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General Considerations on different earth types Should one be recognised as the only original source?

Two very interesting questions have long been asked by naturalists and chemists. Is there or is there not one primitive earth type, that is to say one whose formation predates that of all the others. If this earth exists, can it be regarded as having served as a base for the formation of the others, which would then be merely a modification of it. The many famous scientists who have concerned themselves up to now with the solution of these questions and who have nevertheless remained very undecided, is in itself enough to make one aware of the difficulty. Their work, however, has not been useless; we are indebted to them for a mass of interesting observations on the different types of earth and it is they who have established the main features which differentiate them. It is because of the many insights that they have given us, that I am bold enough to enter the lists with them on this subject. Up till now chemistry has recognised 7 basic earths in the composition of rocks: argillaceous, quartzose or siliceous, calcareous, magnesian, heavy, strontian and circonnian. It is some time since two more, adamantine and austral or sidnian were included; but a more careful examination has caused the two last to be suppressed.

Of these 7 soils, two, the circonnian and the strontian appear only in the composition of some individual substances which occupy a very small corner in

nature and, if I can put it in this way, form in it only small stains which are quite foreign to it.

A third, the heavy earth, although more abundant than the two previous ones, is no more common than they are in the formation of any rocks, either primitive, or even secondary and tertiary. It is seen in Nature only in the formation of either small individual and isolated masses or veins in which occur metallic substances belonging more particularly to lead, to tin and in general to sulphurous metals. It is, therefore, as foreign as the two previous earths to the formation of the solid part of the globe and appeared in it only when the voids which it could enclose, as well as the cracks and fissures which shrinkage had formed in it, became adorned with metallic materials and others which are there today: that is to say at a period much later than that of the formation of this solid part. The formation of these three earths is, therefore, of necessity, also much later than that of the earths which form part of it.

When all the observations which have been made either in this or in previous centuries have been brought together, these earths have been limited up till now to the argillaceous, quartzose, calcareous and magnesian; but these four earths offer characteristics in their relative position as well as in their method of joining together which indicate that they have not arisen at the same period and which can, in the absence of certainties, which are impossible to acquire, about their true connection in formation, offer a few quite satisfying clues to serve as a basis for forming an opinion.

Of these four earths one of them, the argillaceous, is extremely

common and it is usually seen mixed with the others in all the rocks which make up the visible part of our globe. This earth and the quartzose are the only two which are apparent in the really primitive rock, the first formed granite. In the last formation, the texture of which is very often friable and the constituent parts less evenly distributed and very often of very considerable volume, the magnesian earth as well as the calcareous begin to show. They are rather more abundant in the gneiss and the other primitive lamellar rocks becoming successively more common in the rocks formed later; and, finally, one of them the magnesian, the formation of which in small quantities had, as it were, outstripped by a considerable amount in steatite and talcose rocks that of the calcareous earth, disappears to appear only by chance in some isolated parts, while the formation of the calcareous multiplies *to* the point when it becomes the base of almost all rocks which have been formed afterwards on our globe.

I have just said that argillaceous and quartzose earths are the only ones found in the truly primitive stone, the first formed granite. I am very aware that there are authors who have found magnesium in great quantities in mica; that M. de Born cites a mica with broad layers from the province of Dirkutz in Siberia, that he says contains 45 of aerated magnesium, and that Mr Kirwan cites, in the number of constituent parts of this substance, 20 of magnesium. But on the other hand the mica of Altenberg gave only 5 of magnesium to Bergman

and another, analysed by Klaporth, gave him no trace whatever of this earth. I am not at all surprised at the difference between the analyses of these different authors, because under the name mica are generally included substances which resemble each other closely but are in reality very different; to the point when, for me, the name mica is merely a generic term, that must be qualified by an adjective, taken from already known mineralogical terms to which the memory is accustomed, to express the different types. I am, moreover, quite convinced that primitive mica, the one with small, thin, indistinct layers which is found in the true primitive granite does not contain magnesium; but that this substance begins to appear in more or less large quantities in the mica that is found in the last formed granites; and is often in still greater quantity still in substances which are later than these granites. I also know that Mr Kirwan found 8 parts of magnesium in the same crystallised felspar which gave him 11 parts of heavy earth; Mr Hassenfratz 9 in the one from St Yrieux in France, Mr Scopoli 6 in the one from Baveno and Mr Fabroni in the one from an Egyptian granite. But the same substance, analysed by Messrs Wiegleb, Meyer, Heyer, Gerhard and Saussure gave no trace. It is natural to conclude from this that with the variation of 4 to 9 in the result of the analyses that I have just cited, the magnesian earth is in no way necessary for the formation of this substance and that it is very probable that it comes in often and merely as an integral part in the

felspars formed later than the first formed granites.

The argillaceous earth and the quartzose being the only two earths among the constituents of the ingredients which form the primitive rock through their aggregation; the magnesian earth like the calcareous beginning to appear in small quantity only in the last products of this rock and in the substances known under the name of primitive lamellar rock, while they appear in infinitely more abundance in rocks formed later; from this, it appears to me natural to conclude that only the two earths, argillaceous and quartzose can be considered as being of primitive origin.

This truth had already struck M.Foureroy. This author, in his chemical elements, led only by the chemical facts which these four earths show, thought he must designate as simple and elementary earths only the argillaceous and quartzose, relegating to the salts under the name of salino-earth substance the calcareous and magnesian earths.

The title of primitive earth, therefore, seems to me to be merited only by argillaceous and quartzose earths. But are these two earths equally primitive or must one of them be regarded as being a modification of the other? The solution of this question is more difficult than the one I have just undertaken to resolve. Chemistry, up till now, has not been strong enough to do it, or, if it has done, it has been to make two rivals of these two earths, to neither of which it was thought preference should be given, Is it not possible for the naturalist by consulting

a larger laboratory and having at his disposal time and means, to arrive at some results capable of deciding this question, at least to his own satisfaction.

But before consulting this great laboratory, let us cast an eye over the chemical properties shown by each of these earths, such as the work of this science usually obtain.

Argillaceous earth is soft to the touch, completely opaque, insoluble in water and tasteless. It can be combined with acids; when subjected to intense and prolonged heat, it becomes very hard. According to La Voisier, if this heat is increased to melting point, its hardness becomes such that it forms some gem stones and cannot be cut with a file. Its specific gravity, according to Kirwan, is 20,000. It is obtained by the decomposition of all the stones in it and principally by alum and is quite different in its nature from all the substances from which it is extracted.

Quartzose earth is always sensitive and even rough to the touch. It is always to some extent transparent. It combines with no acid except fluoric. The action of fire, however long, causes no alteration. Its specific gravity is 26,600. The one quoted by all chemists has always been extracted from the purest quartz through the action of fixed alkali; and it is recognised that its nature differs very little from that of the quartz from which it is extracted and only by its large division: and so chemistry finds in quartz only pure quartzose earth.

If we were now to question Nature, what would she tell us! That the result, ultimately, of the decomposition of all the primitive granites, when reduced to the earthy state is usually clay; that it is a substance composed mainly of clay which fills its crevices and is deposited in the hollows and the plains which are at their base; that one usually comes across quartzose earth but that this quartzose earth is none other than quartz which is very divided and not decomposed, as one also sees in the proximity of the same granites, small parts of felspar and mica, the latter, especially, so divided that it has only become visible through the almost pearly brilliancy which it gives to the shoes of the observers. But as one moves away from these granites, the decomposition becomes more complete, the mica no longer leaves a trace of its existence and the quartz particles become fewer at the same time.

There are even circumstances in which Nature seems to show us that she includes the decomposition of quartz among her operations and that, in this way, she returns it to the state of argillaceous earth, which would then be the unmodified base of that substance. There is no naturalist observer to whom any doubt could remain that kaolin found in granite mountains is anything other than the direct product of the decomposition of felspar. However, before its decomposition, this substance produced on analysis more quartz and less clay than after decomposition. And so it becomes lighter and more defusible than it was before its decomposition and becomes absolutely infusible after experiencing it. Mr Klaproth, who has not failed to notice this peculiarity thinks that it would be possible that in this decomposition

of feldspar an unknown volatile substance is let loose, a substance in which the principle of fusibility resides. I notice, in this respect, that the argillaceous earth has not been altered in any way; far from being reduced, it has increased, while on the contrary the quartzose earth has diminished: it is, therefore, it that has suffered the loss. It has, therefore, lost one of its constituent parts; it was, therefore, not simple. What was it before being modified by the original substance that it has lost? Argillaceous earth, I think, and it is partly returned to that state. It seems to me that chemistry has not concerned itself sufficiently in the study of the passage of felspar, caught in primitive granites, to a kaolin state. It is, however, it seems to me one of the most interesting facts offered by natural decomposition, which is always instructive in the mineral kingdom.

Comparing now the chemical facts with those that Nature shows us, I note that in the product of the decomposition of granite, chemically pure quartzose earth is always in the crystalline state, whereas the pure argillaceous earth which is mixed with it is in a completely earthy state. It seems to me natural to conclude from this that the one in the crystalline state is the product of a dissolution and consequently of the combination of a pure earth with some basic substance or other which is unknown to us, whereas the other is the result of the precipitation of the simple earth without being the combination. The difference in weight between the argillaceous and quartzose earth also backs me up, and completely prevents me from pausing over the quartzose earth to give it preference as primitive over the other.

Considering these two earths like this, I am not surprised to see the quartzose earth, which would indeed be the result

of a combination, refuse to combine with most acids, while the argillaceous, which is free combines with them. I am no more surprised to see that while heated matter has no effect on quartzose earth, it combines with the argillaceous and then forms a very hard compound which cannot be destroyed except by its decomposition. I imagine that to bring about a new combination, it would be necessary to destroy the one which already exists; and, although recognising my lack of facilities in the matter, I feel no less the truth of the fact. I, therefore, feel disposed to conclude from the facts that Nature shows us and my way of interpreting them, that it is argillaceous earth itself that she has modified thus and that it is only to it that the quality of primitive earth can be attributed.

As for the other earths, if the observation of Nature leads us to recognise that they are not, she covers herself in obscurity when we want to question her to know what they are. It seems to me, after what we have just said, that it must be regarded as certain that they are not primitive, since their origin is very certainly long after that of the earths which coincide with the formation of primitive rock. But are they due, as it appears with quartzose earth, to a simple modification of argillaceous earth? Or are they the result of a new combination which took place in the depths of the waters? Some facts appear to favour the first of these two questions; but many others also favour the second. I, therefore, think that the bulk of our observations on this subject, one of those subjects which has been least considered up till now, does not allow us to adopt an opinion

about it.