

On the Term „Rock“ and on Petrographical Classification and Nomenclature.

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The Russian term „Gornaya Poroda“, as well as the corresponding foreign terms: Gestein, Felsart, Gebirgsart, roche, rock, etc. all denote more or less large masses of stone, which form crags, cliffs and whole mountains and which, of course, differ more or less greatly from other similar stone matter. In order to be able to discriminate correctly and minutely what kind of stone masses they are, we must turn to some concrete examples.

First let us take *granite*, as one of the most familiar and well-known rocks. As we know, the origin of this rock is igneous, intrusive. Its matter is composed, on the one hand, of quartz, felspar and mica, these being its principal constituents, and, on the other hand, of apatite, zircon, titanite, magnetite and others, forming its secondary, unessential and occasional ingredients. Besides its composition most characteristic of granite, is its crystalline granular structure, with a hypidiomorphic development of its constituent minerals. The mineralogical composition, as well as the structure of granite is more or less constant. The constancy of its structure is easy to understand. As to its mineralogical composition, this constancy means that, if we take a large enough part of this rock, we shall find it containing not only the above-mentioned important mineral ingredients of granite, but their proportions will also be more or less constant, viz. about 25—30% quartz, 60—70% felspar, 5—10% mica. The size of granite bodies greatly varies, from enormous masses forming great tracts of the earth's crust, to the finest dykes in other rocks.

Our above characteristic of granite is based on the following features:

- 1) origin, as a result of some natural process (igneousness, intrusion, regarding granite);
- 2) mineralogical composition;
- 3) structure;
- 4) dimensions of bodies formed of rocks;

Of all these features the second and the third, mineralogical composition and structure, must be put first.

With regard to the first feature—the origin of a rock—it is obvious that every natural body is the result of some natural process; this can be taken for granted for every kind of rock. The fourth feature: large dimensions of mineral bodies,—though this character may be understood in the very expression of „rock“,—is not, as we have just seen, binding in each separate case. Thus, there is no necessity to include this feature into a determination of rock, it will be enough to understand that rocks are capable of forming large natural bodies.

As the result of our reasoning, the general determination of the meaning „rock“, as obtained from the particular example chosen by us, is as follows: „rock“ is a mineral aggregate, or else a mineral body of a certain constant composition and structure. Accepting this definition, we just modify it somewhat, replacing the term „constancy“ by its equivalent and in this case more definite term: „homogeneity“.

Rock is a mineral body, homogeneous in matter and structure.

The limit of the homogeneity of rock is obviously its minimal section which shows all the characteristic traits of its composition and structure.

Having derived our general determination of „rock“ from our example with granite, we shall now proceed to consider other analogous examples for the explanation and proof of this determination.

Quartz-porphry.—In its general chemical composition, as well as its ingredient minerals, this kind of rock is very akin to granite, yet differs from it, in the first place, by its porphyritic structure, and, in the second place, by containing besides the above mentioned minerals, as also volcanic glass. In our general determination the expression „mineral body“, as applied to granite, does not differ from „mineral aggregate“. The

question now arises, whether it is possible to apply the term «mineral aggregate» to quartz-porphry, so long as volcanic glass forms its chief constituent — speaking otherwise, is volcanic glass a mineral?

This question, being of general importance, must be answered one way or another. It may be answered variously, what we understand by mineral in general. In the first place, a mineral may be defined as a natural chemical body, chemically and physically homogeneous. Obviously such a determination of the mineral may be also applied to solid solutions, whether they be crystalline bodies like the plagioclases, or amorphous mixtures, as in the case of volcanic glasses. The above given definition is more or less generally accepted, yet it is not without certain drawbacks, as according to it we are sometimes obliged to call one and the same chemical body now a mineral, and now a mineral mixture. Any one of the plagioclases, for instance, labradorite, may serve for an example. With the same composition of its albite and anorthite crystals, these may be either entirely homogeneous, — then it is a mineral; or else they may be zonal, not homogeneous, having a more basic core and acid edges, — then labradorite is a mineral mixture. Therefore it would perhaps be more expedient to accept the second somewhat restricted definition of a mineral, according to which a mineral means a definite chemical composition in a determined physico-aggregative state. This restricted meaning of „mineral“ makes it quite obvious that all solid solutions should be considered as mineral mixtures. Thus, also, volcanic glasses will not form an exception to the general rule; we shall only have to conceive the term „mineral body“, included in the definition of „rock“, as a body consisting of minerals and mineral mixtures. The definition in itself is quite satisfactory and good for quartz-porphry in the same measure as for granite.

Marble. — Like granite this rock possesses a complete crystalline granular structure, but contrary to the former it does not consist of several minerals, but only of a single one—calcite. To our definition of rock we must therefore add the explanation that, being a mineral body, it may as well consist of a single mineral. Still there remains a considerable difference between this one mineral and the rock it forms, which consists in the scope of their homogeneity: the elementary cell of the

pattern lattice in the former, and the whole mineral aggregate of the crystalline granular structure, though ever so small in its dimensions, — in the latter.

Now, there arises a most interesting question: what if we imagine such a change in the structure of marble, in which all its grains should take a parallel position to each other and unite into one general monocrystalline mass? Should we be right in continuing to call „rock“ such a monocrystalline marble, or not? Obviously there remains to us only that one criterion which though not contained in our determination of rock, yet, as has been shown earlier, arises from the very term „rock“, i. e. dimensions of a mineral body. If its dimensions are sufficiently large, then the homogeneous crystalline marble may be treated as „rock“, though the limit of its homogeneity coincides with the limit of the homogeneity of the mineral calcite.

The question which we have just put and answered may at first sight seem to be idle because of the singularity of our suggestion, — and yet we know of the existence of one monocrystalline mineral body of such large dimensions, that we can hardly call it by any other name than rock. This is ice, which closely covers all our water basins and expands into a single crystal of enormous dimensions, with its chief crystalline axis L_3 perpendicular to the surface of the basin.

Truly enough, ice, as a monocrystalline rock, forms quite an exceptional case, but we find a great analogy with it in the above mentioned volcanic glasses. We know a whole range of rocks, consisting solely of volcanic glass, and it is quite clear that in the limit of homogeneity all these rocks do not differ from minerals, or, at least, not from homogeneous mineral mixtures, such as isomorphic mixed crystals.

In our last two examples—ice and glass—we have taken the dimensions of a mineral body as being a characteristic distinction between mineral and rock. Of course, this is no more than a conventionality, because, on the other hand, we cannot withhold the name of „rock“ from such bodies, which never form large independent masses, but are to be found only as veins, fine dykes, etc., so long as they answer to all the other more important characters contained in our definition of rock.

It is to be easily understood, that an apt and proper definition of „rock“ will serve as the best basis for a rational classification and nomenclature of rocks. Not entering into the question of the classification of rocks in all its fullness, as regards their age, genesis, structure, etc., we shall consider here only their most important character, i. e. the composition of their matter. We already have seen that the composition of rock matter may be viewed according to quality and quantity. As regards quality estimate, the several minerals, which enter into the composition of a certain rock, are considered, whereas the quantitative determination concerns the proportions in which they stand to each other in any particular rock. It follows naturally from the above that the classification of rocks, regarding the composition of their matter, must be quantitatively mineralogical.

Accepting as incontestable the quantitative-mineralogical principle in the classification of rocks, as we nevertheless meet with great difficulties in the application of this principle. In the first place, as is well known to us and has been shown above, the greater part of rock forming minerals are not definite chemical compounds, but a mixture of the latter, changeable and varying in their compounds, so that to give an accurate description and classification of a rock, it is necessary not only to determine its constituent minerals, but also to find out the special chemical character of each of these minerals. If, to this end, we were every time to extract from the rock the required mineral and submit it to a chemical analysis, it would evidently be a most cumbersome and often quite impossible proceeding as in the case of finely granulated rocks. In the second place, with regard to these same finely crystalline and half glassy rocks it is very difficult and often also quite impossible to make a quantitative estimate of the minerals contained in the rock.

In view of the above stated conditions, we are obliged to use simpler means for the investigation and classification of rocks. A much used and simple means of finding the chemical composition of rock forming minerals, without subjecting them to chemical analysis, is based upon their optic constants. And, on the contrary, in order to judge of the compound matter of a rock as a whole body, we submit the entire rock to chemical analysis. The obtained results are then submitted to a new determination. There are

several different methods for such a determination, of which the two most important are the following. By using the first method, we put together all the facts obtained from the investigation of a certain rock, i. e. the optic properties of its minerals, its quantitative determination under the microscope, its chemical data, its analogy with other kind of rocks, etc., and we then conclude as to the real chemical-mineralogical composition of the rock matter in question. This method is a very rational one, but of course does not always give satisfactory results, being based on data derived from an ordinary, not very minute investigation of rock. Therefore, we very often content ourselves with the second mechanical method of estimating a rock, based exclusively on its chemical analysis in the whole, without taking into consideration its true mineralogical composition, being an estimate either of some ideal minerals i. e. of such definite chemical compounds which answer to the chemical data, or of the so-called magmatic formulae, which give us a still less correct idea of the true mineralogical composition of a rock.

Most existing classifications of rocks are based on data obtained from the second less perfect method of estimate. Once some years ago, I had occasion to make a critical report on these classifications at the First Geological Meeting (Leningrad, 1922). Not wishing to repeat now what has already been communicated by me at the above mentioned meeting, especially as regards what has appeared in print, I shall just limit myself here to the consideration of one small example in this connection.

The following table I contains the results of the chemical investigation of two species of Darial granite (Caucasus): № 185—a fresh specimen, and № 97—a metamorphic, sericitized specimen.

I once made the estimate of the first granite specimen in reference to its constituent minerals with the approximate results obtained, as follows:

	Quartz	27,5 ⁰ / ₀
Felspar (microcline and oligoclase)	Or	13,5 „
	Ab	28,5 „
	An	15,5 „
	Biotite	15,0 „

The second specimen of granite has been left without estimate. In quality it differs from the first in a total absence of microcline; its oligoclase is strongly sericitized, and nearly all the biotite is changed into chlorite. All, or nearly all of the kali contained in this rock, must therefore be attributed to its replacement by sericite. No less than 20—30% of sericite should be contained in the specimen № 97.

Table I.

Name of rock	Weight %		Molecular quantity	
	185	97	185	97
SiO ₂	67,34	69,58	1,115	1,130
TiO ₂	0,51	0,22	0,007	0,003
Al ₂ O ₃	15,05	14,53	0,147	0,142
Fe ₂ O ₃	1,62	1,31	0,010	0,008
FeO	2,14	3,20	0,028	0,045
MnO	0,07	0,04	0,001	0,001
MgO	1,30	1,24	0,030	0,030
CaO	3,11	1,04	0,054	0,018
Na ₂ O	3,37	2,58	0,053	0,042
K ₂ O	3,60	3,39	0,038	0,036
H ₂ O—110°	0,27	0,35		
H ₂ O+110°	1,00	2,99		
Σ	99,35	100,47		

185		97	
SiO ₂	25,86 ...Q 25,86	35,32 ...Q 25,32	
K ₂ O.Al ₂ O ₃ .6SiO ₂	21,73	21,00	
Na ₂ O.Al ₂ O ₃ .6SiO ₂	28,57 ...F 65,74	23,09 ...F 49,34	Sal 91,81
CaO.Al ₂ O ₃ .2SiO ₂	15,44	5,25	Sal 89,58
Al ₂ O ₃	0,21 ...C 0,21	4,92 ...C 4,92	
MgO.SiO ₂	3,09 ...P 4,72	3,15 ...P 8,00	
(Fe.Mn)O.SiO ₂	1,63	4,85	
FeO.Fe ₂ O ₃	2,38 ...M 3,47	1,94	Fem 8,19
FeO.TiO ₂	1,09	0,48	Fem 10,42

$$\text{№ 185: } \frac{\text{Sal}}{\text{Fem}} = \frac{91,8}{8,2} > \frac{7}{1}; \quad \frac{\text{Q}}{\text{F}} = \frac{25,8}{65,7} < \frac{3}{5} > \frac{1}{7}; \quad \frac{\text{K}_2\text{O}' + \text{Na}_2\text{O}'}{\text{CaO}'} = \frac{91}{54} = \frac{5}{3}$$

Persalane Britannare Toscanose-Colorodase

$$\frac{\text{K}_2\text{O}'}{\text{Na}_2\text{O}} = \frac{38}{53} < \frac{5}{3} > \frac{3}{5}$$

Toskanose-Amiatose

$$\text{№ 97: } \frac{\text{Sal}}{\text{Fem}} = \frac{89,6}{10,4} > \frac{7}{1}; \quad \frac{\text{Q}}{\text{F}} = \frac{35,32}{49,34} < \frac{5}{3} > \frac{3}{5};$$

Persalane Columbare

$$\frac{\text{K}_2\text{O}' + \text{Na}_2\text{O}'}{\text{CaO}'} = \frac{78}{18} < \frac{7}{1} > \frac{5}{3}; \quad \frac{\text{K}_2\text{O}'}{\text{Na}_2\text{O}'} = \frac{36}{42} < \frac{5}{3} > \frac{3}{5}$$

Alsbachase Temahose

Our table, in its second half, shows the estimate of both granites according to the American method.¹ The unsuitability of that method may be seen immediately. In the № 185 granite the 15% of true biotite, contained in it, is divided quite arbitrarily into the following mineral groups: 7% orthoclase, 4,5% rhombic pyroxene, 2,5% magnetite and 1% ilmenite. With the granite specimen № 97 matters are still worse. Such figures as 5% corundum, in quartz rock, or 20% orthoclase in a rock entirely destitute of potash felspar, show plainly, that the mechanical method of the Americans is not available for rocks, altered by metamorphism. The only possible way, it seems to us,

¹ Cross, Iddings, Pirsson, Washington. Journ. of Geol., 1902, vol. X.

of restoring the material composition of granite specimen № 97 to the condition in which it came from the magma, is to give to the pseudomorphs of sericite after oligoclase and of chlorite after biotite their original chemical composition and then make their quantitative estimate under the microscope together with quartz.

There exists a more attractive method, than the American, which is simpler and more modest in its pretensions,—by which an estimate of specially eruptive rocks may be obtained in magmatic formulae—the method of F. Loewinson-Lessing, suggested by him about a quarter of a century ago, and which has since found a wide application. It is, however, easy to conceive that this, like the American, method, is by no means reliable for the determination and classification of metamorphic rocks. Indeed, one has but to compare the following magmatic formulae of the granite specimens № 185 and № 97, in order to see how little they reflect the processes of metamorphism:

№ 185: $1.3 \overline{RO} R_2O_3 7.1 SiO_2; \alpha = 3.3; R_2O : RO = 9 : 11.$

№ 97: $1.5 \overline{RO} R_2O_3 7.5 SiO_2; \alpha = 3.6; R_2O : RO = 8 : 9.$

Both formulae are nearly identical. If we were to base ourselves upon them, we might think that the magmatism of both rocks was also the same. Whereas, as we have already seen, that is not at all the case. Particularly, nearly all of the kali or potash which we find in the specimen № 97, has been conveyed from outside, and is by no means produced in place of the original microcline, which has never even existed in that rock. Neither could it have been formed of the microcline from other neighbouring granite parts, for the Darial microcline, contrary to the Darial oligoclase, is everywhere exceptionally fresh,—fresh in every granite body, where it is found.

The chemical analysis of rocks and their magmatic formulae are often used in order to judge of the magmatism of metamorphic rocks, on the supposition that during the process of metamorphism it is only the mineral composition of rock which changes, whereas its chemical composition, excepting the additional H_2O and CO_2 , remains the same as in the original rock. It is impossible to agree with this suggestion. Indeed, in metamorphism a large part is played by the metasomatic exchange, the addition of substance to the original substratum and the parallel loss of substance from the latter. A good illustration of this we find in the case of Darial granite.

The precise signification of the term „rock“, which has guided us in our judgement on the different methods of investigation and classification of rocks, helps us also to form a clear definition as to the expediency of their nomenclature. We shall not enter here, as has been done in the question of classification, into the structural, genetic and other properties of rocks. Of course, these properties are of great importance for the identification of rocks, — so great, that they must be suggested in one way or other in the very denomination of rocks. Yet the first consideration in such a denomination must be given not to these properties, but to what seems to us to be of much greater importance. This is again obviously the material, mineralogical composition of rocks. It is most deplorable that this material principle, being the only correct one, takes no part whatever in our up-to-date nomenclature, with the exception, perhaps, of some monomineral rocks: pyroxenites, anorthosites, and the like, which are correctly named after their constituent minerals. But, as regards polymineral rocks, such denominations as peridotite, quartz-syenite and the like give us only a partial idea of their constituent minerals. In the greater part of other cases, however, not even such slight allusions exist, we find instead denominations of rocks based on occasional geographical features which have nothing to do with our definitions such, as: laurvikites, nordmarkites, umptekites, etc. Of course, all this is by no means suitable; a text-book of petrography turns out to be a certain kind of universal manual of geography; the memorising of all such petrographic names requires a great unproductive loss of energy; petrography seems to have surrounded itself with a stockade of strange names in order to frighten away non-specialists. Notwithstanding the closeness of this stockade, petrography continues to stick into it new geographical pickets; and this is done by such prominent specialists as Brögger, Lacroix, Duparc and others.

Without discarding the geographical principle, the Americans have tried to arrange and simplify petrographical nomenclature. Basing themselves on the relative quantities in rocks of silic and femic parts, quartz, felspars, etc., they are well known to have divided the rocks into classes, orders, rangs and subrang, inserting into all these cells their new denominations. It may be seen from

table I that the Darial rock № 185, according to this system, falls into the class Persalane, the order Britannare, the rang Toscanose-Colorodase, the subrang Toscanose-Amiatose. The Darial rock № 97 — into class Persalane, the order Columbare, the rang Alsbachase, the subrang Temahose.

These examples are sufficient to show that the attempt of the Americans has not reached its object, — in so much as the very arrangement of the quantitative material into cells is with them of quite a mechanical character.

It seems to me that the time is long ripe for the creation of a new, really scientific, petrographical nomenclature, based on the only rational material — mineralogical principle. As one of the conceivable concrete suggestions, we may mention here the proposition of forming the denomination of a rock from the first syllables or letters of the minerals, which play an important part in its composition.

In order to show what such a nomenclature would look like we submit in the following table II some denominations from Rosenbusch's text-book, in its new Osann-edition, — denominations of all the rocks included in the family of intrusive, non-felspathic, nepheline and sodalite eruptives, giving opposite to them their new names devised on the mineralogical principle.

Table II.

	Denomination of rocks	Their new rational denomination
1.	Urtite	Aeginite { Leuco-aeginite } 2-aeg { Aeginite } 3-aeg { Melano-aeginite } 7-aeg
2.	Ijolite	
3.	Melteigite	
4.	Monmouthite	Amneite
5.	Congressite	Bineite
6.	Tawite	Aegisodite
7.	Naujaite	Anam-aegisodite
8.	Bekinkinite	Barneite
9.	Fasinite	Tipyneite
10.	Riedenite	Pynosite
11.	Turjaite	Binemelite
12.	Uncompahgrite	Dimelite

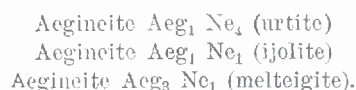
Note to table II. The abbreviations which enter into the denomination of rocks in table II denote the following minerals: aegi—aeigrine; py—pyroxene; di—diopside; tipy—titan pyroxene; am—amphibole; bar—barkevikite; bi—biotite; ne—nepheline; sod—sodalite; nos—nosean; an—analcite; mel—melilite.

There are three rocks in our list which consist of the same minerals, but in different proportions: *urtite*, *ijolite*, *melteigite*. In the rational denomination of rocks this difference may be variously marked.

1. The quantitative mineralogical type, which is more constant than the rest, and which occurs in nature more frequently, may be taken as the principal, standard one; to the others are then affixed prefixes, showing the character of their digression from the principal type, as for instance: leuco-aegineite (*urtite*); or melano-aegineite (*melteigite*).

2. Letter-marks may be used as: β — for the principal type, α — for leuco- and γ — for melano-rocks.

3. In place of prefixes, the rock denomination may be followed up by formulae, such as:



As to the limits of certain quantitative-mineralogical types, they naturally have to be, wherever possible, nonmechanical, as also more or less rationalised and fixed according to their physico-chemical character, statistic data, geological facts, etc.

Naturally, the rational nomenclature of rocks suggested by us will meet with objections. Leaving such objections to the imagination of those who may be interested in our subject, whether in a positive or negative sense, we shall here consider only one of them, which appears to me the most serious of all.

The rational terms, used by us, are very artificial. They do not sound well, they jar upon an unaccustomed ear. The new petrographical language would be something like esperanto in our branch of science.

This objection, in as much as these new terms are unfamiliar, seems to be reasonable, for, according to Newton's principle, every novelty meets with its lawful resistance. As to the reproach in the inharmoniousness of our names, we must consider it by no means deserved. Indeed, we cannot conceive why, for instance, the denomination „barneite“ should be less euphonic than „bekinkinite“; or the expression „dimelite“

should offend our ear more than „uncompahgrite“, etc. There can be no doubt that these terms are much better than those which exist at present, they are much more to the point, because they give a clearer idea of the object they denominate. I presume, if we were to ask a person not versed in petrography, a week or so after his having read this article, what is „uncompahgrite“, that he would hardly be able to answer the question; whereas if after the same length of time we were to mention to him the rock „dimelite“,—he would immediately be able to make out that it is an eruptive, consisting chiefly of diopside—pyroxene and melilite. However, it seems to us, that a rational nomenclature will be of great help not only to a layman, but to a specialist as well, by way of facilitating and accelerating associations, necessary in every scientific work.

The rational terminology of rocks, suggested by us, may be artificial, yet it is no more artificial nor cumbersome than chemical terminology, which has taken firm root. The complex and often polysynthetic denominations of many especially organic chemical compositions, are well known to all. Existing peacefully together with the simpler old ones, which are commonly used, they are useful and most suitable. I shall here limit myself to two examples which have just suggested themselves to me. In organic chemistry urea is called carbamide, which immediately gives us the required idea of its being the amido-derivative of carbonic acid: $\text{CO} < \begin{matrix} \text{NH}_2 \\ \text{NH}_2 \end{matrix}$. Saccharine is the same as the imide of ortho-sulpho-benzoic acid; in calling the substance by that name we immediately reproduce in our mind its chemical composition $\text{C}_6\text{H}_4 < \begin{matrix} \text{SO}_2 \\ \text{CO} \end{matrix} > \text{NH}$, — together with its ring structure, orthoposition of the groups CO and SO₂, etc. Our rational petrographical nomenclature, as shown above, must have the same object in view. Petrographical formulae, analogous with chemical ones, having minerals in place of atoms and radicals, intrude themselves upon our minds.