

## 4. Experiments with granitic powder to illustrate the composition of some quaternary clays in Sweden

by

Ragnar Widman.

---

As is well known the clays within the scandinavian archæan area are considered as washed out products of moraine, which again is principally composed of crushed but not decomposed species of primary rocks. Those clays must therefore in mineralogical as well as in chemical respect be distinguished from such ones, which are formed through washing out of decomposed earth or through restratification of already deposited sediments. As our primary rocks are principally of granitic composition, the clays in the great archæan area, taken as a whole, should be, from chemical point of view, considered as granitic powder. However, as some granitic minerals are more easily crushed than others, one might infer, that by the stratification of the washed out part of the moraine of primary rock there would be sorting products of varying composition, and thus the chemical character of the clay would in some respects differ from the granitic powder.

To get this matter somewhat cleared up Professor HÖGBOM has directed me to investigate, if by the crushing and washing out of a rock an assortment in this respect can really be proved and in such a case in what direction it acts.

When carrying out this investigation one can evidently make use of two different methods. According to one nature itself would perform the crushing as well as the washing out of the rock. One should then in some river collect sand and mud of different coarseness and analyse it. But as it might be difficult to decide, if the different specimens are of the same kind of rock, I have preferred to experiment with a material, which I have prepared myself. I went to work in the following manner.

The *rock* was first broken up with a hammer into small pieces, which further were crushed in a steel mortar until I got a material, which contained grains of all possible dimensions, from 5 or 6 mm. to the finest powder. The washing was carried out as follows. About 300 grams of the crushed rock were put into a glass-jar of 12 cm. diameter, filled with distilled and boiled water up to the height of about 13 cm. and stirred.

After some time the water together with the suspended powder was taken out by the use of a syphon. In this manner four different fractions were procured of which:

*N:o I* was not deposited after  $2\frac{1}{2}$  hours.

*N:o II* not after  $\frac{1}{2}$  hour,

*N:o III* not after one minute,

*N:o IV* on the contrary was deposited nearly at once and could only be procured by vigorously shaking the jar and then immediately pouring out the fluid.

To get the separation as complete as possible every fraction was decanted five times.

After fraction IV has been separated, there is rather a large residue in the glass-jar, which cannot be suspended in water. Fraction IV has a rather homogeneous structure, the size of the grains being about 0,1 mm., wherefore all the larger ingredients will be found in the residue.

In this manner I have treated two kinds of granite of different qualities, one acid alkaline granite from Ragunda, the other basic hornblende-granite from Upsala.

The procured fractions were as follows.

	Ragunda granite	Upsala granite
N:o I . . . . .	4,5 grams	4 grams
N:o II . . . . .	3 »	3 »
N:o III . . . . .	25 »	13 »
N:o IV . . . . .	48 »	2 »
Residue . . . . .	210 »	220 »

When making microscopic examinations it proved impossible to distinguish between the different kinds of minerals in fractions I and II. Regarding fractions III and IV there was no difficulty in that respect, but any real difference as regards their mineralogical composition could not in this manner be ascertained. The grains in the corresponding fractions of the two rocks proved to be perfectly alike, and their size will be seen from the following table.

N:o I . . . . .	0,002 — 0,007 mm
N:o II . . . . .	0,007 — 0,015 »
N:o III . . . . .	0,015 — 0,037 »
N:o IV . . . . .	0,037 — 0,111 »

The chemical composition of the different fractions is shown by analysis below.

	Ragunda-granite			Upsala-granite				
	Granite <sup>1</sup>	N:o I	N:o IV	Granite	N:o I	N:o II	N:o III	N:o IV
SiO <sub>2</sub>	70,70	66,31	72,19	66,10	61,34		65,03	68,15
Al <sub>2</sub> O <sub>3</sub>	13,13	15,05	13,53	15,40	16,44	15,28		12,90
Fe <sub>2</sub> O <sub>3</sub>	2,73	2,22	3,46	5,66	5,97	6,32		6,70
FeO	0,69							
MnO	0,13							
CaO	1,15	2,23	0,81	4,23	4,38			3,79
MgO	0,49	0,71	0,44	2,29	2,04			2,66
K <sub>2</sub> O	4,41	7,02	5,49	3,34	4,90	4,13	3,93	3,91
Na <sub>2</sub> O	4,94	4,46	3,63	3,01	2,54	2,80	2,44	1,91
Lose by heating	1,49	2,39	0,53	1,10	3,36	2,83	1,18	1,15
Sum total	99,86	100,39	100,08	101,13 <sup>2</sup>	100,97 <sup>2</sup>			101,17 <sup>2</sup>

It is evident from the analysis, that the fractions, into which the rocks are divided, have a chemical composition differing very much from one another. While in the finer fractions one finds alumina, lime and alkalis gathered, the coarser contains more silica.

Concerning the question how the separation acts on the different minerals, which the rock contains, one meets with certain difficulties in obtaining a positive answer from the table of analysis, even if certain conclusions can be drawn to elucidate the matter.

First regarding the **Ragunda-granite** a description of its mineralogical composition is to be found in HÖGBOMS »Ragundalens geologi».<sup>3</sup> It is described as a rock of pretty pink colour consisting mostly of perthitic grains of *felspar*, varying between 0,3—0,8 mm. in diameter and grains of *quartz* about as large as hempseed or larger, which often are surrounded by those of *felspar*. Further one usually finds a little white *soda-plagioclase*, which often in like manner surrounds the red *orthoclase-perthite*. The »dark minerals» are *biotite* and *hornblende* in varying but always small quantities; amongst the »small minerals» only *zircon* is always present. *Titanite*, *magnetite* and *fluorite* also occur but more occasionally.

<sup>1</sup> This analysis is taken from "Ragundalens geologi" by Högbom (Sveriges Geologiska Undersökning 1899 N:o 182) Professor Högbom has kindly placed at my disposal a stuff of the analysed rock with which the experiments afterwards have been made.

<sup>2</sup> Regarding the high sums total see below.

<sup>3</sup> l. c.

Thus one finds from the chemical analysis and the mineralogical description, that the Ragunda-granite is an acid granite of a comparatively simple mineralogical composition. Certainly it contains, besides the principal minerals as *quartz*, *orthoclase* and *soda-plagioclase*, also several others, but these occur in so small quantities that, if one excludes biotite, hornblende and magnetite, hardly any consideration regarding them need to be taken at the present discussion.

The analysis show, that the finest fraction (N:o I) presents a higher percentage of potash, soda and lime than the coarsest (N:o IV). As the presence of potash must be due to the *orthoclase* and that of soda to the *soda-felspar*, it is evident that those minerals gather in the finest fractions; this is also confirmed by the percentage of alumina being higher here than in the other analysed fraction. Still the circumstance, that the percentage of silica in the coarsest fraction with no less than 5,88% exceeds its percentage in the finest, seems to show, that the free *quartz* strongly gathers in the coarser fractions. The percentage of iron, which principally must be due to the presence of *magnetite*, makes it probable, that this mineral is most abundantly to be found in the coarsest fractions; the percentages of lime and magnesia, which principally are due to *hornblende* and *mica*, seem to show, that these minerals are gathered in N:o I. Regarding the lime however the presence of fluorite may possibly have complicated the matter, and regarding the magnesia the difference between the percentages is so small and the percentages themselves so low that hardly any conclusion can be drawn therefrom.

At the experiments with the **Upsala-granite** the separation seems to have acted in a fully analogous manner. The mineralogical composition of the Upsala-granite is described in the following manner by HÖGBOM in his: »Om basiska utskiljningar i Upsalagraniten»<sup>1</sup> The principal mineral constituents are *potassic felspar* (both *orthoclase* and *microclin*), *plagioclase* [oligoclase], *hornblende*, *quartz* and *biotite*; Although they occur in rather varying proportions, still one may take the following as an average: *potassic felspar* 25%, *plagioclase* 25%, *hornblende* and *mica* 25–30% and *quartz* 20–25%. Mica occurs in very varying quantities but can never constitute any larger percentage in the rock.

The analysis show here as with the Ragunda-granite, that, though the percentage of potash, soda, lime and alumina found there, *felspar* occurs most abundantly in the finer fractions and through the percentage of silica, that *quartz* is to be found more in the coarser. As regards the occurrence of *dark minerals* they seem here to have gathered in the coarser fractions, which is shown by the percentage of  $\text{Fe}_2\text{O}_3$  as well as by the percentage of Mg O. Still one could have expected, that the separation would have been more evident here than with the Ragunda-granite, where they occur less frequently. That such is not the case may

<sup>1</sup> Geologiska föreningens förhandlingar X sid. 219.

possibly be due to the relative proportions of the dark minerals in both rocks and also to the fact, that the crushing and washing out perhaps does not act alike on all of them. How the matter really stands may be difficult to decide. and in any case one cannot from the above table of analysis come to any definitive conclusion about the separation of the dark minerals. Neither have I with the aid of microscope been able to decide the question.

The greatest part of iron to be found in the Upsala-granite and to a certain extent in the Ragunda-granite certainly appears as ferrous iron, but in the worked out analysis the whole has been put down as ferric oxide and that from following reason. In an essay:<sup>1</sup> »On the determination of ferrous iron in rock analysis» MAUZELIUS shows, that, when a mineral is pulverized, one part of the ferrous iron, there present, is oxidized to ferric oxide and that this oxidation is the more complete the finer the pulverization is. As we have here to deal with differently coarse fractions of a rock, containing ferrous iron, it is evident, that those generally must be partly oxidized and mostly in the finest fractions. However, as one in no case knows the quantity of ferrous iron oxidized in this manner, it is clear, that one from special determinations cannot come to any conclusion whatever regarding the separation of minerals containing ferrous iron. However, that ferrous iron is to be found in all the fractions of Upsala granite the high sums total of the analysis show.

Looking closer into the matter one will find, that the table of analysis, even in other respects than above mentioned offers certain peculiarities; thus all the fractions of Upsala-granite contain more ferric oxide and more potash and those of Ragunda-granite more potash than the rocks themselves. Further all the fractions of both granites contain less soda than the granites themselves. Of course this could be explained in this way, that the substances, of which the fractions show a surplus, have been taken from the large, not analysed residue after the washing, and that those substances, in which the fractions show a deficit, are to be found in the residue. Specially regarding potash and soda there is however another phenomenon to take into consideration. It is already known and specially proved in an essay by DITTRICH:<sup>2</sup> »Chemisch-geologische Untersuchungen über Absorptionerscheinungen bei zersetzte Gesteine», that rocks, specially granites, when subject to pure water change in such a way, that certain substances, specially soda, are dissolved and others, specially potash, increase their percentages. This change, according to other authors, is said to take place in a comparatively short time. To make sure of the effect of this phenomenon I made the following experiment.

About 5 grams of the above used Upsala-granite, not too finely pulverized, were put into a glass-jar filled with about  $\frac{3}{4}$  of a liter of distil-

<sup>1</sup> Sveriges Geologiska Undersökning 1907. Ser. C. N:o 206.

<sup>2</sup> Zeitschrift für anorganische Chemie (1905) 47: 151.

led water; the jar closely covered. I then let it stand some time. Afterwards I poured out the clear solution, and a determination of potash and soda in the residue was carried out.

	Undecom- posed rock	Rock decom- posed by water
$K_2O$	3,43	3,98
$Na_2O$	3,01	2,69

The differences in percentage are not great, but even here it seems as if soda had been dissolved and the potash had increased.

That the whole deficit in soda and gain in potash, which the fractions show, can be explained in this way is hardly possible, but that the dissolution has contributed to the chemical composition of the fractions is, I think, likely, even if it largely depends upon above mentioned fact regarding the residue.

From above described experiments it is evident, that a granite, when subject to crushing and washing out, is in chemical and mineralogical respect divided into differently composed fractions, of which the finest are richest in felspar, while the coarsest principally show a surplus of quartz. If this is applied to the circumstances in nature then the finest washing-out products of the moraine, that is, the ordinary clays within the great archæan area, must be especially rich in felspar, while the more or less coarse sand ought to have an abundance of quartz.

From an agricultural point of view this might be of importance to the fertility of the clays. Amongst the minerals, which the granite contains, felspar can certainly be considered as the most useful to vegetation. It contains substances, as potash and lime, very important to the plants, and can easier than others, through secondary changes be converted into a kind of soil with physical and chemical qualities very important to vegetation. Thus one would come to the conclusion, that the purely mechanical processes, which have caused the formation of the different kinds of soil out of the moraine, will effect such a separation of the constituent parts of the same, that the clays will contain the most important food-substances for the plants and thus, not only on account of their purely physical qualities, but also on account of their chemical composition, constitute the most suitable soil for cultivation,