I.—*On the Mineralogical Composition and the Microscopical Structure of the Belgian Whetstones.*

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Among the rocks used as fine whetstones, there are none, I think, more justly celebrated in Europe than those found in the neighbourhood of Viel-Salm, in the province of Liege, Belgium. They are in shape parallelopipeds, composed of a stratum more or less deeply coloured yellow, and of a stratum coloured blue-violet; and are exported to every country in Europe and the Orient.

Although I intend to direct attention chiefly to their constitution as found from their study under the microscope, and to the light which this method of study throws upon the origin of those rocks and upon their physico-chemical constitution, yet I shall briefly notice some of the interesting geological considerations relative to their bearing and to their relations with the adjacent strata.

The hones of the neighbourhood of Viel-Salm are found among the rocks which Dumont called Salmien, but which seem to resemble very much the English Cambrian, and to be the equivalent of the schist of Tremadoc.

They form veins in the Cambrian slate of from one to two centimeters thick, but whose direction is so irregular, and whose composing strata are so winding and tortuous, that many geologists have mistaken them, and they have been not seldom described as real veins; whilst I have shown, supported, moreover, by Baur and Dumont, that they are regularly intercalated in the stratification, and form real strata in the slate, with which it is intimately united.

The facts upon which I base my deductions and the macroscopical descriptions, are given at length in a memoir which I devoted to this question.

Before touching upon the microscopical study, let me say a word or two on the relations between the whetstone and slate, as by that means I may be more readily understood in the description of the whetstone as it appears under the microscope.

When one sees a hone having one layer of a yellowish white material, and another of bluish slate distinctly separated by a straight line, sometimes of perfect regularity, there is a tendency to suppose that they are two fragments of different rocks fastened together one above the other, the juxtaposition being due rather to art than to nature; but when these stones are seen in the place which they occupy in the strata, one readily observes that the vein of whetstone is intimately united to the slate, and that the workman has nothing else to do than to square the fragments. In certain exceptional cases, however, art is made to imitate nature; and the workman sometimes, by fastening together fragments of different colours, gives to the market a hone that differs not in appearance from those formed by nature.

Although this line of demarcation is usually found very distinct between the two layers and marking the direction of stratification, it also happens frequently that the whetstone passes imperceptibly into the slate, in such a way that at a certain point it is no longer possible to distinguish whether slate or whetstone is in question. It might be said there was a sort of mutual penetration of the two layers.

There is one character, common to the veins and the incasing layers, to which special attention should be given. It is this: the foliation, oblique to the stratification, is prolonged from the slate into the whetstone. Sometimes this foliation is but faintly characterized in the compact varieties, but it is always present in a latent state, and if the slate be broken, the lamina comes off, passing across the whetstone, and the fissure is prolonged with a regularity and constancy of angle which shows evidently that the two rocks have a common cleavage. I have proved that there is also present in these two rocks a second cleavage, not so easy, but, like the first, clearly distinct from the stratification. The existence of this cleavage shows, first, that the layers of whetstone existed before the uplifting of the strata; and the coexistence of the two cleavages obliges us to admit that the rocks of this group have been subjected on two different occasions to a pressure, brought to bear in two different directions, as contended in similar cases by Mr. Sorby. The easier cleavage must have been produced while the rocks were still in the plastic state, the second when they were already more solidified. I have dwelt upon the characters common to the two rocks, because they are in close relationship with the details of microscopical analysis which follow. To sum up, the whetstones are contemporary layers with the incasing slates, and have been subjected to the same mechanical actions as all of the phylladic rocks of this group.

After this exposition, belonging rather to geology, let us inquire what are the minerals that constitute the whetstone of the neighbourhood of Salm. It should be remarked that this question cannot be answered by macroscopical examination alone, since the compactness of the rock and the fineness of its grain is such that, even with the aid of the magnifying glass, it is impossible to individualize the mineral species which make up the whetstone. It appears in general as a homogeneous substance of clear colour, and the geologists who have occupied themselves with this rock have limited themselves to giving the description of some of its physical properties and the details relative to its bearing, touching only incidentally on its composition. This, however, is not surprising when it is remembered that these skilful observers had not at their disposal microscopical analysis, which I have been able to use.

Still, on examining with attention the laminæ or the fractures, peculiarities may be seen at their surface which give a glimpse of the elements that microscopical analysis makes known. With the naked eye phylladic plates, closely aggregated, may be perceived. This phyllite has not the silvery or pearly aspect of sericite; neither has its pyrognostic characters. It is these lamellæ which make up the fundamental mass of the rock. By the reflexion of a strong light there may be seen on these phylladic membranes a glistening due to crystalline granules of infinitesimal dimensions. These shining grains would naturally be attributed to quartz, were it not that study at the microscope discovers in them optical properties and crystalline forms which put aside this supposition. The microscopical dimensions of the elements mingled with the phyllite never determine the structure which we have called by the name of *gneissic* in our study of the rocks of the French Ardennes; at least, it does not appear to the naked eye nor under the magnifying glass. Among the accidental elements visible to the naked eye should be counted iron glance, hydroxid of manganese, which often impregnates whetstone, quartz, and pyrophyllite.

Let us pass now to the study of the ultimate constitution of the whetstone, as shown by microscopical analysis. In order to come at the results given in this paper, I have cut and polished more than seventy thin sections of this rock. To have a general idea of the ultimate structure of the whetstone, we should study it first with the help of weak magnifying powers. There is then perceived a colourless micaceous substance which seems to make up in great measure the fundamental mass. These phylladic fibres, generally elongated and colourless, appear peppered with a black dotting, owing to a numberless quantity of granules which have the appearance of opaque points. There are seen also innumerable microliths, some like simple dashes, and others of larger dimensions, but much more rare, showing a light bluish tint. Finally, with the help of a polarizing apparatus, it may be seen that one part of the mass belongs to an isotropic substance.

Commonly the phyllite is completely covered by the prodigious number of particles, more or less circular, scattered along the surface of the filaments. The elongated microliths are in line, and grouped with their greater axis parallel to the direction of the micaceous laminæ. Clearer regions are also remarked in this mass, almost without interpositions, the arrangement of which contrasts with the general disposition of the elements. These veins, having a thickness of less than a millimeter, advance irregularly across the rock. They are made up chiefly of micaceous substance, and do not seem to be fissures filled up later on, but rather to have been formed at the same time that the rock took its distinctive petrographic character. They are found to contain, though in small proportions, all the elements which we discover as constituent parts of the whetstone. A fissure, filled later on, would not be filled with all the substances identical with those which form the rock. This kind of microscopical *primary veins* does not cross the whole of the thin section. They often form lenticular regions in it, of the same structure and composition as the little veins of which we have just spoken.

None of the microscopical characters by themselves allow of a certain identification of the lamellæ with a determined phyllite. I give up, however, the opinion of Dumont, who considered, without sufficient proof, pyrophyllite to be the constituent principle of the *phyllas* of the Ardennes; and I would bring these phyllitous fibres into connection with Damourite, a mineral which the chemical analyses of Messrs. Davreux and de Koninck, jun., have shown to exist in a garnet-bearing rock of Salm, that presents, as will be seen, many analogies with the whetstone. Still it is very difficult to decide this point with certainty, since it is impossible to isolate the lamellæ for a separate analysis, and they are dotted with foreign minerals. On the other hand, the optical reactions are unsatisfactory; for, as is known, one of the problems the most difficult of solution in the microscopical analysis of rocks is the specific determination of the different micas, especially when they are found without distinguishable crystalline forms, and with extremely small filaments, as is here the case.

Let us now pass to a more minute study of the different elements contained in that rock. For this we must use a magnifying power of from 400 to 600 diameters. With such aid we may perceive the innumerable granules, scattered over the surface of the laminæ, become clearly and distinctly individualized, and the rock, at certain points, appears to be composed of globular forms whose agglomeration almost completely veils the micaceous element. The mean dimensions of these circular forms rarely exceed 0·02 mm.; and, according to an approximative calculation, some parts are so beset with them, that a millimeter cube of rock contains over 100,000. These globules, for the most part rounded, sometimes also elongated, are, in some cases, terminated by crystallographic forms. They may be perceived to be bounded by regular lines, and one may discover their lozenge-shaped faces, which are to be referred to the rhombo = dodecahedron. The dimensions of these crystals are ordinarily so minute that they are not attacked in the polishing process, and thus they are preserved to us in the integrity of their form. They are therefore, in general, complete on all sides. It is difficult to judge of their optical properties, as they are set in a double refractive substance; but by observing those of larger size that protrude on both sides of the micaceous laminæ, or those isolated at the extremities of the thin sections where the thickness is least, they may be seen to be dark between the Nicols' crossed prisms.

Their perfect isotropism and their crystalline form place them amongst the minerals of the first crystallographic system. Seen by transmitted light they appear completely devoid of colour, bordered by zones of deep black, which diminish in intensity toward the centre of the crystal, where the colourless part sparkles with exceeding brilliancy. I have found these crystals in great numbers in all the various kinds of whetstones of the Salm formation. At one time they are gathered together at one point, at another they form lines or chaplets, and again they are isolated.

With this ensemble of characteristics one may ask to what mineral species we are to refer these globular-formed crystals. However strange the conclusion may appear, I refer them to the garnet. In support of this I may show that the interpretation making it a garnetiferous rock is in no way opposed to any of the details of the micrographic description I have given, that it explains naturally all the facts that I have mentioned as well as the physical properties of the whetstone of Salm.

The rhombo = dodecahedral forms, or globular crystals, which, however, now and then present a rhombic face, point out a mineral of the first system. The single refraction on which I before insisted now comes to support my interpretation. The high index of refraction of the garnet ($\mu = 1{\cdot}772$) shows itself by the unusual brilliancy displayed by the crystals when observed by transparency.*

The high specific gravity of the rock (= 3·223) is also explained by the density of the garnet, which forms a great part of it. The specific gravity of garnet, as is known, reaches to 3·4 and even 4·3. Hitherto it has been frequently asked what the substance could be that enabled these whetstones to wear even steel, and it was the supposition up to the present time that the element

* To explain this fact, it is to be remembered that luminous rays penetrating a refracting body by a point, and forming at the point of incidence a hemispheric pencil, form in refraction a cone whose angle at summit is given by the equation $\sin.\ r = \frac{1}{n}$. This angle diminishes in proportion as n increases.

was no other than quartz finely divided and dispersed through the stone. My researches prove, however, that they contain scarcely any quartz. Hence it is to the garnets that we are to attribute this hardness of the rock, for we know that the specific hardness of garnets is comprised between 6·5 and 7·5 of the scale of Mohs. The discovery of garnets in the slates of Recht by my friend Dr. Zirkel, Professor at the University of Leipsic, is another support of this interpretation, as the slates of Recht belong to the same formation as the rocks of Salm, of which they are the continuation in Germany.

The largest garnets of our preparations show inclusions which are found so often in this mineral when studied under the microscope; we observe also in the largest those irregular fissures which are so characteristic of garnet.

But how is the yellow colour of the whetstone explained if we admit that this rock is, as we have said, almost exclusively composed of garnet? In our endeavours to explain this colouring, we have succeeded in determining the sort of garnet to which this mineral belongs. We place it in the variety called Spessartine, and we shall soon see that another kind of proof confirms us in this classification.

In considering spessartine as the principal element of the whetstone, we see that the union of a very great number of infinitely small crystals of this mineral should produce, when regarded "*ensemble*," a yellowish-white tint; for the purest spessartine is in little transparent crystals of a pale yellow, in the island of Elba, at St. Marcel, in the diamond sands of Brazil, and in Maine in the United States. We thus easily understand, in admitting that spessartine is present here, how an agglomeration of small garnets of this variety can produce the yellow tint of the whetstone. But what indicates still more certainly the manganese garnet is chemical analysis. M. von-der-Mark has found as much as 21·71 per cent. of MnO, and M. Pufal has found 17·54 per cent. in a specimen he has had the kindness to analyze for us. This large quantity of manganese should not cause surprise, since it is known that the spessartine of Haddam, in Connecticut, analyzed by Rammelsberg, gave 33 per cent. of MnO. Let us also bear in mind that the presence of manganese manifests itself in a remarkable manner when tested by a bead of borax. Let us also remark that all the surrounding rocks are as it were impregnated with manganese; it is found in the form of veins, or combined in the remarkable metamorphic minerals (ottrelite, dewalquite, &c.) of that region.

And it is near veins of whetstone that MM. de Koninck and Davreux discovered the beautiful little garnet crystals of which they have given the description,* and whose composition approaches

* 'Bulletins de l'Académie Royale de Belgique,' 1873.

more nearly that of the typical variety of spessartine than that of any specimen of which an analysis has been published up to the present. I may add, that some specimens of whetstone have lost their colour through an impregnation of hydroxid of manganese. These became completely black, but in thin sections there immediately appeared all the essential elements of the rock, coloured, however, a faint brown by the foreign matter.

A third element of the whetstone of Salm is schorl. This mineral is far less widely spread than the two which I have just made known. The principal microscopic characters which this mineral offers in the rock are the following: the form of the sections is that of a parallelogram whose great axis may have on an average from 0·07 mm. to 0·08 mm. In width it reaches 0·01 mm. Ordinarily the sections of the mineral are terminated at one extremity by planes intersecting each other at an angle more or less open; the opposite side being terminated by an almost straight line. They are traversed by crevices which are sensibly parallel to the base, and often appear notched. Their tint is not homogeneous; it is pale green, blue, greyish, sometimes growing stronger at one extremity of the section. This mineral is birefringent, and is strongly dicroscopic. Thesections are often filled with black and opaque little spots. It is known, moreover, that M. Angor has discovered this mineral in a great number of slates and schists. We find again in our thin section a most perfect resemblance between the mineral he considers to be schorl and those which we have been led to consider as the same. The forms of that mineral, we have said, show a difference of development for the two extremities: this difference is the very same as that which affects schorl; which presents us so frequently with the most classic examples of enantiomorphism. We have said that certain sections show two different tints at the two extremities this difference of tint is a well-known fact in the case of this mineral. Indeed, we know that the transparency of the tourmaline varies in the same crystal with the direction relative to the axis of the rhombohedron. It is more sensible in a perpendicular, and feebler in a parallel section, a fact which must be referred to its dicroscopism. But besides this phenomenon it is not uncommon to find that the same crystal presents different colours at the two extremities, or at least a tint of unequal intensity. According to M. von Lasaulx, the same thing is noticeable in the microscopic tourmalines enclosed in the garnets of the granulites of Saxony. We have just said that these crystals of schorl sometimes appeared as if broken; that they had undergone certain deformations. We remark, indeed, that these small sections of schorl appear broken, and that their various fragments lie at a short distance. M. Rosenbusch observes that those which are seen by the microscope are ordinarily curved, a fact we have remarked ourselves. As we have said, it is not rare to find the sections of schorl furrowed by fissures more or less parallel to the base. It was believed by some microscopists that this fissure represented a cleavage. Now, the best mineralogical works make no mention of a cleavage in this direction. Dana, Naumanm, and Des Cloizeaux mention cleavages only following R, ∞ P 2; besides this, these cleavages are not easy. We are therefore inclined to admit that these ruptures are the effect of mechanical action, as, for example, the stretching of the beds at the moment of foliation. The rupture in these little prisms must necessarily be made parallel to the base, where the points of more feeble resistance are found. I add that M. Zirkel and myself have been able to prove that these prisms belong to the hexagonal system. In a research that I made with him, we have found that in a thin section of a schist of the Ardennes a hexagonal section of this dicroscopic mineral was dark between the crossed Nicols' prisms. This fact wholly confirms our interpretation as to the crystalline system of these little prisms.

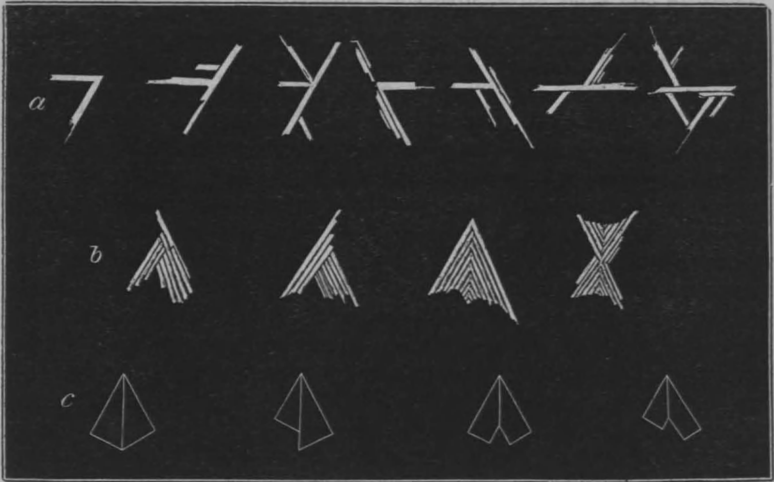
In the few pages devoted by M. Zirkel to a microscopic description of the slates of Recht, he pointed out the presence of a prismatic mineral of a greenish yellow colour. High powers of the microscope are needed to observe this mineral, the prisms not being more than 0·03 mm. in length and 0·005 mm. in thickness, so that it is difficult to determine all the faces of the crystals, which, though complete, have not very well defined edges. Irregular aggregations are often found composed, sometimes of one or two individuals, sometimes of twins in the form of a knee. As none of the characteristics of these small crystals are opposed to those of augite,* M. Zirkel believed that he could class it with that mineral. Such are, in brief, the micrographic details he gives upon these microliths.

We find them again in great abundance in the whetstone, and there under a great variety of very interesting crystalline forms, which have not as yet been pointed out by any micrographer. These prisms, which are identical with those remarked by M. Zirkel, are scattered through the whetstone sporadically, and are distinguished from the prisms of schorl by their form, by the way they are grouped, by their tint, and also by their exiguity. At different times these prisms are ranged in lines, verge towards each other, and interlace, maintaining the while almost constant angles in their superposition. In some sections it is remarked that the prisms follow the undulations of the micaceous substance. We shall add nothing to the excellent description which M. Zirkel has

* On this subject M. Zirkel remarks that our friend C. A. Lossen, of Berlin, has found in inferior Devonian, near Winterburg, some crystalline schists in which the macroscopic augite appears as an essential element.

given of the simple crystals of this kind. We find, however, in our sections, remarkable examples of grouping and of twins, of which we shall speak more in detail.

When there is a certain quantity of these microliths gathered together, one is sure to remark, for some among them, a certain manner of adhesion or of superposition, which is too regular and constant in its repetition not to be subject to some crystallographic law (Fig. *a*).



Among these little crystals those of simpler form show the geniculated twins with an angle of about 60°, and in general it is with this angle that the crossings or superpositions of the minute prisms take place. Oftentimes it is a granule of spessartine that serves as a point of attachment. The prisms do not preserve the same thickness through their entire length. In the upper part, for example, they appear a simple line, and toward the middle they suddenly bulge or swell out. Finally, in many cases they give rise, by their ramified disposition, to forms that may be considered as the skeletons of crystals that I have discovered in the whetstone of Sart, and of which I am now about to speak.

In the thin sections of this whetstone there are to be observed triangular compound crystals, yellow, less transparent, and whose dimensions reach even to 0·05 mm. (Fig. *b*). These groups may be reduced to a single fundamental type, namely, a heart-shaped twin having an angle of 60° at the summit. These crystals are formed of minute prisms that adhere to one another very perfectly, of which I have spoken above. These sections are covered with parallel striæ on both sides of the triangles, producing very distinctly those striæ which crystallographers generally call *oscillatory.*

It is not the microliths of Sart, however, that show the most remarkable crystalline forms. Some specimens of the whetstone of Ottrez exhibit, with a microscope of 600 or 700 diameters magnifying power, a multitude of minute triangular crystals of the utmost delicacy and perfection (Fig. *c*). It has been shown that these little geometric solids are to be classed, on account of their angular measure and their form, with the geometrically disposed microliths of Sart and with the geniculated twins. But, on the other hand, inasmuch as the fundamental character seems to point them out as belonging to those regular aggregations, even in so much do they differ from them by their perfect transparency. They are not formed by the gathering together of a number of minute prisms, as is the case in the specimens from Sart, and are perfectly colourless. They are exceedingly small, the base often not measuring more than the thousandth of a millimeter. That some idea may be had of their delicacy, it may suffice to state that it is not rare to find two or three of them superposed. If the observer turn the micrometric screw he can readily convince himself that they occupy different planes even in the extremely minute thickness of the thin sections. Thanks to the delicacy and the perfection of their forms, one may attempt, with some chance of success, to determine the crystalline type in which the mineral is to be classed. The minuteness, however, of its dimensions, and the impossibility of isolating it, impose the necessity of pronouncing with great reserve on the mineralogical nature of these remarkable microscopic twins to which I now for the first time call attention.

By the inspection of the outline and of the extremely delicate line that joins the summit with the obtuse angle opposed the observer may readily recognize hemitropical forms; and the two halves polarizing with complementary colours prove in their turn that these two parts have their optical axes placed as they should be in the case of a hemitropy similar to that which we find in the greater number of these twins.

This mineral constitutes, in the great majority of cases, twins by juxtaposition; however, some are found which are twins by penetration; those, for example, which cling together by their summits, recalling what one sees in certain twins of tridymite, mentioned by Vom Rath. The angles of these rhomboids, to judge them by approximate valuations, such as can be made by the microscope, are of 60°, 90°, and 120°. In other terms, these are the angles given by the hemitropies of the crystals of the rhombic system which have an edge of about 120°, and for which the hemitropy is made following the rule = Plane of hemitropy = a face of the prism of about 120°, that is to say, a dome, $3 \bar{P} \infty$ for example, the principal axis of two individuals forming together an angle of about the 60°.

This interpretation explains the heart, or geniculated, twins which are presented to us in the little prisms contained in almost every thin section of the whetstone, and of the regular groupings of the rocks of Sart.

In spite of all the details resulting from a minute study of these remarkable crystals, we must, however, confess that they are not sufficient to determine to what species of mineral they belong. We are here before one of the most difficult problems of petrography, that of identifying with a macroscopic species, crystals of such small dimensions as those which we have discovered, and which besides show characteristics which seem to bring them near to known minerals. Yet there is nothing to prove that these microliths are not a new species. The abundance of material that we have at hand, and the extraordinary development of these forms in certain specimens that we have endeavoured to analyze with a scrupulous care, authorize us to think that they ought not to be referred to augite; in truth, epidote offers points of resemblance for the colour and the twin; for we know that Kokscharow has found hemitropies of epidote resembling these we have here; but the other characteristics of epidote are too different to permit us to ascribe to it these little twinned prisms.

In order to dissipate the doubts raised on this point, I have examined the analogous forms given us by the mineralogists for the minerals of the class of silicates, and I have been struck with the resemblance between the twins of chrysoberyl and our little twin crystals. What, besides, adds a certain value to this consideration is, that chrysoberyl is found in crystalline schist, as, for example, at Tarakoja in the Ural Mountains, and Marschen in Moravia. Stratigraphical and petrographical studies, moreover, lead us in like manner to consider the whetstone that we are describing as belonging to the series that we designate as crystalline schists.

In terminating this micrographical part of the article relative to the whetstone, let me remark that the oligiste iron appears but rarely, and even then sporadically, in this rock, and that it appears more generally, and especially, in contact with oligistiferous slate, whose relations with the rock we have just described we will now briefly study.

At the commencement of this paper I drew attention to the fact that the whetstone appears almost constantly associated with the oligistiferous phyllade, in which it forms regularly intercalated strata. We have seen that these two rocks are perfectly adherent, as also that the foliation of the one is common to the other; now it remains to inquire whether their mineralogical composition and micro-structure cannot throw some light on the relations that exist between them.

Let us see therefore what data the microscopical analysis gives us for the oligistiferous phyllades. Here we have as guide M. Zirkel, who examined some thin sections of the phyllade of Recht, which is definitively the same as that associated with the Belgian whetstones. My observations on the oligistiferous phyllade of Ottrez, Bihain, Viel-Salm, &c., agree in every point with those of M. Zirkel.

M. Zirkel finds that the red grains scattered throughout this rock are in fact, as Dumont had admitted, oligiste iron; that under the microscope they appear of a red colour, and the sections, though generally irregular, are, however, sometimes hexagonal. M. Zirkel attributes the red colour of the phyllade to the accumulation of lamellæ of this mineral. These lamellæ, as well as the other constituents of this rock, are enclosed in a micaceous substance, which constitutes the fundamental mass of the schist. The third constituent recognized by M. Zirkel is garnet, which appears in his preparations with the same characteristic marks that we have already seen in the whetstone. We would remark, however, that this mineral is far more abundant in this rock than in the slate. He makes mention besides of prismatic microscopical crystals, some of which are geniculated twins, and a fifth mineral composed of granules generally flattened, black and opaque, irregularly terminated, and which are less than 0·015 mm. He is inclined to regard them as carbonaceous particles so often found in black or blue schist.

We have but little to add to this excellent description of oligistiferous slate; the only additional element that we have yet recognized in plates of this rock is schorl, whose sections appear here like the sections of this mineral which we have examined in describing the whetstone of Salm.

If now we compare the results which M. Zirkel has obtained for the composition of the oligistiferous slate and those which we have noted in this communication, we shall remark striking analogies in these two rocks, which we were far from suspecting, but which perfectly explain the phenomena presented by their microscopic study. In both cases a micaceous substance constitutes the fundamental mass; there is the same structure, both contain garnet and small prisms quite identical, and in both schorl is present. The difference consists only in the fact that the slate contains lamellæ of oligiste iron and carbonaceous granules, while these two minerals are rare in the whetstone.

There yet remains an important geological question to be discussed: it has reference to the origin itself of the rocks. Let it suffice to remark that I have not met there any elements with traces of clasticity. On the contrary, everything seems to show that its essential elements are crystalline, formed *in situ*. Resting on the ensemble of facts which I have observed, stratigraphic as well as petrographic, I am inclined to admit that the bands or zones of the whetstone are real layers imbedded in the Cambrian formation of the province of Liege, and that they were deposited in the same way as the adjoining slates, in the Cambrian sea, with the proper characteristics that make them differ, from the very moment of their deposition, from the sediments that furnish phyllades. Without denying that a metamorphic action has affected this mass, in a general way, I am inclined to think that this phenomenon alone has not been able to effect the concentration of the mineralogical elements that constitute the whetstone.

In conclusion, I add that this rare rock of Salm and the neighbourhood presents a mineralogical composition such as I have never found in any of the rocks ordinarily designated as razor-stones. I may be permitted here to thank MM. Richter and Dana for the information and specimens of whetstones they have forwarded to me.

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