissolved out, has its surface below that of the other minerals. The four colours—green, fawn, pale blue, and reddish—respectively represent serpentine, saponite, calcite, and tremolite. Where any of these minerals are in the *granular* or *flocculent* condition, as often is the case, they are *white*; and consequently such cases are represented in this colour.

Fig. 1. A pseudomorph, imbedded in serpentine, after a crystal of py-

\* Hexagonal prisms of calcite occasionally have a translucent interior and an opaque exterior, but not due, as in tremolite, to structural variations.

- roxene, partly restored. It has the colour, lustre, and cleavage of ordinary chlorite. Slightly magnified.
- Fig. 2. Transverse section of a similar crystal, showing its lamellar or cleavage structure. Slightly magnified.
- Fig. 3. Vein of chrysotile composed of three layers: *a*, chrysotile in the incipient stage, *i. e.* green serpentine slightly fibrous; *b*, in the fully developed or asbestiform condition; *c*, a layer altered to such an extent that its structure is nearly destroyed; it is divided in the middle by a film of calcite. Magnified 37 diameters.
- Fig. 4. Bands of serpentine differently coloured. Slightly magnified.
- Fig. 5. Configurations shaped like the figure 7, consisting of saponite in a granular condition, and consequently of a white colour. They are ridges imbedded in calcite, but rising above the surface of the matrix in consequence of its being partially dissolved.
- Fig. 6. A mass of mineral provisionally identified with tremolite, having one side (right) removed, as shown by the band *a* (everywhere else seen) being absent. This case may be regarded as proving that the calcite occupying the place of the absent band has replaced the tremolite which composed it. The white diverging lines are much finer, and more numerous than are represented in the figure. Magnified 37 diameters.
- Fig. 7. A vein of dolomite in three structural conditions—indefinitely fibrous, prismatic, and with rhombohedral cleavage. Slightly magnified.
- Fig. 8. Piece of tremolite enclosing two cylindrical rods (seen on their transverse section); their interior is composed of saponite, and their exterior of serpentine. Through an oversight, the exterior has not been coloured green in the figure. Magnified 37 diameters.
- Fig. 9. Piece of tremolite enclosing four cylindrical rods composed of serpentine. Magnified 37 diameters.
- Fig. 10. One cylindrical rod composed of both white-granular and green serpentine, and another apparently with all its serpentine in the white-granular condition. Both are fixed in calcite. The serpentine in the centre of the upper figure is in a granular or flocculent state, and ought to have been coloured white. Magnified 37 diameters.
- Fig. 11. Piece of tremolite enclosing four cylindrical rods composed of calcite: they are now represented by empty spaces, in consequence of their component mineral being dissolved out. Magnified 37 diameters.
- Fig. 12. Fissure-like opening in saponite containing calcite: the saponite on one side of the opening is in the acicular condition. The aciculæ, some separated and others in contact, projected into the calcite before it was dissolved out. Magnified 37 diameters.
- Fig. 13. Cavity in saponite containing calcite, in which is imbedded a dendroidal configuration composed of white granular saponite. The configuration, which is attached by its right extremity, rises above the surface of the calcite through the partial removal of the latter mineral by decalcification. Magnified 37 diameters.
- Fig. 14. Cluster of spherical bodies (resembling ova) composed of white granular saponite, and imbedded in calcite: some are above the surface of this mineral; others, faintly seen and isolated, are imbedded in it. Magnified 37 diameters.
- Fig. 15. Vermiform and other bodies imbedded in saponite; some are translucent, others white opaque, and a few are in both conditions. Slightly magnified.
- Fig. 16. Vermiform and other bodies composed of serpentine and imbedded in saponite. Slightly magnified.
- Fig. 17. Transverse section of a mass of *Stenopora*-like tubulation formed

- of tremolite, and imbedded in saponite: the smallest tube-like forms appear as if they were empty. Magnified 37 diameters.
- Fig. 18. Longitudinal section of the same (at the part lying immediately in contact with calcite). Magnified 37 diameters.
- Fig. 19. A body composed of tremolite simulating a *Globigerina*. Magnified 37 diameters.
- Fig. 20. Spherical bodies composed of flocculent (white) and amorphous (pale green) serpentine, with a perforated exterior resembling the shell of *Orbulina*. Two have a core of saponite (fawn-colour). These bodies are contained in a mass of tremolite imbedded in saponite. Magnified 37 diameters.
- Fig. 21. A mass of tremolite imbedded in serpentine, and consisting of a sponge-like tissue with its walls perforated. The large dark portions represent what appear to be the mouths of canals. Magnified 37 diameters.
- Fig. 22. A crystallized specimen of tremolite composed of fasciculi: its free end was imbedded in calcite, now removed by decalcification. The upper fasciculi are either fibrous or prismatic. Many of the prisms have white opaque bounding planes and a translucent interior. The lower fasciculi are altogether translucent, with the exception of their boundary surfaces, which latter form a network with large meshes. Slightly magnified.

XXXIV. *On the Magnetism of Steel Bars.* By Dr. CARL FROMME, *Instructor in Physics at the University of Göttingen.*

[Concluded from p. 204.]

§ 9. **O**N the occasion of these experiments I noticed some relations which were quite new to me; and they appeared so extremely interesting that I resolved to pursue them further. It was only after I had finished a great part of these investigations (which shall now be communicated in what follows), that I observed, on perusing the literature, that the same subject had already, some years since, attracted the attention of Frankenheim. His results were published in Poggen-dorff's *Annalen*, vol. cxxiii. p. 49 *et seq.*

Frankenheim proves that the *duration* of the action of a magnetizing force has no influence at all upon the amount of the residual magnetism, while the *number* of operations of the same force has a very great influence. If it has been put in operation only once, we have not thereby attained the residual moment which the same force generally (*i. e.* by repeated action) is capable of generating. The residual magnetism is increased much more by each successive operation, approximating to a boundary value, above which the same force cannot raise it.

From this I deduce the significant conclusion, confirmed by experiment, that when by repeated action of the force P the residual magnetism has reached its boundary value (the satu-