ART. XV.—*On the General Principles of the Nomenclature of the Massive Crystalline Rocks*; by A. WENDELL JACKSON.

INTRODUCTION.

THE objects of the present paper are, first, to suggest the complete separation of rock-nomenclature from rock-classification, and, second, to investigate and to establish, as far as may be, the principles upon which any system of nomenclature for the massive crystalline rocks should be based. Throughout my paper the term "nomenclature" is to be understood as referring to the names of the rocks themselves and not of the larger groups recognized in rock-classifications.

The existing confusion in rock-nomenclature is due to several causes, not the least of which is the admission of classification as a controlling feature in nomenclature, and the tendency seems to be more and more in this direction. This principle is even directly advocated in a recent able work (Dutton, "Geology of the High Plateaus of Utah," Chap. iv). Its general recognition can only result disastrously to the science. The true function of present systems of classification is to express relations between the objects classified. The true function of a system of nomenclature is to furnish each of these objects with

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a name that shall be as little subject to change as possible, for change produces confusion.

Classifications are constantly changing and if our rock-names are made dependent upon them, an element of confusion in nomenclature is introduced that is both undesirable and unnecessary. Our only remedy lies in a complete divorce of nomenclature from classification such as has long been recognized in zoology, botany and mineralogy.*

In the following pages I wish to discuss the principles of nomenclature as considered thus entirely distinct from classification; it goes without saying that the chemical, mineralogical, and geological considerations which I discuss with reference to the bearing on *nomenclature* are entirely open to a re-discussion with reference to their bearing on *classification*; and one may arrive at diametrically opposite conclusions as to their value for classification from my own as to their value for nomenclature without in the least invalidating the results reached in the present paper.

In the first chapter I state and explain the principles which I conceive should guide us in the formation of rock-names and I then examine the considerations at our disposal to determine how far they may be used in conformity with the principles laid down. In the second chapter I explain why I hold it to be inexpedient to formulate a system of names in accordance with the principles suggested and give reasons for adopting provisionally a different system of names.

CHAPTER I.

I conceive the fundamental principles to be borne constantly in mind in the formation of a system of nomenclature to be three: I. *Uniformity*, II. *Stability*, III. *Adaptability*. I shall examine each of these and indicate its bearing upon the question at issue.

I. *Uniformity*. No one will for a moment dispute the desirability of having but *one* name for each rock. There is something of a tendency toward the formation of "schools" in this respect. That is all wrong however; all geologists should call the same rock by the same name. Zoologists, botanists and mineralogists recognize this principle in their respective sciences. Indeed it is so evident that one who will dispute it is not to be reasoned with.

II. *Stability*. By a "stable" nomenclature, I mean one that is not subject to change. A rock that has once received a definite name should continue to be known by it. This principle is second in importance only to the first. If *all* geologists would agree to change any given name, there would of course

* For a more extended discussion of this topic see the reprint of this paper in the Proceedings of the California Academy of Sciences. Volume for 1882.

be no objection to the change; uniformity would still be preserved. This principle as well as the first has been frequently violated in petrography.

III. *Adaptability.* In considering this principle it is desirable to bear in mind the peculiar nature of a rock as distinguished from a mineral. A mineral is a definite homogeneous chemical compound and one usually has no difficulty in recognizing it and applying at once the name that has been agreed upon for that particular compound. But a rock is usually a mechanical mixture of two or more minerals, admitting considerable variation in the relative amounts of the different constituents, remaining in the estimation of the geologist substantially the same rock. By the "adaptability" of a name I mean that it should adapt itself to this variation. A change in the relative amount of the constituents within certain not all-too-broad limits should not necessitate the use of a new name.

It is here that I conceive some may take issue with me as to the practicability of upholding this principle. It will be contended that rocks grade off into each other by insensible transitions and that the *transitional forms* are just as common as those we may choose to set up as *typical forms*; that a name consequently cannot be made to adapt itself to this indefinitely shifting mixture of minerals. The answer to this has been so finely stated by Rosenbusch (*Massige Gesteine*, p. 25) that I cannot refrain from quoting it in full, premising that I have fully experienced the truth of his statement.

He says: "In the same way that insensible transitions from one rock to another are brought about by change in the mineralogical composition, so also is it true that similar transitions are sometimes the results of a change in texture. I believe myself justified in the statement that every thoughtful petrographer will have passed through three stages of development in his scientific views, with increasing experience in this direction, stages which possess more than a personal interest, from the fact that they are likewise recognizable as three stages in the development of the science itself. In the first of these stages, one is a fanatic for a *simple system*; one recognizes a series of well characterized types and no transitional forms. In the second stage, the conviction presses itself gradually upon the mind that nature cannot be fitted into so exact and rigid a frame; the well characterized rock-types become fewer and fewer, the transitional forms more and more numerous. One turns away from the rigid system and becomes an inspired advocate of the uninterrupted series, of the gradual development of one rock from another, of the insensible transitions which bind together and totally obliterate the types of the first stage. Finally, in the last stage, one begins gradually to discover cer-

tain fixed points in this vague and indefinite mass of transitional forms; or, to express myself petrographically, in the formless magma of our views crystallization-centra begin to appear, about which homogeneous material begins to deposit itself concentrically with gradually decreasing density as we recede from the center. Thus arise rock-groups whose central types are well-defined and distinctly separated from one another, while their peripheries tangent and in many ways coalesce. One now returns to the definite system which no longer possesses however the rigidity and dead immobility of the first period."

One who believes there is no such thing as a definite rock-type, finds himself in the second stage of his development and only needs a more extended range of experience to discover the rock-types and to view them in their true relations; and he will then perceive the true significance of this principle of adaptability and will recognize the importance of conceding to it a high degree of influence in the construction of rock-names.

Mr. Darwin has demonstrated the necessity of recognizing this principle in the organic natural sciences and the mineralogist has to bear it constantly in mind.

Were the necessity at all incumbent upon us to form a system of nomenclature for material that had reached a *perfect* natural classification, I should certainly add a fourth principle to the three thus suggested, namely, that a name should be constructed so as to suggest the relation of the rock to all allied rocks; in other words I would seek to construct a complete *systematic* nomenclature that should be an exact expression of the *systematic* classification.

As such a system has not yet and may never be reached, it is certainly unwise to allow this principle to enter largely into the determination of present nomenclature. It would at once conflict with the first two principles of uniformity and stability. To a slight extent it may perhaps safely be done; we shall consider such cases later.

Having thus laid down certain principles to guide us, I will now examine the considerations that might influence our selection of rock-names. In so far as these considerations are in accord with these principles, they will be endorsed; in so far as they are in conflict, they will be rejected.

I claim, first, as of fundamental importance that *facts*, and facts alone, should determine names and that *speculations*, *hypotheses* and *theories* should be entirely ignored. Facts are susceptible of demonstration, and a nomenclature founded upon them is sure to be uniform and stable, while speculations, hypotheses and theories admit of differences of opinion, and if our names are to be influenced in any way by them, we at once admit an element

of nonuniformity and instability. Although it is in a general way true that the theories of one generation become the facts of the next, it is equally true that *most* of the theories of one generation *fail* to become the facts of the next; and so long as they remain in the condition of a theory they should be totally ignored in forming rock-names. The value of a fact in this connection is to be measured by its generality; facts of local value should be reserved for local distinctions.

The kinds of facts which are more immediately accessible to the geologists are three: *chemical*, *geological* and *mineralogical*. I will indicate what I conceive to be the value of each class for the formation of names.

1. *Chemical*. Perhaps the most striking evidence of the impossibility of basing nomenclature upon chemical composition can be presented in the fact that during all of the years preceding the use of the microscope in petrographical investigation, chemistry was unable to discover distinctions that become evident with the first glance into the microscope. Rocks are not minerals and have not the same well-defined stoichiometric composition that minerals have. On the contrary, rocks that are mineralogically identical show considerable variations in chemical composition, while the same bulk-analysis may be true for rocks of widely different mineralogical composition. It is to be observed from this that knowing the analysis one is not able to predict mineral composition while the converse is *not* true; if we know the mineral composition we can predict always qualitatively, and to an approximation quantitatively, the chemical composition. It would seem then that the fact of mineral composition is of a higher order of utility than the fact of chemical composition. The latter is a function of the former and a nomenclature based upon mineralogical facts will necessarily express sufficiently clearly the chemical facts, without the inconvenience of determining the chemical composition in each case before deciding what name shall be applied.

Again, it is held by some (Scheerer, *Jahrbuch der Mineralogie* etc., 1864, 385, and others) that the chemical composition of a rock is a fact of the first importance and should be made the leading element in classifying (and naming?) because it gives us a clear conception of the nature of the original fluid material out of which the rock crystallized; and that it is this original fluid material which constitutes the true "rock-type" about which all of our interest centers. Now, while I fully admit the value of this conception and appreciate the significance of the results to be gained by tracing different rocks back to a common magma, still I hold that a rock is something more than a certain chemical mixture, it is a chemical mixture *with a history that is equally interesting*. It has been subjected to various

physical conditions of temperature and pressure that have determined its rate of crystallization and that, equally with the original magma, have determined the precise minerals which we now find in the rock itself. It is true we do not yet know enough of the relations between varying conditions of temperature and pressure, and the resulting minerals to be able to reason backward from the minerals themselves to the conditions of which they are the (partial) expression; some progress has been made in this direction and certainly more is to be expected.

The mineral composition of a rock will give us a conception, then, not only of the original chemical composition of the magma from which it was derived, but also (particularly with *texture*, see p. 19) of the physical conditions which have prevailed during the process by which the rock acquired its present appearance; it suggests both chemical and physical conditions while the chemical analysis suggests only the former. Whence I conceive that the use of chemical facts in constructing rock-names is superfluous.

The inconvenience of making a quantitative chemical analysis before deciding the name of a rock is certainly not the least objectionable feature of the plan.

Geology must always remain more or less of a natural history science and the field geologist will always need a name that will convey some conception of the *appearance* of a rock, such as a mineralogical name will give him.

2. *Geological.* The geological facts that might be used in this connection are *form*, *age* and *origin*. *Form* has been used to some extent, but it is now so generally recognized that the same rock can occur as dyke, bed, sheet, stream, or stock, that it has properly ceased to have any significance so far as name is concerned. Not so, however, with *age*. The continental geologists divide the massive crystalline rocks into two classes which they call "older" or "younger" according as the rock was formed *before* or *after* the inception of the Tertiary period; and based upon this distinction, the same mineral aggregate is provided with two different names according as it is of Pre-Tertiary or Post-Cretaceous age. Thus I have held in my hand two specimens that could not be distinguished from each other even in thin sections under the microscope. Both contained quartz and sanidine porphyritically developed, the ground-mass of both was crypto-crystalline throughout and yet the one was "quartz-porphry" because Pre-Tertiary, and the other was "quartz-trachyte" because Post-Cretaceous. For the same reason melaphyr is separated from basalt, with which it is otherwise identical; hornblende porphyrite from hornblende

andesite; augite porphyrite from augite andesite: orthoclase porphyrite from trachyte; and diabase from dolerite.

Those who hold to this distinction do not indeed deny the frequent mineralogical identity of the rocks thus separated; but they hold that it is *desirable* to express thus the difference in age of the same mineral aggregate. With Prof. J. D. Dana * I must confess myself unable to see the value of this distinction for the nomenclature of the science. It appears to me much more rational to call a certain mineral aggregate "quartz porphyry" or "liparite" (use which name one will) and to recognize the fact that the rock thus named is sometimes of Silurian, sometimes of Carboniferous, sometimes of Permian, and sometimes of Post-Cretaceous age. We find no difficulty in mineralogy of uniting the quartz of the Pre-Tertiary quartz porphyry with the quartz of the Post-Cretaceous quartz-trachyte (or liparite, or rhyolite) under one species, in spite of the fact that geological periods separated the dates of their formation. One who would advocate their separation into two species would be properly ignored and yet the geologist makes a similar unnecessary and unphilosophical distinction daily.

Moreover those who insist upon this distinction are not consistent. They separate quartz porphyry from liparite, but they fail to separate the Paleozoic granite of the Harz Mts. from the Mesozoic granite of Cornwall; and they fail to separate certain Triassic quartz porphyries of Germany from Silurian quartz porphyries of England. In other words, the line is drawn between Mesozoic and Cenozoic but not between Mesozoic and Paleozoic. The reason for this (Roth, *Beiträge zur Petrographie der plutonischen Gesteine in den Abhandlungen der Akademie der Wissenschaften zu Berlin*, 1869, p. 74) probably lies in the fact that the earlier geologists were led, through the study of the Mesozoic rocks of Central Europe, to the conception that a period of comparative quiet separated the widespread igneous activity of the Azoic and Paleozoic ages from what appeared to be a renewal of this activity in a different form in Tertiary and Post-Tertiary times. It appeared as though the nature as well as the products of this renewed activity were different. The pronounced absence of volcanoes, lava streams, and tufas seemed to indicate that Pre-Tertiary activity was *subterranean* while *recent* activity finds expression *at the surface* in the form of volcanoes, lava streams, tufa eruptions, and such tremendous sheet overflows as those of Utah, and of Washington Territory, Oregon, and Northern California.

The results of more recent and more widely extended researches do not seem to favor this idea. Paleozoic volcanoes, lava streams, and even tufas have been found and we should

* J. D. Dana. On some points in Lithology. This Journal, iii, p. 336.

certainly expect *à priori* that they would have been formed then as now; but in the tremendous lapse of time that has intervened they would necessarily have become either greatly modified in form by erosion or in appearance by subsequent metamorphism so as to become unrecognizable as such, or indeed entirely obliterated. It would require peculiarly favorable conditions to preserve a Paleozoic tufa in a recognizable condition to the present day. On the other hand, it is now conceived that granitic rocks are forming in the subterranean depths at the present time. The differences that do exist between so-called "older" and "newer" rocks may be due then not to their difference in age, but to the difference in the physical conditions of their crystallization, conditions which held equally in Paleozoic times and in Tertiary times, only the Paleozoic superficial formations have been mostly swept away and the deep seated rocks of that age exposed by the removal of thousands of feet of superincumbent strata while the superficial rocks of Post-Cretaceous times, the trachytes, andesites, phonolites, basalts, etc., are preserved to us because of their recent origin and the granitic rocks *now forming* are too deep-seated to be exposed for observation.

I would oppose then this distinction of rocks into "older" and "newer" (for purposes of nomenclature) first, because the original grounds upon which it was made seem no longer tenable; second, because such distinctions as exist *in fact* between older and younger rocks can be accurately expressed by a purely mineralogical nomenclature; third, because the distinction is not and cannot be consistently carried out between rocks of Mesozoic and Paleozoic age; fourth, because of its great inconvenience. It is not always possible to tell the age of a rock; in the meantime its name must be held in abeyance or at least subject to change. More than one instance will suggest itself to the specialist where the name of a rock supposed to be Pre-Tertiary has been changed when subsequent study in the field has proved the rock to be Tertiary or Post-Tertiary. This element of uncertainty plays sad havoc with rock-names and should be set aside entirely.

The third geological consideration to be noticed is *origin*. The first objection to be urged against its use in rock-naming is the fact that the whole subject of rock-genesis lies too much within the region of theory and even speculation; whence for reasons previously indicated, it should be disregarded in this connection. But even if we could determine for each rock its exact mode of formation, even if we could attach definite conceptions to such terms as "metamorphism," "aqueo-igneous fusion," etc., the objection similar to that urged against "age" would still remain, namely, rocks with the same mineralogical

composition would be provided with different names according as they were formed by one process or another. When actual differences in composition result from different modes of formation, such differences will find expression in a mineralogical nomenclature, and when no differences exist, it would seem far more rational to use but a single name. I would quote here, with additions of my own in italics, from Prof. J. D. Dana's *Manual of Geology*, 3d edit., p. 76. "Further, rocks, as objects in science, should be defined and named according to their kinds,—not according to the era of formation *nor the method of formation*,—since the same things are the same whenever made *and however made*." Fortunately there is no pronounced tendency to transgress in this direction.

3. *Mineralogical.* We come now to an examination of the mineralogical facts at our disposal, in the light of the three principles previously laid down. Under this head I propose to include both the *minerals* themselves and the manner in which they are combined together, in other words *rock-texture*.

First, with respect to the minerals themselves. They are susceptible of exact determination, there can be no differences of opinion as to what the essential constituents of a rock really are. The use of the microscope, the application of polarized light whereby the positions of optical planes can be accurately determined, Sorby's method for determining the indices of refraction of minerals in rock-sections, Thoulet's method of mechanically isolating rock constituents so that they may be quantitatively analysed if necessary, have all reduced the process of mineralogical determination of the constituents even of compact rocks to great exactness.

It may be conceived that the difficulty, rarely perhaps impossibility, of distinguishing between the different kinds of plagioclase * would interpose a serious obstacle in the way of a purely mineralogical nomenclature. But it should be remembered on the one hand that Descloizeaux' optical distinctions and Thoulet's method of mechanical isolation, together enable us, in most cases, to make the distinction with the greatest accuracy and, on the other hand, that the practical distinction between the different forms of plagioclase that occur as rock constituents is of secondary importance compared with the fundamental distinction between orthoclase and plagioclase, and this latter we have always been able to make with the greatest ease.

While it cannot be regarded as proved that albite and anorthite, the soda-plagioclase and lime-plagioclase, do not widely occur as rock constituents, still the results of investigations up to the present point in this direction. It is the intermediate

* I use the term "plagioclase" in its original sense, including the albite-anorthite series and excluding microcline.

members of the plagioclase group for which oligoclase and labradorite stand as types, that most commonly occur. No great element of uncertainty would be introduced into our nomenclature if we considered plagioclase a single mineral species, subject of course to variation in the amounts of soda, lime and silica, and in the future progress of the science, as the exact nature of the plagioclase for each individual case became determined, the name of this variety could easily be substituted for plagioclase in the name of the rock, or used as an adjective modifying the name, if a purely trivial one. We should have, e. g. "oligoclase-basalt" and "labradorite-basalt" in the place of "basalt" as now used. It must certainly be conceded (as indeed it is generally believed) that no weight can attach to the objection that the constituent minerals of a rock cannot be accurately determined.

Supposing, now, that our nomenclature is to be based upon purely mineralogical grounds, it becomes necessary to determine what minerals shall be utilized for this purpose. The mineral constituents of a rock have been divided into *primary* and *secondary* according as they are the product of immediate crystallization out of the original rock-magma before or at the final solidification of the rock; or are produced by changes in the rock subsequent to its final solidification brought about by atmospheric waters or local metamorphism. To these may be added such minerals and fragments as may have been mechanically enclosed during the process of eruption; I shall call such foreign minerals and fragments. With the fragments of course we have nothing to do.

Of these the secondary and foreign minerals should unquestionably be disregarded in naming the rock, as in fact has always been the practice. They are evidently purely adventitious and have nothing whatsoever to do with the rock as such. Their true nature can always be recognized and they consequently introduce no element of uncertainty to create confusion in names. There remain the primary constituents. Among these a certain liability to confusion may exist in the distinction between *essential* and *accessory* constituents. The accessory mineral of one rock is the essential mineral of another, and just where to draw the line is not always at once evident from the fact that an approximate quantitative estimate of the mineral has to be made. It is here that practice only can render skillful. From the nature of the case it can never be otherwise, and serious embarrassment is not to be feared from this source. It is to be presumed that geologists are to be educated and the ability to make such distinctions must be learned. He who runs cannot expect to read. On the other hand, it must be observed that mistakes arising from this

source are liable only about the *peripheries* of the rock-groups, to take up Rozenbusch's figure once more; and the alternative is to place the rock in a closely allied group where the mistake, if it be one, can do the minimum of harm.

I have shown thus far that *uniformity* and *stability* would result from a purely mineralogical nomenclature; let us now examine the *adaptability* of such names. I have already called attention to the variation within certain limits in the relative proportion of the essential constituent minerals of any rock. It is not worth while to express this variation in our nomenclature. In fact it is so irregular, so completely beyond the control of any known or conceivable general law that it would be altogether impossible to express it if we would. Names founded upon mineral composition would ignore this variation so long as it took place within the limits assigned for *essential* constituents. Such names would therefore completely adapt themselves to the natural conditions. They would have moreover even a higher order of adaptability than this. I have quoted Rosenbusch on the subject of rock-groups wherein he asserts the substantial unity of rock-types but of rock-types that are themselves united by transitions due to the gradual replacement of one or more constituents by other minerals, or by a gradual change of texture. Such names can be made to adapt themselves most perfectly to the expression of the relations between the different members of a rock-group and between each and the central type. *To this limited extent* the attempt could safely be made to be *systematic* in our nomenclature; for the relations between the closely allied rocks of each group both chemically and geologically as well as mineralogically are too evident ever to become questioned.

To illustrate with the granite group, Rosenbusch (*Massige Gesteine*, p. 18) following and developing the suggestion of Gustav Rose has divided and named the group in accordance with these principles. Quartz, orthoclase, and plagioclase are present in every granite; associated with these are muscovite, biotite and hornblende, sometimes one, sometimes two. When muscovite alone is present we have muscovite granite; when biotite alone, biotite-granite (or *granitite*): when hornblende alone, hornblende granite, when muscovite and biotite together, granite (in strict sense); when biotite and hornblende, biotite hornblende granite, or, more conveniently, hornblende *granitite*. Muscovite and hornblende do not occur simultaneously with the type constituents, but if they did it would be a simple matter to make a name for the rock.

The basalt group furnishes another good instance. From basalt as a central type (plagioclase, augite, olivine) we pass to nephelite basalt (—plagioclase + nephelite), or to leucite basalt

(—plagioclase + leucite), or to diallage basalt (—augite + diallage.)

In this way then our nomenclature could easily adapt itself to the special circumstances of each case. If it were considered desirable, purely trivial names could be given to each of these closely allied rocks; but my own preference would be for descriptive names so long as they could be formed by the use of a single mineral name as a modifier, such as "biotite granite," "leucite basalt," and for the reduction in number of the purely trivial names to a minimum.

In addition to the mineral constituents, many rocks contain more or less of the solidified magma-residuum that was not taken up by the crystalline elements before molecular freedom of motion was stopped by the final solidification of the rock. This varies in quantity all the way from 100 per cent (as in obsidian) down to 0 per cent as in granite. This evidently can not be disregarded; but the part it should play can be better discussed perhaps under the head of *texture*.

Rock Texture.—From the earliest times texture has been utilized for the purpose of naming rocks, and the desirability of continuing its use particularly for purposes of descriptive petrography is evident. It is none the less so from the fact that it is the expression, so far as we yet understand it even more perfectly than the minerals themselves, of the prevailing physical conditions during the process of cooling and solidification.

Can rock-texture be used in forming a nomenclature, without danger to our fundamental principles? Does it present itself in such forms as to be accurately and universally recognized? The accuracy with which Rosenbusch has defined (l. c. p. 70 et seq.) certain important forms of macro-, and micro-texture renders possible an affirmative answer to these two queries. I will reproduce his definitions. Ground-mass is the term applied to the compact portion of a rock as distinguished from the large, distinctly visible, disseminated crystals. It is entirely a macroscopic conception. Under the microscope this ground-mass may be developed entirely crystalline, i. e. anisotropic; or as a mixture of crystals and isotropic material called the *base*; or entirely isotropic. If entirely anisotropic, it may be either micro-crystalline, i. e. made up entirely of distinct crystalline granules; or cryptocrystalline, i. e. consisting of anisotropic material throughout but with the crystalline individuals altogether indistinguishable from one another. No sharp distinction can be drawn between these two; they pass by insensible transitions into each other.

If the ground-mass contains isotropic material, this material may be developed as a *microfelsitic base*, i. e. showing no polar-

ization and no glass, but consisting entirely of granules, scales and thread-like forms; or as a *glassy base*, i. e. a glass with products of devitrification; or as a pure *glass* without any of these devitrification products.

I would not pretend to base any distinction in nomenclature upon differences between these three latter forms of ground-mass. They are exceedingly interesting and important as showing at precisely what stage molecular freedom of motion was arrested in the cooling magma; or if one will, the precise stage of subsequent molecular rearrangement in the "older" rocks. But the distinction cannot invariably be sharply drawn between them.

One can however at once distinguish sharply between the *presence* or *absence* of isotropic material in the ground-mass, and upon this a distinction in nomenclature can safely be based. Bearing in mind the terms thus defined, I will illustrate the use that can safely be made of rock-texture, by applying it to the series of rocks having obsidian at one extreme and granite at the other, including thus the liparites and quartz porphyries.

If the rock is to the unaided eye distinctly and completely granular, it would be "granite." If some of the constituents were developed in larger crystals than the rest it could be indicated by the term "porphyritic granite." If the size of the granules diminished until the rock became compact and the texture were micro-crystalline or crypto-crystalline, it could be called with Rosenbusch "microgranite," and if porphyritic, "porphyritic microgranite." If the ground-mass contained isotropic material it would be desirable to distinguish between two cases; first, where the crystalline portion is in excess (the "quartz porphyries"), second, where the isotropic portion is in excess ("the obsidian porphyries.") I would call the first kind "quartz porphyry" whether the base were microfelsitic, glassy or pure glass. Or the trivial name "liparite" could be used, with the understanding however that the name should always indicate the presence of base in the ground-mass with disseminated crystals in excess. The "obsidian porphyries" could be distinguished, if desirable, as "microlitic obsidian porphyry," "felsitic obsidian, porphyry" and "glassy obsidian porphyry" according as the base showed a microlitic differentiation (as in the "younger" pitchstones), a felsitic devitrification (as in the "older" pitchstones) or remained in a purely glassy state. Finally when no recognizable crystalline minerals were present, the term "obsidian" could be used, and, if desirable, we could also distinguish "microlitic obsidian" (trachyte pitchstone), "felsitic obsidian" (felsite pitchstone) and "glassy obsidian."

Subjoined is a table of the terms I have thus constructed,

opposite to each the term Rosenbusch has applied to the same mineralogical and textural aggregate.

<i>Jackson.</i>	<i>Rosenbusch.</i>
Granite,-----	{ Granite.
Porphyritic granite,-----	{ Granitic liparite (in part).
	Porphyritic granite.
Microgranite,-----	{ Microgranite.
	Felsite fels.
Porphyritic microgranite,-----	{ Quartz porphyry.
	{ Granitic liparite (in part).
Quartz porphyry,-----	{ Liparite.
	Felsophyr.
	{ Vitrophyr (in part).
Obsidian porphyry {	microlitic,-----Trachytic pitchstone porphyry.
	felsitic,-----Felsitic pitchstone porphyry.
	glassy,-----Vitrophyr (in part).
Obsidian {	microlitic,-----Trachytic pitchstone.
	felsitic,-----Felsitic pitchstone.
	glassy,-----Obsidian.

In these names which I have thus suggested, the much abused term "porphyry" obtains a perfectly definite meaning; it indicates always the presence of determinable crystalline constituents and of a base, which is of course always isotropic. The term "porphyritic" would be used only in the macroscopic sense. These names are as much as possible descriptive; trivial names could be substituted throughout but, as I have said before, I think such names should never be coined where a convenient descriptive one will answer the same purpose. It will be observed that, following the principles previously laid down every possible textural aggregate in the series has received a name, that each has received but *one* name, that, consequently, the same name is never applied to aggregates that are objectively distinct, and finally that they are based upon distinctions about which there can be no differences of opinion.

In a similar manner these textural distinctions could be applied to every similar rock-series and perfect uniformity and consistency established throughout.

I have discussed in the present chapter only the most general considerations. Even if the principle of a strictly mineralogical nomenclature were accepted, the exact part which the different essential rock-constituents would play therein would still remain to be determined. The discussion of this question is premature, however, until the more fundamental proposition is recognized.

It seems to me clear that a rock-nomenclature founded upon purely chemical or geological or upon mixed chemical or geological principles either with each other, or with mineralogical principles, necessarily *must* lead, as it certainly *has* led, to much

confusion in the science; and that we can only hope for a satisfactory, uniform and consistent nomenclature when based upon mineralogical grounds alone. It is only thus that an exact system of names can arise that can give worthy expression to the exact work that is now being done in this department of geology. Until some such uniform system is established we must continue to waste our energies in struggling to understand one another when the real difficulty is not with the *facts* but with the *terms* in which we express them. The energies expended in this effort would be far more profitably utilized in advancing our knowledge of the facts themselves.

Justin Roth says that Petrography as a descriptive science loses all significance.* True, but it must be remembered that the purely *descriptive* stage of a science must always precede the *scientific* stage; and that the latter stage is only possible after the former has become *exact*. Whatever conduces to exactness of expression in descriptive petrography will add greatly to the *scientific* usefulness of this branch of geology in helping to solve many of the profoundest problems that engage the attention of the geological thinker of the present day.

CHAPTER II.

It will be observed that I refrain from any attempt to frame a system of names in accordance with the principles I have laid down. I do this because I think that no new name should be introduced into a science unless it is tolerably sure of being accepted in the sense in which it is proposed. Names are used to promote *clearness* and not *confusion* and unless this end can be attained it is better to refrain entirely from their introduction. The reformation of the entire nomenclature of a science is a task that should be attempted only by one who has gained authority by long years of special work, by one who is universally recognized as fitted for the undertaking. There are but one or two men living who could hope to succeed.

All that can be hoped for under the circumstances is that every writer should use the *same* nomenclature; *uniformity*, even if based upon principles that all will not accept as valid, is of the first importance. It is better that each should forego the luxury of insisting upon individual idiosyncracies, which in the majority of cases can never hope to become currently accepted than that by so doing he should add to the existing confusion. Just as strongly as Capt. Dutton † would insist upon

* Gest. Anal., 1873, p. 90. Die Petrographie, welche nicht mit den beschreibenden Zweigen der Naturwissenschaft in einer Reihe gestellt werden kann, gewinnt nur durch die Unterordnung unter die geologische Forschung ihre Bedeutung.

† Geol. of High Plateaus, p. 85.

the duty of each to express his ideas in the form of a classification, just so strongly would I insist upon the duty of each to refrain from using a name in a different sense from that in which it was originally proposed, or from that which is already current.

In selecting a nomenclature, that one should be chosen which is embodied in a convenient form accessible to all, which is freest from inconsistencies, and which has already attained the widest recognition. No American author, nor English, nor French can pretend to claim that his names are authoritative even in his own country. Germany if not the mother is at least the foster-mother of petrography and the literature of every other country is small compared with her own. In Germany two men—Zirkel and Rosenbusch—have won the highest recognition for their contributions to this branch of geology. Zirkel's "*Lehrbuch der Petrographie*" (1866) while still the best for field petrography is already too old to represent the present condition of the science. Of more recent works, Zirkel's "*Mikroskopische Beschaffenheit der Mineralien und Gesteine*" (1873) and Rosenbusch's "*Mikroskopische Physiographie der massigen Gesteine*" (1877) are most worthy of being cited. The latter is later and goes more systematically over the entire field. I think Rosenbusch's names are better chosen and capable of better defense than Zirkel's, where they differ. I shall follow Rosenbusch in the series of papers which I propose to present to the Academy of Sciences of California on the rocks of the Pacific coast.

SUMMARY.

Permanence of rock-names is desirable; hence names should not be dependent in any manner upon the system of rock-classification, for classifications change.

The names of rocks should be *uniform*, i. e., used in the same sense by all geologists; they should be *stable*, i. e., not subject to change; they should be *adaptable*, i. e., to the somewhat variable nature of each rock.

In forming rock-names both *facts* and *theories* offer themselves as determining elements. The latter should be rejected as they admit of honest differences of opinion. Of facts, we have chemical, geological and mineralogical at our disposal.

Both chemical and geological facts should be rejected in determining rock-names, because mineralogical (and textural) differences among massive crystalline rocks can be adequately expressed by a purely mineralogical (and textural) nomenclature, and where such differences do not exist, it is undesirable to have names based upon geological or slight chemical differences.

It is only by the adoption of names based upon purely mineralogical differences that we can hope to obtain a nomenclature that shall conform to the three fundamental principles of Uniformity, Stability, and Adaptability.

As it is not to be hoped that a sweeping reform in petrographical nomenclature can be carried out at once, the good of the science requires that at least the first and most important of these principles, viz: Uniformity, should be recognized and in conformity therewith that all should use some one published and easily accessible system of names until a *better* complete system of names can be offered with some chance that it may be generally adopted.

In the opinion of the writer, the nomenclature of Rosenbusch as recorded in his "Massige Gesteine, 1877," is the most widely recognized and the best now accessible.

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