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A REPORT OF WORK DONE

IN THE

DIVISION OF CHEMISTRY AND PHYSICS

MAINLY DURING THE

FISCAL YEAR 1888-'89

F. W. CLARKE, Chief Chemist

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PREFACE.

The present bulletin represents work finished in the Division of Chemistry and Physics during the fiscal year 1888–'89, and resembles in general design and purpose its predecessors, Nos. 9, 27, 42, 55, and 60. It covers, however, only a part of the work actually accomplished, for some investigations are not yet completed, others will appear in special bulletins now in course of preparation, and many analyses will be published in forthcoming reports of the field geologists.

F. W. CLARKE,
Chief Chemist.

WORK DONE IN THE DIVISION OF CHEMISTRY AND PHYSICS IN 1888-'89.

A THEORY OF THE MICA GROUP.

By F. W. Clarke.

Ever since its publication in 1878,[1] in spite of a few dissentient voices, Tschermak's theory of the mica group has been generally in vogue. Nevertheless, upon careful inspection, the theory seems open to serious objections. In brief, omitting details for the present, Tschermak regards the micas as made up of four fundamental molecules; to which the following formulæ are assigned:

1. $R'_6Al_6Si_6O_{24}$.
2. $Mg_{12}Si_6O_{24}$.
3. $H_8Si_{10}O_{24}$.
4. $F_{24}Si_{10}O_8$.

R′ stands obviously for K, Na, Li, or H; Mg is equivalent to Fe″, and aluminum may be replaced by ferric iron. The first of these formulæ represents fairly well the composition of normal muscovite and paragonite; the only objection to it being that, as used by Tschermak, it assumes the double atom of quadrivalent aluminum. Since it has been proved by Nilson and Petterson, Combes, Quincke, and others, that aluminum is truly trivalent, the formula should become $R'_3Al_3Si_3O_{12}$; which, as I have shown in several previous papers, may be regarded as a substitution derivative of normal aluminum orthosilicate.

The second, third, and fourth of Tschermak's formulæ represent hypothetical compounds, the second being a polymer of chrysolite, to which, in nature, some varieties of talc offer the nearest approximation. The third and fourth formulæ are analogous to no known substances, and are, moreover, improbable chemically. No mica, by itself, resembles in composition either of the three. One formula, then, corresponds to an observed mineral, while the others are purely speculative; a state of affairs which is not altogether satisfactory. Furthermore, the four formulæ represent as many distinct chemical types, whereas it would seem as if all the true micas should be reducible to one general form, under which their isomorphism would be more readily intelligible.

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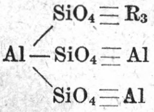
[1] Ber. Wien. Akad., vol. 78, p. 5. Zeitschr. Kryst., vol. 3, p. 122.

There is still another objection to Tschermak's system of formulæ, which, if sustained by future investigation, will be fatal. Under his theory the ratio of oxygen to silicon in the micas can never exceed four to one; while the published analyses of micas often show values far higher, ranging in some cases nearly up to five. In certain instances, as Tschermak himself suggests, this excess of oxygen over the orthosilicate ratio may be due to water inclosed between micaceous laminæ; and in other cases it may indicate partial alteration. There are micas, however, in which neither of these explanations appears to be satisfactory, and the weight of evidence goes to show that the excess of oxygen is essential. If this be true, Tschermak's theory is so far inadequate, for to such micas it can not apply without serious modification. The question can only be settled experimentally, but at present the objection raised by it can not be ignored. Some of its details will be considered later.

Now, in order to conclusively replace Tschermak's theory by something better, two fundamental conditions must be satisfied. First, all micas, with the possible exception of the pseudomica, margarite, should be reducible to one general type of formula, which shall express all known relations equally well with the formulæ proposed by Tschermak. Secondly, hypothetical compounds must be so far as possible avoided, and admitted into consideration only when their assumption can be shown to be absolutely necessary. The chief difficulties to be overcome are the variations in the silicon-oxygen ratio, and the presence of fluorine in many common micas.

In a number of papers published during the past four years,[1] I have sought to show that all orthosilicates containing aluminum may be represented as substitution derivatives of the normal salt $Al_4(SiO_4)_3$. Muscovite can be so derived, theoretically, through the replacement of one aluminum atom by R'_3; and in many other cases we have equal simplicity of expression. The ferro-magnesian micas, the phlogopites, and the lepidolites, however, are less simply derived; and I have in certain cases suggested a linking together of two orthosilicate nuclei to the group $Al_2(SiO_4)_5$ in order to account for their formation. I am now inclined to believe, however, that all the true micas are referable to the same general type, and have discussed nearly one hundred published analyses from that point of view. If we take magnesium as a generic representative of the bivalent metals, and give univalent elements or groups the general symbol R, we can imagine the following derivatives of $Al_4(SiO_4)_3$ as easily possible:

1.



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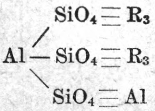

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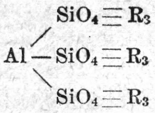

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[1] Am. Jour. Sci., Nov., 1886, and Aug., 1887. Also, Am. Chem. Jour., vol. 10, p. 120 (March, 1888).

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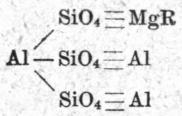

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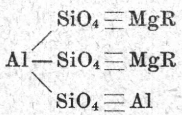

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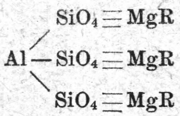

To these we may add, as No. 7, the compound $Al_2(SiO_4)_6Mg_9$, the bivalent analogue of No. 3, and identical in type with it. Now, so long as we have only orthosilicate micas to consider, these seven formulæ cover all their variations in composition; provided that fluorine, when present, is represented either by $-Mg-F$ or $-Al=F_2$, univalent groups which are included under the general symbol R'. Most of the micas appear as intermediate mixtures of these presumably isomorphous types. No. 1 represents muscovite and paragonite, and No. 6 agrees tolerably with some phlogopites. No. 2 may be resolved into a mixture, in equal molecules, of No. 1 and 3; and similarly No. 5 may be regarded as composed of Nos. 4 and 6. Nos. 5 and 6, moreover, may be simplified into mixtures between 3 and 7, so that numbers 1, 3, 4, and 7 represent all the necessary relations. Even No. 4 is possibly superfluous.

So much for the normal orthosilicate micas. But in the lepidolites, phlogopites, and some muscovites, the oxygen silicon ratio is low; and in the lepidolites especially it approximates more or less closely to the metasilicate type. This order of variation is clearly established, while variations in the opposite direction, that is toward excess of oxygen, may be questionable. If, however, in any mica the oxygen can be properly in excess of SiO_4, that excess may be fairly regarded as present in the group $-Al=O$, which is obviously equivalent to $-Al=F_2$, and takes place with the latter as a part of R'. Examples of this kind are given in one of my former papers.[1] In all such cases the system of formulæ proposed above applies perfectly, and needs no qualification. The variations in R' always fall within its limits.

The lower values for the silicon-oxygen ratios are explicable as follows: The polysilicic acid $H_4Si_3O_8$, which, like H_4SiO_4 is tetrabasic, is represented in nature by orthoclase and albite. In anorthite we have an orthosilicate, and its mixture with albite gives, as is well known to all mineralogists, the intermediate triclinic feldspars in which pseudo-metasilicate ratios often appear. $H_4Si_3O_8+H_4SiO_4=H_8Si_4O_{12}=4H_2SiO_3$. If we assume a similar state of affairs among the micas, and regard orthosilicates and polysilicates as isomorphously miscible, the lepidolites and other low oxygen micas are completely accounted for. We have then the same system of general formulæ for all micas, the normal salts $Al_4(SiO_4)_3$ and $Al_4(Si_3O_8)_3$ being the theoretical starting points for derivation. In every case the composition of a mica becomes reducible to the one general type, under the proposed theory of substitution. Representing the groups SiO_4 and Si_3O_8 by the common symbol X, the micas all fall within limits indicated by the formulæ $Al_3X_3R'_3$, and $AlX_3R'_9$. We may test this principle and the preceding formulæ by application to actual examples, taking the different micas group by group.

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[1] Am. Jour. Sci., Aug., 1887, p. 131.

MUSCOVITE.

This mica, the most typical and most abundant of all, is also the simplest chemically. It is best represented by formula No. 1, which, in its special application, becomes ordinarily $Al_3(SiO_4)_3KH_2$, with some variation in the ratio of K to H. In most cases muscovite contains small amounts of magnesia and ferrous iron; and if these are deducted, as shown in formula No. 6, the residue agrees still better with formula No. 1. Fluorine is often present in small quantities, and appears to vary in relation to hydrogen, being the lowest when the latter is high, and the reverse. Hence it is probable that the group AlF_2 replaces H rather than K. This is shown more clearly among the lepidolites, in which fluorine reaches a maximum, while the proportion of water is almost insignificant.

Some muscovites, however, vary from the normal compound in that they contain more silicon and less oxygen; thus approaching somewhat to lepidolite. These micas, which Tschermak has called "phengites," are represented by him as mixtures of $Al_6R'_6Si_6O_{24}$ with $H_8Si_{10}O_{24}$ in the ratio of three to one. It is simpler, however, to follow out the analogy offered by the feldspar group, and to assume the existence in muscovite of the isomorphous compound $Al_3(Si_3O_8)_3KH_2$. True, this compound has not been found by itself in nature, and so far its assumption is objectionable. But the compound $H_8Si_{10}O_{24}$ is also non-existent, is different in type from ordinary muscovite, and is not easily conceivable as a definite entity. The alternative which I offer for it is therefore, it seems to me, more philosophical and more satisfactory; and it accounts completely for all the oxygen variations in muscovite. For the sake of brevity, however, we may well retain the name of *phengite* in our vocabulary, and may speak of micas containing the Si_3O_8 group as more or less *phengitic*.

In order to show the method of discussion which I have employed, we may take the four muscovite analyses considered by Tschermak. A, muscovite from Bengal, analyzed by Blau; B, East Indies, by Sipöcz; C, Rothenkopf in the Zillerthal, by Sipöcz; D, Soboth in Steiermark, by Löbisch. Of these, C and D are phengites.

	A.	B.	C.	D.
SiO_2	45.57	45.71	45.87	48.76
Al_2O_3	36.72	36.57	30.86	29.91
Fe_2O_3	.95	1.19	5.70	4.24
FeO	1.28	1.07	1.69	.41
MgO	.38	.71	1.56	2.63
CaO	.21	.46	.23	.33
K_2O	8.81	9.22	9.07	6.83
Na_2O	.62	.79	.54	2.31
Li_2O	.19			
H_2O	5.05	4.83	4.60	4.60
F	.15	.12		
	99.93	100.67	100.12	100.02

Now, computing the molecular ratios in the usual way, uniting ferric oxide with alumina, ferrous iron and lime with the magnesia, and consolidating the alkalies under the general symbol R'_2O, we have the following empirical formulæ for the four micas:

A. $Al_{732}Mg_{30}R'_{220}H_{560}F_6Si_{759}O_{3027}$.
B. $Al_{732}Mg_{39}R'_{222}H_{536}F_6Si_{762}O_{3037}$.
C. $Al_{676}Mg_{66}R'_{212}H_{512}Si_{765}O_{2972}$.
D. $Al_{634}Mg_{78}R'_{220}H_{512}Si_{813}O_{3021}$.

Regarding the fluorine as AlF_2, and uniting it and the H with R′, these formulæ become, almost exactly:

A. $Al_{729}Mg_{30}R'_{783}(SiO_4)_{753}(Si_3O_8)_2$.
B. $Al_{729}Mg_{39}R'_{761}(SiO_4)_{753}(Si_3O_8)_3$.
C. $Al_{676}Mg_{66}R'_{724}(SiO_4)_{699}(Si_3O_8)_{22}$.
D. $Al_{634}Mg_{78}R'_{732}(SiO_4)_{642}(Si_3O_8)_{57}$.

Combining the two acid groups under the indiscriminate symbol X, we have:

A. $Al_{729}Mg_{30}R'_{783}X_{755}$.
B. $Al_{729}Mg_{39}R'_{761}X_{756}$.
C. $Al_{676}Mg_{66}R'_{724}X_{721}$.
D. $Al_{634}Mg_{78}R'_{732}X_{699}$.

These are equivalent to the following mixtures of the isomorphous salts represented by the general formulæ 6, 3, and 1, in the fundamental system above cited:

A. $10\ AlX_3Mg_3R'_3+4\ AlX_3R'_9+238\ Al_3X_3R'_3$.
B. $13\ AlX_3Mg_3R'_3+239\ Al_3X_3R'^3$.
C. $22\ AlX_3Mg_3R'_3+218\ Al_3X_3R'_3$.
D. $26\ AlX_3Mg_3R'_3+7\ AlX_3R'_9+200\ Al_3X_3R'_3$.

In each case the final formulæ vary from the original ratios only to an extent which is ascribable to the minute residual errors of calculation. The new expressions conform perfectly to the evidence of analysis. Eight other muscovite analyses, similarly discussed, gave strictly similar and equally sharp results.

LEPIDOLITE.

In this species, the most phengitic of all the micas, we find little water, high fluorine, and a very notable proportion of lithia. It always occurs with muscovite, and commonly implanted upon the latter in such a way as to clearly indicate its later formation. In composition it is regarded by Tschermak as a mixture of $Al_6K_6Si_6O_{24}$ with $F_{24}Si_{10}O_8$, the former being about half replaced by the corresponding $Al_6Li_6Si_6O_{24}$, and the latter in part by $H_8Si_{10}O_{24}$. The objections to this interpretation have already been pointed out.

Under the new mode of interpretation, lepidolite becomes much simpler. In every case, if we eliminate traces of magnesia and iron, as was done under muscovite, the residue corresponds sharply to a mixture of the two molecules $AlX_3R'_9$ with $Al_3X_3R'_3$, X representing

Si_3O_8 and SiO_4 indiscriminately. In the purest lepidolites these molecules are in the ratio 1 : 1, corresponding to $Al_2X_3R'_6$; but in general the second molecule is slightly in excess, due to small admixtures of normal muscovite. In the discussion of fourteen published analyses of lepidolite the ratio $Si_3O_8 : SiO_4$ varies from 1 : 1 to 1 : 3; and the sum of $Li + AlF_2$ appears to be directly related to the proportion of Si_3O_8. In brief, expanding the general formulæ given above, typical lepidolite may be expressed by the two compounds $Al_3(SiO_4)_3KHLi$ and $Al(Si_3O_8)_3K_3Li_3(AlF_2)_3$ in equal molecules. All the variations may be accounted for by admixtures of muscovite, with sometimes a trivial amount of the magnesium or iron salt, No. 6, as an impurity.

For purposes of illustration, four of the lepidolite analyses may be considered in detail, as follows: E, from Rozena, by Berwerth,[1] F, Juschakova, by Rammelsberg;[2] G, Schüttenhofen, by Scharizer;[3] H, white lepidolite from Norway, Maine, by Riggs.[4]

	E.	F.	G.	H.
SiO_2	50.98	50.96	49.26	49.52
Al_2O_3	27.80	22.20	25.26	28.80
Fe_2O_3	....	....	....	.40
Mn_2O_3	....	5.38	....	....
MnO	....	....	.85	.07
FeO	.05	....	.84	.24
MgO	....	....	....	.02
CaO	....	....	....	.13
K_2O	10.78	11.39	13.85	12.63
Na_2O	....	.32	.35	.13
Li_2O	5.88	5.65	5.38	3.87
H_2O	.96	....	1.76	1.72
F	7.88	8.58	5.68	5.18
P_2O_5	.05	....	....	....
SnO_2	....	....	.06	....
	104.38	104.48	103.29	102.71
Less O	3.32	3.61	2.38	2.18
	101.06	100.87	100.91	100.53

Disregarding trivial impurities, and computing the ratios as before, we have from these analyses the subjoined empirical expressions:

E. $Al_{347}K_{230}Li_{392}H_{106}(AlF_2)_{207}(Si_3O_8)_{181}(SiO_4)_{306}$.
F. $Al_{280}K_{252}Li_{376}(AlF_2)_{226}(Si_3O_8)_{212}(SiO_4)_{212}$.
G. $Al_{345}R''_{24}K_{250}Li_{358}H_{196}(AlF_2)_{149}(Si_3O_8)_{156}(SiO_4)_{353}$.
H. $Al_{434}R''_7K_{272}Li_{258}H_{192}(AlF_2)_{136}(Si_3O_8)_{141}(SiO_4)_{403}$.

Condensing, these become:

E. $Al_{347}R'_{935}X_{487}$.
F. $Al_{280}R'_{854}X_{424}$.
G. $Al_{345}R''_{24}R'_{953}X_{509}$.
H. $Al_{434}R''_7R'_{858}X_{544}$.

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[1] See Tschermak's paper, l. c.

[2] Wiedemann's Annalen, vol. 7, p. 143.

[3] Zeitschr. Kryst., vol. 13, p. 467.

[4] Am. Jour. Sci., Nov. 1886.

Whence we get, very nearly:

E. $70\ AlX_3R'_9+92\ Al_3X_3R'_3$
F. $71\ AlX_3R'_9+70\ Al_3X_3R'_3$.
G. $8\ AlX_3R''_3R'_3+75\ AlX_3R'_9+87\ Al_3X_3R'_3$.
H. $2\ AlX_3R''_3R'_3+52\ AlX_3R'_9+127\ Al_3X_3R'_3$.

Two other highly fluoriferous lithia micas, cryophyllite and zinnwaldite, may properly be considered here. For the former we have Riggs's analysis, and for the latter, analyses by Berwerth and Rammelsberg. From these analyses we get the following empirical formulæ: 1, Riggs, cryophyllite; 2 and 3, Berwerth and Rammelsberg, zinnwaldite.

1. $Al_{186}Fe''_{94}K_{256}Li_{324}H_{146}(AlF_2)_{178}(Si_3O_8)_{227}(SiO_4)_{185}$.
2. $Al_{239}Fe''_{186}K_{236}Li_{218}H_{102}(AlF_2)_{209}(Si_3O_8)_{151}(SiO_4)_{312}$.
3. $Al_{244}Fe''_{167}K_{242}Li_{224}H_{116}(AlF_2)_{200}(Si_3O_8)_{156}(SiO_4)_{306}$.

Condensing these formulæ they become:

1. $Al_{186}Fe_{94}R'_{904}X_{412}$.
2. $Al_{239}Fe_{186}R'_{765}X_{463}$.
3. $Al_{244}Fe_{167}R'_{782}X_{462}$.

Expanding again, these formulæ give:

1. $31\ (AlX_3Fe''_3R'_3)+81(AlX_3R'_9)+25(Al_3X_3R'_3)$.
2. 62 " +49 " +43 "
3. 56 " +53 " +45 "

The component molecules here correspond essentially to Nos. 6, 3, and 1 of the fundamental series, the last one in each expression being muscovite. Whether the separate components of R′ and X can be distributed with certainty among the several molecules is an outstanding question; but not, I believe, an unanswerable one.

PHLOGOPITE.

In order to ascertain the composition of this mica I have discussed the four analyses cited by Tschermak (l. c.), and three of Rammelsberg's.[1] All of these are fluoriferous, and all but one are phengitic, the exception in the latter case being the Edwards, N. Y., mineral, which Tschermak regards as somewhat altered. I have also considered the new phlogopite from Edwards, recently described by Penfield,[2] which is remarkable as being free from fluorine.

In general, phlogopite agrees closely with the formula $AlX_3Mg_3R'_3$, but there are often variations which are not easy to explain, and which are greater than can be accounted for by presumable errors of analysis. They may be due in part to impurities arising from the great alterability of the mineral; but I am inclined to trace the difficulties to other sources.

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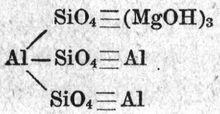
[1] Wiedemann's Annalen, vol. 9, p. 129.

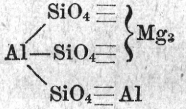
[2] Am. Jour. Sci. (3), vol. 36, p. 329.

In order to satisfy the conditions of the formulæ proposed by me, it is necessary that the aluminum atoms, apart from AlF_2, shall be in number at least one-third of X; but in several phlogopites the alumina is too low to fulfill this requirement, and the difficulty is best obviated by assuming an MgF group in place of AlF_2. In Penfield's phlogopite, however, there is no fluorine, and yet the alumina is considerably—about two per cent—too low. If we suppose in his mineral, which came from a talc mine, a small admixture of talc, the residue agrees with the theoretical formula, X being wholly SiO_4; but if that impurity is absent we must assume that the mica differs from ordinary phlogopite by containing the group —Mg—OH instead of the usual MgF. The composition of the mineral then reduces to the uniform type. I am now disposed to believe that phlogopite differs from the other micas in that it contains these special groups MgF and MgOH, both as part of R′; but the supposition is not yet fully justified. It is, however, I think, susceptible of experimental investigation, and a laboratory research upon the problem is now being carried out under my direction. Apart from that, the supposition is strengthened by the composition of certain vermiculites, some of which have certainly been formed by the alteration of phlogopite. Three of these interesting minerals are represented fairly well by the subjoined formulæ, in which ferric iron, present in small quantities, has been reckoned with the alumina.



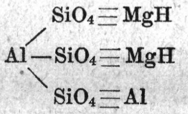
$+3H_2O$.

Dudleyite.



$+3H_2O$.

Culsageeite.



$+3H_2O$.

Jefferisite.

It is by no means certain that the vermiculites are so simple in composition or so definite as these symbols would seem to indicate; but the formulæ are decidedly suggestive, and they show how clearly the relations between the micas and their derivatives may be expressed.

THE FERRO-MAGNESIAN MICAS.

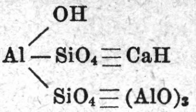
This group of micas, which includes biotite, lepidomelane, annite, haughtonite, siderophyllite, and other supposed species, is apparently quite complex. In place of magnesia, ferrous iron is often predominant; in the lepidomelanes, ferric iron replaces aluminum, and in forty-four out of the fifty-six analyses discussed, the oxygen was in excess of SiO_4. Only seven of these micas appeared to be phengitic; and only sixteen of the analyses reported fluorine in small quantities. In six instances AlO and AlF_2, were both absent.

For thirty-four of the micas in this group, formulæ could be easily computed upon the lines already followed; that is, in each case the composition was represented by a mixture of $AlX_3R''_3R'_3$ with $AlX_3R'_9$ and $Al_3X_3R'_3$, the second or third of these molecules being occasionally absent. Among the lepidomelanes there was an approximation to a distinctively muscovitic type; and in two cases formula No. 4, $Al_3X_3R''R$, seemed to apply. With each mica an attempt was made to determine the proportions of the several admixed molecules; but the results, although numerically conformable to the general theory, were not absolutely conclusive. The chief difficulty lay in the uncertainty attaching to the water determinations, upon which the question of oxygen excesses depends. Since water has a low molecular weight, a small error in its estimation becomes relatively large in the molecular ratios, and two sorts of errors are presumable: First, an excess of water may be inclosed mechanically in the material analyzed, and secondly, a determination by simple ignition is likely to be too low because of the oxidation of ferrous iron. If these errors occur together, they obviously tend to compensate each other; but either one alone seriously affects the co-efficient of R′, and appears in the ratio between $Al_3X_3R'_3$ and $AlX_3R'_9$.

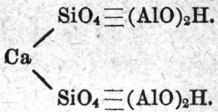
In twenty-two of the fifty-six analyses, however, the symbol $AlX_3R''_3R'_3$ failed to account for all the bivalent metals, iron and magnesium. In these cases R″ was in excess of R′, and it became necessary to make use of formula No. 7, $Al_2(SiO_4)_6R''_9$. With the aid of this expression all the ferro-magnesian micas, without a positive exception, including the phlogopites, were resolvable into mixtures of $Al_3X_3R'_3$, $AlX_3R'_9$, and $Al_2X_6R''_9$. Upon this basis formula No. 6 becomes useless, for $AlX_3Mg_3R'_3$ is evidently equivalent to a mixture, in equal molecules, of $AlX_3R'_9$ and $Al_2X_6Mg_9$. All micas, then, so far as the analyses are authentic, may be represented as mixtures of the molecules 1, 3, and 7, these being symbols of one and the same general type. The magnesium (or ferrous) salt thus assumed, moreover, is not absolutely hypothetical; for, with six molecules of water of crystallization added, it approximates to certain individuals of the chlorite group. Some examples of penninite, for instance, approach rather closely to the composition $Al_2(SiO_4)_6Mg_9 . 6H_2O$, which requires 38.71 of silica, 10.97 alumina, 38.71 magnesia, and 11.61 water. We have thus a clue to the constitution of the chlorites, by means of which they may be brought into simple relation with the micas. This problem is now under investigation, and I can only state as a probability that most of the chlorites, if not all, may be represented as mixtures of three fundamental molecules, $Al_2X_6R''_9$, $6H_2O$; $AlX_3R''_3H_3$, $3H_2O$, and $Al_2X_3(MgOH)_6$. I hope to speak more positively upon this subject before long; at present I need only point out that two of these molecules are simple hydrates of Nos. 6 and 7, while the third is covered by the general symbol No. 3, in which R'_6 becomes $(MgOH)_6$. The easy alterability of garnet, $Al_2(SiO_4)_3R''_3$ into mica and chlorite, is a suggestive bit of evidence bearing upon these expressions.

MARGARITE.

Whether this species is to be considered as a true mica or not, is perhaps an open question. Its composition is relatively simple, and is represented by the empirical formula $H_2CaAl_4Si_2O_{12}$. Structurally, this may be written in two distinct ways, as follows:



or

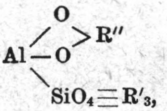


The first of these symbols derives the compound from the normal aluminum salt, and indicates a similarity of type with the micas proper. The second assumes a normal calcium salt as the point of derivation; and I am unable as yet to assign a distinct preference to either expression. A careful study of the genesis and associations of margarite may determine which of the two formulæ is the better. Possibly the occurrence of the mineral in such mixtures as euphyllite, and the probable existence of a similar barium salt in œllacherite points to the first of the two formulæ as the better. The common occurrence of margarite with diaspore also points in the same direction. Corundophilite, which occurs associated with both margarite and diaspore, also reduces to a type resembling the first margarite formula.

THE CLINTONITE GROUP.

These minerals, the so-called "brittle micas," have also been discussed by Tschermak,[1] who includes under this heading seybertite, brandisite, xanthophyllite, chloritoid, masonite, ottrelite, sismondine, and sapphirine. Physically, they are closely related to the micas proper, and to margarite in particular; but chemically they are much more basic. The first three species Tschermak regards as mixtures of the hypothetical compounds $H_2CaMg_4Si_3O_{12}$ and $H_2CaMgAl_6O_{12}$; to chloritoid he assigns the composition $H_2Si_2Fe''_2O_7, \times H_2Al_4O_7$, and sapphirine he represents by the formula $Si_2Mg_2O_6+Al_6Mg_2O_{11}$.

Using the analyses cited by Tschermak, I find that all these minerals, with the possible exception of sapphirine, may be represented by the general expression



which is clearly and directly related to the formulæ already assigned to the micas and to margarite, and in which the mode of union of R″ with Al, when R″=Mg, suggests the common association of members of this group with spinel. In seybertite we have a mixture of

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[1] Zeitschr. Kryst., vol. 3, p. 496.

$AlO_2R''SiO_4(MgOH)_3$ with $AlO_2R''SiO_4(AlO)_3$, R'' being partly Ca and partly Mg. In brandisite we have a similar constitution, with about one-fourth of R'' replaced by H_2. In chloritoid, $R''=Fe$ and $R'_3=H_2(AlO)$; and sismondine is similar, with R'_3 possibly replaced in part by Al. The compound $AlO_2MgSiO_4(AlO)_3$, found in seybertite, is a rough approximation to sapphirine, which mineral possibly has this composition plus some impurities as yet unidentified. A wider range of analyses is needed in order to establish these formulæ completely; but they seem to have distinct advantages over the formulæ proposed by Tschermak.

CONCLUSIONS.

All the micas, vermiculites, chlorites, margarite, and the clintonite group may be simply represented as isomorphous mixtures, every constituent being a substitution derivative of normal aluminum polysilicate or orthosilicate. To the latter compound a structure may be assigned somewhat different in form from the one I have chosen, without affecting in any notable way the general system adopted. Upon this basis all the minerals named are reducible to the same general type, which accounts for observed isomorphisms, and for the relations of the micas to other species, with fewer assumptions of hypothetical compounds than are necessary under other known schemes of interpretation. In most cases the evidence is clear, direct, and conclusive; in other cases, few in number, it is at present somewhat obscure. It may be claimed, without extravagance, that the formulæ have the merit of suggestiveness, and that they form a scientific basis for future research.

A PLATINIFEROUS NICKEL ORE FROM CANADA

By F. W. Clarke and Charles Catlett.

During the autumn of 1888 we received, through two different channels, samples of nickel ores taken from the mines of the Canadian Copper Company at Sudbury, Ontario. From one source we obtained two masses of sulphides, to be examined for nickel and copper; from the other source came similar sulphides, together with a series of soil and gravel-like material, seven samples in all. In the latter case an examination for platinum was requested, and in five of the samples it was found, the gravel above mentioned yielding 74.85 ounces of metals of the platinum group to the ton of 2,000 pounds. At the outset of the investigation we were decidedly incredulous as to the existence of platinum in such ores; but the discovery of sperrylite by Mr. Wells in material from the same mines gave our work a wholesome stimulus, and the assays were carefully carried through.

The sulphide ores submitted to us from Sudbury were all of similar character. They consisted of mixed masses, in which a gray readily tarnishing substance was predominant, with some chalcopyrite, possibly some pyrite, and a very little quartz. Two samples were examined in mass; one gave 31.41 per cent of nickel with a little copper, the other gave 35.39 per cent of nickel and 5.20 of copper. The nickel mineral itself proved to be a suphide of nickel and iron, and as ores of that composition are not common, it was thought desirable to examine the substance further.

As above stated, the nickel mineral is the predominating constituent of the masses submitted for examination. It is steel gray, massive, and exceedingly alterable in the air, and its specific gravity, determined by pycnometer, is 4.541. An analysis of carefully selected material gave the following results:

Ni	41.96
Fe	15.57
SiO_2	1.02
Cu	.62
S	40.80
	99.97

Neither cobalt nor arsenic could be detected.

The foregoing figures work out sharply into the ratio R : S : : 4 : 5; and approximately into the formula Ni_3FeS_5. If we deduct silica, together with the copper reckoned as admixed chalcopyrite, and recalculate the remainder of the analysis to 100 per cent, we have the following figures:

	As found.	Calc. as Ni_3FeS_5.
Ni	43.18	44.6
Fe	15.47	14.4
S	41.35	41.0
	100.00	100.0

In short, the mineral has the composition Ni_4S_5, with *about* one-fourth of the nickel replaced by iron. The only known species with which this agrees is Laspeyres's polydymite, of which the Sudbury mineral is evidently a ferriferous variety. What relations it may bear toward beyrichite, pyrrhotite, etc., is as yet a matter of considerable uncertainty. Probably in most cases the nickeliferous constituent of pyrrhotite is millerite, but other sulphides, like the polydymite, may perhaps occur also.

The polydymite which was selected for the above analysis came from the mass in which, in average, 35.39 Ni and 5.20 Cu had previously been found. The mass weighed several kilograms, and was remarkably free from quartz. The same mass, with two smaller pieces resembling it, were also examined for platinum, by the following method: One assay ton of the finely ground ore was treated with nitric acid until all or practically all of the sulphides had been dissolved. The dried residue was then assayed in the usual manner; except that, to facilitate cupellation, a little pure silver was introduced into the lead button. From the final bead the silver was dissolved out by sulphuric acid, leaving the platinum in a finely divided gray powder. The latter dissolved easily in aqua regia, and gave all the reactions needful to identify it thoroughly. The results were as follows, "A" representing the large mass in which the polydymite was determined:

	Per cent.
A, 2.55 ounces Pt to the ton, or	0.0087
B, 1.8 ounces Pt to the ton, or	.0060
C, 7 ounces Pt to the ton, or	.0240

That the metal weighed was nearly all platinum is certain; but it may have contained small amounts of other metals of the same group. The material separated was not sufficient to warrant a search for the rarer associates of platinum. Probably the platinum exists in the ore as sperrylite, although this point was not proved. The amount of platinum in the mass most thoroughly examined would require, to form sperrylite, only about 0.007 per cent of arsenic, which is too small a quantity for detection by ordinary analysis. That platinum should exist in appreciable quantities in an ore of such character is something quite extraordinary. Whether it could be profitably extracted is an open question.

A NEW OCCURRENCE OF GYROLITE.

By F. W. Clarke.

In the autumn of 1888, during a visit to the New Almaden Quicksilver Mine in California, Dr. D. T. Day, of the U. S. Geological Survey, was shown specimens of a mineral which was locally supposed to be white fluor-spar. It occurred in well-developed crystals lining crevice veins in the mine, and was easily recognizable as apophyllite. Dr. Day secured a good series of the specimens, and finally turned them over to me for examination. The largest crystals were about two centimeters in diameter, and fairly transparent, and grew out of crystalline masses of considerable thickness, the exposed definite faces nearly meeting at the center of the seam or vein. All of the specimens were saturated with bituminous matter, but except for that staining they were quite colorless.

In several of the specimens received the wall of the seam was distinctly shown, and between it and the crystalline apophyllite there was a fibrous layer from one to three centimeters in thickness. That layer was also colorless, except for bituminous staining, and on account of its relations to the apophyllite it appeared to deserve investigation. A sufficient quantity of the material having been selected, it was digested for about twenty-four hours with ether in order to cleanse it from bitumen, and then analyzed. I give the result in comparison with How's figures for a Nova Scotia gyrolite:

	Clarke.	How.
H_2O	14.60	15.05
SiO_2	52.54	51.90
Al_2O_3	0.71	1.27
Fe_2O_3		....
CaO	29.97	29.95
MgO	....	0.08
K_2O	1.56	1.60
Na_2O	0.27	....
F	0.65	....
	100.30	99.85
Less O	0.27	....
	100.03	....

It will at once be seen that the two analyses, except for the small amount of fluorine, coincide quite sharply, and establish the New Almaden mineral as gyrolite. The Nova Scotian gyrolite is also associated with apophyllite, from which species How supposed it to be derived.[1] In the present instance, however, the relative position of the two minerals in the vein suggests that the gyrolite is the older; and that the apophyllite may have been formed from it by a partial solution and redeposition of its material through the agency of waters containing alkaline fluorides. The gyrolite is obviously not absolutely pure, but it agrees approximately with the formula $Ca_2Si_3O_8 . 3H_2O$. Its chemical structure and relations to apophyllite are not altogether clear.

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[1] Am. Jour. Sci, (2), vol. 32, p. 13.

ANALYSES OF THREE DESCLOIZITES FROM NEW LOCALITIES.

BY W. F. HILLEBRAND.

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1. MAYFLOWER MINE, BALD MOUNTAIN MINING DISTRICT, BEAVERHEAD COUNTY, MONT.

Through Messrs. W. H. Beck and George E. Lemon, of Washington, D. C., was received about a year ago for examination a large lump of friable, uncrystallized material, having a dull yellow to pale orange color, and consisting chiefly of a vanadate, but carrying a large percentage of gangue. Two samples as pure as could be selected from different parts of the lump were analyzed with the following results:

	I.	II.	Mean.	Molecular ratios.		
PbO	56.02	55.84	55.93	.2508	.4718	4.02
CuO	1.16	1.13	1.15	.0145		
FeO	0.70	0.70	0.70	.0097		
ZnO	15.96	15.91	15.94	.1968		
V_2O_5	....	20.80	20.80	.1140	.1173	1.00
As_2O_5	0.32	....	0.32	.0014		
P_2O_5	0.27	....	0.27	.0019		
H_2O	4.37	4.36	4.37	.2428	......	2.07
SiO_2	0.20	0.16	0.18			
CaO	0.10	....	0.10			
MgO	0.06	....	0.06			
			99.82			

From I 27.62 per cent of gangue insoluble in cold dilute nitric acid has been deducted, and from II 22.20 per cent; manganese was present in the gangue in small quantity, apparently as pyrolusite, but it was not dissolved by the acid. The insoluble portion was found also to retain very small quantities of lead and zinc, which were estimated and included in the analysis as probably belonging to the vanadate. The water had to be estimated indirectly by deducting from the total amount of water afforded by the dried mixture of vanadate and gangue that belonged to the latter alone, which was found as follows: The mixture, dried at 100° C., was dissolved in cold dilute nitric acid, and the insoluble matter collected in a Gooch crucible was dried at the same temperature and then ignited. The loss on ignition gave the water in the gangue, there being no ferrous iron in the latter to influence the result. The traces of SiO_2, CaO, and MgO may be neglected as probably derived from the gangue. The water, it will be noticed, is double that required by descloizite, $R_2(OH)VO_4$, but in view of the liability to error inherent in the method of water estimation employed, this is not deemed sufficient cause for separating the mineral from descloizite, although the close agreement of the two water determinations, made as they were on samples containing different proportions of gangue, would indicate the correctness of the formula $2[R_2(OH)VO_4]+H_2O$.

Other specimens have since been received from the above-named persons in which the earthy vanadate was associated sometimes with compact cerussite and galena in process of alteration. A dull reddish substance which constituted a part or even the whole of some lumps contained, besides silica, iron and some antimony in an oxidized condition, but carried little or no vanadium.

Prof. F. A. Genth has already called attention[1] to the occurrence of vanadinite and probably of descloizite in the Bald Mountain mine, Beaverhead County, Mont. His specimens, however, showed the supposed descloizite as a pale brownish crystalline coating on yellow ferruginous quartz, whereas the present mineral shows no evidence of crystalline structure.

2. COMMERCIAL MINE, GEORGETOWN, GRANT COUNTY, N. MEX.

This is one of the most interesting occurrences of descloizite known, because of the extreme brilliancy of coloring of the mineral. The ore bodies in the Commercial mine, as well as in the adjoining MacGregor and Naiad Queen mines, occur in limestone immediately under an overlying slate, and appear to narrow in depth where certain eruptive dikes cut through the lime, as Mr. MacIntosh, foreman of the Commercial mine, informed me. The absence of the superintendents of the several mines and the very brief visit I was forced to make prevented obtaining more certain and detailed information.

In places where the rock is most fractured and crushed the descloizite appears in greatest quantity and finest condition as an incrustation on quartz, often covering large surfaces, and in color varying from yellow through all shades of orange-red to deep reddish brown, the last-named colors predominating. The black color so frequent in descloizite from Lake Valley, N. Mex., caused by a superficial coating or admixture of pyrolusite, is, so far as my observation extended, wanting, hence specimens from Georgetown are likely to be much sought after for their showy appearance. A specimen in one of the banks at Silver City, N. Mex., taken from one of the Georgetown mines, resembled a stalactite in form. It was probably fully three feet in height by six to eight inches or more in diameter, and was deep reddish brown in color.

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[1] Proc. Am. Phil. Soc., 1887, vol. 24, p. 38.

The incrustations are for the greater part distinctly crystalline and are generally made up of aggregates of more or less globular forms of a size ranging from microscopic to a diameter of one or two millimeters. Each of these is composed of a great number of apparently flat crystals, intergrown, and projecting sufficiently from the surface to give brilliant reflections when observed under the lens, and to the naked eye a frosted appearance where the globular growths are largest. The richest reddish brown color is always coincident with this development in size. The globular character changes frequently to acicular. In such cases the incrustation seems to have originally formed on bunches of radiating acicular, almost colorless, vanadinite, which frequently appears thus coating the quartz and running under the descloizite incrustations. Sometimes the vanadinite has entirely disappeared, and then there may be a hollow through the center of the descloizite needle.

The occurrence of vanadate of lead in the MacGregor mine at Georgetown has been noticed by Professor Genth (l. c., p. 38). The specific gravity of the mineral was not determined; the hardness is about 3.5; the color of the powder is orange-yellow. An analysis gave the following results after deducting 11.91 per cent of insoluble matter, almost entirely quartz:

		Molecular ratios.			
PbO	56.01	.2512	.4843	.4788	4.12
CuO	1.05	.0132			
FeO	0.07	.0010			
ZnO	17.73	.2189			
V_2O_5	20.44	.1119	.1178	.1162	1.00
As_2O_5	0.94	.0041			
P_2O_5	0.26	.0018			
H_2O	2.45	.1361	.....	.1361	1.17
Cl	0.04	.0011			
SiO_2	1.01				
CaO	0.04				
MgO	0.03				
	100.07				

The third column of molecular ratios gives those values after allowing for admixed vanadinite calculated on the basis of the chlorine found. A further correction has probably to be made for an admixed soluble hydrous (zinc ?) silicate, which might make the ratio approximate more closely to 4 : 1 : 1.

3. LUCKY CUSS MINE, TOMBSTONE, COCHISE COUNTY, ARIZ.

Mr. W. F. Staunton, superintendent of the Tombstone Mining and Milling Company, and Mr. Frank C. Earle, assayer at Tombstone, kindly placed at my disposal for examination specimens of a vanadium mineral the identity of which had not been established. It was found in the Lucky Cuss mine as an incrustation, sometimes half an inch thick, on quartz, showing more or less botryoidal surfaces of an indefinable dull greenish color. On a fractured surface the color is brown; the luster is resinous; the structure granular, only occasionally diverging fibrous; the hardness 3.5; the specific gravity of sample analyzed containing a little impurity, 5.88 at 19° C.; color of powder lemon-yellow. Analysis gave the following results after deducting 0.67 per cent of insoluble matter:

		Molecular ratios.			
PbO	57.00	.2556	.4485	.4385	3.93
CuO	11.21	.1412			
FeO	Trace.	.....			
ZnO	4.19	.0517			
V_2O_5	19.79	.1084	.1145	.1115	1.00
As_2O_5	1.10	.0048			
P_2O_5	0.19	.0013			
H_2O	2.50	.1389	.....	.1389	1.25
Cl	0.07	.0020			
SiO_2	0.80				
CaO	1.01				
MgO	0.04				
K_2O	0.10				
Na_2O	0.17				
CO_2	0.82				
	98.99				

The low total is probably owing to a loss of zinc during analysis. Calcite was present as an impurity, and as the CO_2 just suffices for the CaO and MgO these are rejected in considering the composition of the vanadate. The figures in the third column of molecular ratios are found by allowing for probably admixed vanadinite calculated from the chlorine found. In another specimen a qualitative test for chlorine indicated a greater admixture of vanadinite. As in the case of the descloizite from Georgetown, N. Mex., previously described, a further allowance has perhaps to be made for a soluble hydrous silicate. There can be no doubt that the general formula for the vanadate is that of descloizite.

In almost every respect this mineral resembles, so far as the published descriptions allow of judging, the descloizite of Penfield,[1] the cupro-descloizite of Rammelsberg,[2] and the ramirite of de Leon,[3] perhaps also the tritochorite of Frenzel,[4] to the similarity of which with his variety of descloizite Penfield draws attention in his paper. Professor Genth's surmise (l. c., p. 39) of the specific identity of all these sub-

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[1] Am. Jour. Sci. (3), vol. 26, p. 361.

[2] Monatsb. Berl. Acad., 1883, p. 1215.

[3] La Ramirita, nueva espécie mineral, Mexico, 1885.

[4] Tschermak's Min. and Petr. Mitth., vol. 3, p. 506, 1880, vol. 4, p. 97, 1881.

stances seems highly probable. Characteristic of the present variety is the greater replacement of the lead-zinc vanadate—true descloizite—by the isomorphous lead-copper vanadate and the lessened tendency toward a fibrous structure, which in the other varieties described seems to be a decidedly pronounced feature. Possibly this last characteristic of the Tombstone mineral, if it be not accidental in view of the few specimens (three) examined, is a condition of the first.

According to Rammelsberg,[1] the lead-copper vanadate corresponding to the lead-zinc vanadate (descloizite) is mottramite or psittacinite, though it seems not improbable that it may be the chileite of Dana's Mineralogy. Domeyko's analyses,[2] which led Kenngott to ascribe the above name to the Chilian mineral, show a deficiency of 2.5 and 2.8 per cent, which may very well be V_2O_5. At all events, a recalculation of his analyses based on this assumption leads to a proportion for $PbO+CuO : V_2O_5 : H_2O$ of nearly 4 : 1 : 1.

In view of the well defined character of all these highly cupriferous varieties of descloizite it would be well to designate them once for all by some distinctive name. Tritochorite would have precedence if the substance to which that name has been given is really identical with the others, but Rammelsberg's cupro-descloizite is more appropriate as indicating at once the relationship to descloizite, and I would suggest that it be henceforth used for all cupriferous descloizites showing the physical characteristics of the mineral above described.

NOTE.—Since the foregoing was written there has appeared in the Bull. Soc. Franc. Min., Feb., 1889, p. 38, a paper by F. Pisani, in which he gives another analysis of the Mexican cupro-descloizite and discusses briefly the relations of various vanadates. The essential identity of all the above-enumerated cupriferous lead-zinc vanadates, with the addition of another—schaffnerite, concerning which I have been unable to find any further reference in mineralogical literature—is therein upheld, and the suggestion of Penfield regarding the possible identity of tritoshorite and cupro-descloizite is confirmed by Frenzel himself, who is quoted as writing to Professor DesCloizeaux that he had not thought it necessary to consider as an essential constituent the two per cent of water which he had found in tritochorite.

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[1] Chemische Natur der Mineralien, p. 32.

[2] Ann. d. Mines, IV, vol. 14, 1848, p. 150; Phil. Mag., III, vol. 34, 1849, p. 395.

A NEW METEORITE FROM MEXICO.

BY J. EDWARD WHITFIELD.

While in Mexico during the summer of 1888, Prof. H. A. Ward, of Ward and Howell, Rochester, N. Y., obtained an undescribed mass of meteoric iron weighing 33.0 kilos.

The meteorite was found on a peak of the Sierra de San Francisco, called La Bella Roca, in front of Santiago Papasquiaro, in the State of Durango. The date of its discovery and the name of the finder are unknown.

The composition of the metallic portion does not differ materially from that of other meteoric irons, as the following analysis will show:

Fe	91.48
Ni	7.92
Co	0.22
P	0.21
S	0.21
C	0.06
	100.10

A feature of the meteorite is the presence of large, deep pittings on one side; these are a little greater in diameter just below than immediately at the surface and each one has a little substance left at the bottom, which evidently is the remains of what originally filled the cavities. I succeeded in breaking from the bottom of one pitting material sufficient to determine its nature. It proved to be troilite as the analysis will show:

NiS 2.13, FeS 85.27, Fe 9.37.

The exposed surface of the troilite was greatly decomposed; this portion gave by analysis the following figures:

NiS 2.07, FeS 37.51, Fe_2O_3 37.80. Moisture, 19.85.

This decomposition gives grounds for the idea that the deep pittings were formed by the removal of troilite nodules, partly while the mass was hot and partly by the subsequent weathering.

There are nodules of troïlite throughout the entire mass of the meteorite, but none are removed so as to form pittings, on any other part of the surface but the side which is supposed to have been forward.

The mass is deeply furrowed and all the furrows tend away from the side containing the pittings.

Slices of the meteorite, when etched, show rather coarse Widmanstättian figures and also dark diagonal bands of troilite.

From the locality in which this meteorite was found it is but proper that it should be called "La Bella Roca."

I am indebted to Messrs. Ward and Howell for the material for examination and the privilege of description.

DUMORTIERITE FROM HARLEM, N. Y., AND CLIP, ARIZ.

By J. S. Diller and J. E. Whitfield.

In 1887 Dr. R. B. Riggs published a description, including a chemical analysis, of "the so-called Harlem indicolite," which was regarded as probably a new boro-silicate. The notice led to correspondence with Prof. E. S. Dana, who identified the mineral as dumortierite, and kindly sent us some of the original dumortierite from near Lyons, France, for comparison.

The physical properties of the Harlem dumortierite agree very closely with those mentioned by Bertrand,[1] Gonnard,[2] and Damour.[3] Crystals are very rare. An imperfect one[4] has been observed with $a(\infty\bar{P}\infty)$ and $m(\infty P)$ equally developed. Both planes are striated parallel to the vertical axis. Indistinct reflections allowed only approximate measurement $am=152^\circ$, and therefore $mm=124^\circ$. Obtuse terminal planes rarely observed on embedded crystals.

Cleavage parallel to a is distinctly developed so that when the mineral is crushed and examined under a microscope cleavage plates may be found which show an obtuse bisectrix lying parallel to $b(\infty\breve{P}\infty)$. Cross fractures occasionally yield basal sections which may be made to exhibit an acute bisectrix. Extinction always takes place parallel to the vertical axis and the mineral is evidently rhombic.[5] In cross-sections imperfect cleavage is rarely seen parallel to some prismatic plane. Polysynthetic twinning is very common parallel to b as well as to other planes in the prism zone. Liquid inclusions and long tubular cavities parallel to the vertical axis are abundant. Hardness $=7$ and specific gravity slightly above 3.265.

The rock in which the dumortierite occurs at Harlem is the pegmatoid

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[1] Bull. Soc. Min. d. France, vol. 3, 1880, p. 171, and vol. 4, 1881, p. 9.

[2] Bull. Soc. Min. d. France, vol. 3, 1881, p. 2.

[3] Bull. Soc. Min. d. France, vol. 4, 1881, p. 6.

[4] It was kindly loaned to us by Mr. R. T. Chamberlin, of New York. Our thanks are also due to Mr. George F. Kunz for the material he so generously furnished for this investigation. It was collected along Fourth avenue at One hundred and twentieth and One hundred and twenty-second streets, as well as near Fort George, a new locality of the same district.

[5] My observations, noted in Mr. Riggs's paper, already referred to, were very hastily made with imperfect apparatus, and published before I had an opportunity for their revision.—J. S. Diller.

portion of a biotite gneiss. These coarse vein-like parts are composed of quartz with both red and colorless orthoclase, some plagioclase and tourmaline. The other portions of the rock contain much biotite and garnet. The fibers of dumortierite are sparingly scattered through the quartz in the coarse granular rock. A few were observed penetrating plagioclase. The thin, thread-like fibers are occasionally so small as not to be distinctly dichroic, but they are intermingled and connected with larger dichroic fibers by every intermediate gradation in size, so that an observer at once regards them all as the same mineral. They sometimes closely resemble the trichitic forms in granitic quartz, which Dr. G. W. Hawes[1] and many others following his suggestion regarded as rutile.

The presence of tourmaline in the rock at Harlem was not at first recognized. It is so intimately associated with the dumortierite that they can not be easily separated. Their pleochroic phenomena, however, are so unlike that they can be readily distinguished under a polarizing microscope. The presence of tourmaline renders the results of Mr. Riggs's analysis less trustworthy. By means of the Klein solution and an electro-magnet the tourmaline was separated from the dumortierite. The .217 gram of the latter thus obtained was analyzed with the following result.[2] Only the smallest trace of B_2O_3 was observed.

SiO_2 31.44 Al_2O_3 68.91

Fortunately, at the time it became particularly desirable to obtain a larger quantity of dumortierite for analysis a collection of minerals was sent by Mrs. C. A. Bidwell from Clip, Yuma County, Arizona, to the National Museum for identification. Among them Prof. F. W. Clarke noticed a blue mineral, which proved to be dumortierite. It is finely fibrous and so abundant as to give color to the rock, which is composed chiefly of granular quartz. A few grains of magnetite and limonite are the only other minerals intermingled with the quartz and dumortierite, so that it seems an easy matter by means of a heavy solution and an electro-magnet to obtain the latter mineral for chemical analysis. The results are given under I, below.

These figures appear to show the material analyzed to be impure, and it was thought advisable to obtain more of the rock and endeavor to separate the dumortierite as far as practicable from all impurities. Mrs. C. A. Bidwell kindly furnished a sufficient amount of much better material, in which the only mineral associated with the dumortierite was quartz. As dumortierite is not acted upon by hydrofluoric acid; the rock, after being crushed to small particles, was digested in this acid for a length of time sufficient to decompose most of the quartz. The mass was then washed with water, dried, and any quartz that might still remain separated by Thoulet's solution. After thorough washing

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[1] Mineralogy and Lithology of N. H., 1878, p. 45.

[2] The chemical work for this paper was done by Mr. Whitfield.

the material was examined with the aid of a microscope and found to be free from gangue. Having been ground exceedingly fine and dried at 104° C. for about three hours, the mineral was analyzed with the following results (II):

	I.	II.
Si_2O_2	31.52	27.99
Al_2O_3	63.66	64.49
CaO	trace.	
MgO	.52	trace.
Na_2O	.37	
K_2O	.11	
B_2O_3	2.62	4.95-4.93
P_2O_5		0.20
Ignition	1.34	H_2O 1.72
	100.14	99.35

Analysis II shows less impurity than the first specimen analyzed. These results indicate either that dumortierite is not a simple silicate of aluminum as stated by Damour;[1] or else that the material analyzed was a mixture of dumortierite with some other compound.

If we assume the formula of Damour to be correct and estimate all the SiO_2 in the analysis as belonging to the formula $Al_8Si_3O_{18}$, then there will be left unaccounted for a small amount of Al_2O_3, H_2O, and B_2O_3, and these are present in the proportions represented by the formula $AlB_3O_6 . 2H_2O$. If this mode of interpretation be correct, then the mineral from Arizona corresponds approximately to the formula $3Al_8Si_3O_{18}.AlB_3O_6 . 2H_2O$ which requires $Al_2O_3=65.2$ per cent; $SiO_2=27.6$ per cent; $B_2O_3=5.4$ per cent; $H_2O=1.8$ per cent, agreeing quite closely with the actual analysis. A borate of aluminum corresponding to the above formula is, we believe, not actually known, and concerning its properties nothing can be predicted. If it exists it is certainly remarkable that it should withstand the treatment with hydrofluoric acid which the dumortierite received during the process of purification.

We are greatly indebted to Mrs. C. A. Bidwell for the supply of material for investigation, which at the cost of much personal labor she so liberally furnished.

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[1] Bull. Soc. Min. de France, vol. 4, p. 6.

CHEMICAL ACTION BETWEEN SOLIDS.[1]

By William Hallock.

In a note on a new method of forming alloys published some time ago,[2] I suggested some additional experiments which I intended to make, and I now give the results thus far obtained. Unfortunately, other work prevents my continuing the investigation at present.

Inasmuch as the method and principle[3] seemed well established where metals were used to produce alloys, an attempt was made to include some chemical reactions in the list. The most natural cases were the freezing mixtures where solid reagents are used. In order to surely have both constituents in a decidedly solid state the experiments were performed in a vessel cooled to a temperature of minus 10° or 12° C., care being always taken to leave the reagents in the vessel long enough for them to assume a temperature decidedly below zero Centigrade. Under these conditions a crystal of rock salt (NaCl) and a piece of clean, dry ice were gently brought in contact, lying side by side on a watch glass. Of course the result was the solution of salt, but old as this experiment may be, it appears here in a new connection, as an example of the union of two solids below the melting point of either, but above that of the product. The piece of ice was frozen to the glass and during the operation the crystal was drawn several millimeters across the glass, doubtless by capillarity, as the solution ran out at the bottom of the surface of contact as fast as it formed, the attraction being sufficient to move a crystal several grams in weight.

Similar experiments were performed with sodium and potassium, nitrate potassium, calcium and ammonium chloride, and sodium and potassium hydrate, with a similar result in all cases. These are all well known results, but wherein do they differ from the new method of forming alloys? This question suggests another. Are the metals combining to form an alloy in the new way a freezing mixture? A thorough

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[1] This paper was read in part before the Phil. Soc. of Washington, D. C., October 13, 1888, and appeared in full in the Am. Jour. Sci., vol. 37, 1889, p. 402.

[2] W. Hallock, Zeitschr. f. Phys. Chem., vol. 2, 1888, p. 6. Science, vol. 11, 1888, p. 265.

[3] O. Lehmann, Wiedemann Ann., vol. 24, 1885, p. 5, suggested the theoretical possibility of producing an alloy in this way. I had overlooked his paper until recently. Mr. Lehmann, however, evidently did not consider it possible to fulfill the necessary conditions and did not try the experiment.

investigation of the question would require more complicated experiments than I had time to perform. One test, however, is very simple, that with potassium and sodium.

Into a small porcelain crucible weighing 15 grams and containing about an equal weight of petroleum were placed pieces of the two metals, about 3 grams of each. One junction of a thermo-element was forced into the piece of potassium and gave its temperature accurately. After the whole had assumed the room temperature, clean faces of the two metals were brought into contact, the liquefaction began, and *the temperature immediately fell.* It required about two hours to complete the liquefaction and about one and a half hours to attain the minimum of temperature. No precautions were taken to prevent the calorimeter taking up heat from its surroundings, and, no doubt, it absorbed considerable in the long time, and yet the maximum fall in temperature amounted to 2.4° C., very large, considering the small weight of the reagents compared with the calorimeter. Thus it appears that sodium and potassium are, under such circumstances, a "freezing mixture," and analogy at least would lead one to believe that other alloys also absorb heat in their formation; but future experiment must decide the point.

In the cool vessel above described a piece of sodium or potassium was placed upon a piece of dry ice; almost instantly the reaction commenced and proceeded vigorously. It is, however, scarcely safe to consider this a case of chemical action between solids, because the reaction is probably as follows: The vapor from the ice attacks the metal, forming the hydrate which unites with other ice, forming a solution, which is then further acted upon by the metal, and in the whole process heat is generated sufficient to raise the temperature of the reagents very considerably. Perhaps in the other freezing mixtures, ice and salt, etc., it is the vapor of the water or ice which initiates the reaction.

In view of these and other considerations, the idea is evident that perhaps many substances have a slight vapor tension at temperatures considerably below their melting points, and are surrounded by a thin atmosphere of their own vapor over their clean surfaces, and it is only necessary to bring two such atmospheres to interpenetration in order to initiate the reaction which will then continue, provided the product (liquid or gas) escapes easily and does not clog the operation. In very many cases substances are found to give off a vapor below their melting point, and it is natural to suppose that there is a film of that vapor over the surface of the body, as there is a layer of saturated air over water. The mechanical theory of the composition of matter lends plausibility to the above suggestion. If these considerations are correct they foretell the regelation of substances like camphor and ice, without any pressure whatever. That loose pieces of camphor will become welded together by simple contact is well known. The operation appears to me thus: In an irregular mass of camphor in an atmosphere of camphor vapor, there is a constant interchange of state for the molecules at the surfaces of the solid, molecules previously solid are getting too far off and becoming gas, and molecules previously gas are beating upon the solid and staying there; thus the state of equilibrum is when, as a whole, there are as many molecules which fly off and become gas as fly on and become solid. On a projecting point of the solid the chances are in favor of more flying off than on; in a reentrant angle the reverse is true. Theoretically, then, the piece ought ultimately to become a sphere, not only by the rounding down of the corners, but by the building up of the flat or reentrant sides. That the corners do round off all know. If this is all true we only need to bring the two pieces together and consider them as one, and the crack between them as a reentrant angle, and the union is brought about as above indicated. If in the above the word liquid be substituted for vapor or gas, the explanation will apply to the regelation of ice in water at 0° C.

We may go even further and predict a uniting without actual contact, and this prediction has been experimentally demonstrated in the case of ice and water. A large rough block of ice (about 15 pounds) was sawed nearly in two, the slit washed out and all the fine pieces removed. In this way it was possible to hold two plane surfaces of ice parallel and near each other (1 to 2^{mm}) without danger of actual contact. Into the outer edge of the saw-cut a cotton wick was pressed, thus isolating the space between the faces from the outside and preventing any currents from circulating through the crack. The whole block was then placed in water at zero and inclosed in non-conducting cases and left for twenty-five to thirty hours. This experiment was tried three times and each time a freezing across the space had taken place. The whole space was not filled, but in numerous places, notably along just inside the wicking and up from the bottom of the cut. No doubt the regelation would have gone further if the experiment could have been continued longer. The melting of the whole block puts an end to each experiment. As these experiments were performed in summer there is scarcely a possibility that the ice was colder than 0° C.

Inasmuch as there appears to be an increasing inclination to regard solutions and alloys as chemical compounds, it seems justifiable to speak of the action according to the alloy law as chemical. On the other hand, there are some cases which at first appear as chemical action between solids which upon closer investigation can be explained on a simpler assumption.

For example, Mr. W. Spring,[1] in a recent paper on this subject, cites three particular cases as being chemical action between solids, the union of copper and sulphur, the reaction between copper and mercuric chloride, and between potassium nitrate and sodium acetate.

The formation of the sulphide of copper and other sulphides was accomplished by Mr. Spring by compression of the elements. But it is

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[1] W. Spring, Zeitschr. für phys. Chemie, vol. 2, 1888, p. 536.

not even necessary that the sulphur and copper be in contact. I have made the sulphide at ordinary temperatures with the two an inch apart and a wad of cotton in the tube between them. It is simply the *vapor* of sulphur which attacks the copper. That sulphur gives off a perceptible vapor at ordinary temperatures, especially in vacuo, is a fact any one can easily demonstrate. The case of the copper and mercuric chloride is precisely the same. The *vapor* of the chloride will go through a whole tube past cotton wads and attack the copper, or color potassic iodide. Hence we can scarcely assert that these reactions are between *solid* bodies. The reaction between potassium nitrate and sodium acetate is equally unconvincing. Mr. Spring expected an interchange of bases and acids and left the mixture of the dry fine powders four months in a desiccator to give time for the exchange. On removing them from the desiccator a deliquescence was noticeable and he therefore concludes that the interchange had taken place, since the original salts do not easily deliquesce; but the product of the reaction (potassium acetate) does. It appears to me thus: The moment the powders were brought to the air, the water vapor enters the operation and we have potassium nitrate, water vapor, and sodium acetate, and the result of their mutual interaction is a solution of potassium acetate and sodium nitrate. In fact, if the dry powdered salts are stirred together, in a very few moments deliquescence begins, showing that whatever the reaction it goes on at once, and is a matter of moments and not of months. Thus even this experiment in its present form does not convince us that a chemical exchange took place *before* the water vapor entered the reaction.

The question of chemical action between solids is by no means new, but is being constantly extended. I may say I believe chemical action may take place wherever the product or products are liquid or gaseous even though the reagents are solid, with perhaps the added condition that one or both the reagents be soluble in the liquid produced. If this be true my new method of forming alloys is but a special case of the above general principle.[1]

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[1] Experiments endeavoring to produce carbon disulphide from the elements at ordinary temperatures, are in hand and give promise of positive results. Also, experiments on the interaction of potassium nitrate and sodium acetate have been started; it will, however, be some time before further results can be given.

THE FLOW OF SOLIDS: A NOTE.

BY WILLIAM HALLOCK.

The American Journal of Science, vol. 34, 1887, p. 277, contained an abstract of my paper under the above title, which appears in full in Bulletin 55 of the U. S. Geological Survey. The results obtained were so different from those of Mr. Spring that I was led to a criticism of his work and seem to have been misunderstood.[1]

The justice of Mr. Spring's[2] protest against a part of my original paper I am glad to admit, as far as it concerns an ill-advised use of terms, and a consequent misrepresentation of his views, of course entirely unintentional. Not realizing that many were not so familiar with Mr. Spring's works as myself, I neglected in the brief paper to give his views, and thus my deductions from his results seemed to represent his own conclusions.

The object of my original investigation[3] was a solution of the question whether pressure alone is capable of producing true liquefaction; many have certainly believed so, or even do believe so, and a few, at least, including myself, saw in Mr. Spring's earlier results evidence of such a possibility. I believe that to produce such phenomena, as some recrystallizations, and diffusion, an increase in the freedom of motion of the molecule, an increased diffusibility, *i. e.*, the beginning of a liquefaction, is indispensable. Hence I looked upon his results as pointing to a liquefaction by pressure. My own experiments with the same substances and pressures showed the impossibility of liquefying them by pressure and even brought out an enormous increase in the rigidity of bees-wax and paraffin[4] under such pressures. In concluding I wished only to call attention to the difference between Mr. Spring's *results* and my own, but unfortunately a loose and abbreviated quotation caused the misunderstanding, which I wish to explain.

Since obtaining my own results there seems to me little doubt that many, at least, of Mr. Spring's effects are caused rather by a *motion*

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[1] The following appeared in Am. Jour. Sci., vol. 36, 1888, p. 60.

[2] W. Spring, Am. Jour. Sci., vol. 35, 1888, p. 78, also Bull. de l'Acad. R. Belg., vol. 14, 1887, p. 585.

[3] W. Hallock, Am. Jour. Sci., vol. 34, 1887, p. 277.

[4] Compare also Ordnance Department Tests of Metals, etc., 1884, Government Printing Office, pp. 252-254, 285-287.

under pressure, a kneading, as it were, and by the regrinding. The holders in which his compressions were made were not tight and the most perfect welding[1] always took place at the surface of the block, or the corners, or where the material was forced into the cracks, often even while the center, under equal pressure, remained almost unaffected. My holders were tight, allowing no leaking or motion, and the substances showed scarcely a trace of a welding under pressure. I must therefore reiterate that which I wished originally to impress, namely, that the majority of Mr. Spring's results are not produced by simple cubic static pressure.

In the cases of chemical action and the formation of alloys, I believe that the *motion under pressure* will be found to be the all important factor, perhaps just as stirring assists diffusion to completely mix two liquids. Even if blocks of barium sulphate and of sodium carbonate[2] were brought into actual chemical contact, I think no one would expect that simple diffusion would complete the interchange of bases and acids in finite time so long as both substances remained solid; nor that a piece of copper and of tin soldered together would diffuse and form a homogeneous bronze; nor would they expect that simple cubic static pressure would promote these reactions; if pressure will assist them to completion, it will increase the diffusibility of solids, increase the freedom of motion of their molecules; that is, it will make them more like liquids—will begin to liquefy them.

I wish to refer here to a new law I recently proposed[3] concerning the formation of alloys, where the fact is brought out that the melting point and liquidity of the product are quite as important as those of the constituents in determining the possibility of a reaction. Mr. Spring[4] has produced Wood's alloy by compressing the constituents together, and quotes Mr. Romna[5] as having failed to obtain fine platinum wire by electro silver-plating a platinum wire, drawing it down and dissolving off the silver in nitric acid, because the silver and platinum alloyed under the pressure of the draw plate. Messrs. W. & L. E. Gurley, of Troy, N. Y., have for several years made fine platinum wires by the well-known Wollaston[6] method of *casting* silver around the platinum and treating as above. In the note referred to[4] I have described the production of Wood's alloy *without pressure at* 100° C. of a tin-lead alloy at 190° C. of the sodium-potassium alloy at ordinary temperatures, etc. Hence it appears to me that pressure alone is the least important factor in the production of the effects obtained in Mr. Spring's investigation.

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[1] W. Spring, Bull. d. l'Acad. R. Belg., vol. 49, 1880, p. 352. Phosphore amorphe et seq.

[2] W. Spring, Bull. Soc. Chem., vol. 44, 1885, p. 166.

[3] W. Hallock, Science, Mar. 2, 1888, vol. 11, p. 100; also Ostwald Zeitschr. f. Phys. Chem., vol. 2, 1888.

[4] W. Spring, Ber. der deutsch. Chem. Gesell., vol. 15, 1882, p. 595.

[5] Ibid.

[6] Ganot's Physics, Atkinson, New York, 1883, p. 76.

MISCELLANEOUS ANALYSES.

1. TYROLITE.[1]

From the Mammoth Mine, Tintic district, Utah. New material, very pure, collected and analyzed by W. F. Hillebrand.

CuO	45.08
FeO	.08
CaO	6.78
MgO	.04
H_2O	17.21
As_2O_5	28.52
SO_3	2.23
Insoluble	.16
	100.10

2. GADOLINITE.

From Llano County, Texas. Analyzed by L. G. Eakins.[2]

SiO_2	23.79
ThO_2	.58
Fe_2O_3	.96
Ce_2O_3	2.62
$(DiLa)_2O_3$	5.22
$(YEr)_2O_3$	41.55
FeO	12.42
GlO	11.33
MnO	trace
CaO	.74
MgO	trace
Alkalies	trace
H_2O	1.03
P_2O_5	.05
	100.29

In the rare earths from this mineral the absorption spectrum of didymium was strong, and that of erbium was weak. The molecular weight of the oxide $(YEr)_2O_3$ was 260.

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[1] Compare analyses in Bulletin 55, p. 41.

[2] Compare Hidden & Mackintosh, Am. Jour. Sci., Dec., 1889.

3. WARWICKITE.

From the well-known locality at Edenville, Orange County, New York. Analyzed by J. E. Whitfield. The material could not be completely freed from an admixture of spinel.

SiO_2	1.16
TiO_2	18.68
FeO	14.23
Al_2O_3	9.44
B_2O_3	18.96
CaO	.38
MgO	34.41
H_2O	2.80
	100.06

From this composition no simple formula can be deduced; but if we reject obvious impurities, and throw out the alumina in the form of spinel, the residue agrees approximately with the ratios

$$TiO_2 \,.\, B_2O_3 \,.\, 4R''O.$$

This expression is not quite satisfactory, and may need revision.

4. MINERALS AND ROCKS FROM MARYLAND.

Collected by Dr. G. H. Williams.

Chrome tourmaline and fuchsite.—Found in chrome pits a mile west of Etchison post-office, a little east of Great Seneca Creek, in Montgomery County. The tourmaline occurs in dark-green needles, with chromite, and the mica is associated with it. Analyses by T. M. Chatard.

	Tourmaline.	Fuchsite.
H_2O	3.74	6.77
SiO_2	36.57	42.21
B_2O_3	8.90	....
F	.06	....
P_2O_5	.04	....
TiO_2	.09	....
Al_2O_3	32.58	34.55
Cr_2O_3	4.32	2.03
Fe_2O_3, FeO	.79	1.03
NiO	.05	....
MnO	trace	trace
CaO	.75	.47
MgO	9.47	3.13
Li_2O	trace	....
Na_2O	2.22	.82
K_2O	.13	9.16
	99.71	100.17

These minerals are more fully discussed by G. H. Williams and A. C. Gill in Circular No. 75 of the Johns Hopkins University. In the same paper is described epidote from the Woodstock granite, of which the following analysis has been made by Dr. W. F. Hillebrand, on only 0.4473 gramme of material:

SiO_2	37.63
$Fe_2O_3(+FeO)$	15.29
Al_2O_3	18.40
TiO_2	3.78
MnO	.31
CaO	22.93
MgO	.31
P_2O_5	.44
Ignition	2.23
	101.32

Rocks from Baltimore County.—Analyses by J. E. Whitfield. A, pyroxenite, Johnny Cake Road. B, pyroxenite, Johnny Cake Road, first stage of alteration. C, pyroxenite, Johnny Cake Road, second stage of alteration. D, smaragdite, Dogwood Road.

	A.	B.	C.	D.
SiO_2	50.80	50.10	51.94	53.22
SO_3	trace	trace	.19	trace
Cl	.24	.26	.16	.26
P_2O_5	trace	none	none	....
Al_2O_3	3.40	2.00	2.53	3.14
Cr_2O_3	.32	.36	.60	.23
Fe_2O_3	1.39	2.38	2.88	trace
FeO	8.11	8.68	9.38	7.95
MnO	.17	.29	trace	.11
CaO	12.31	5.06	3.60	14.44
MgO	22.77	26.85	25.97	20.09
Alkalies	traces	none	none	traces
H_2O	.52	4.16	2.82	.98
	100.03	100.14	100.07	100.42

Titanium was absent from all four.

Another pyroxenite (E), and a diallage-bronzite rock (F), from the same region, were analyzed by T. M. Chatard.

	E.	F.
SiO_2	43.87	53.98
TiO_2	.12	.15
P_2O_5	trace	trace
Al_2O_3	1.64	1.32
Cr_2O_3	.44	.53
Fe_2O_3	8.94	1.41
FeO	2.60	3.90
MnO	.19	.21
NiO	trace	trace
CaO	6.29	15.47
MgO	27.32	22.59
Alkalies (AsNa_2O)	.50	undet.
H_2O	8.72	.92
	100.63	100.48

5. SERPENTINE AND ITS ASSOCIATES.

From Moriah, New York.—Derived from pyroxene. Four analyses by Charles Catlett, as follows: A, serpentine from the ophiolite of Reed's Quarry. B, "dolomite" from the same rock. C, pyroxene from an abandoned quarry. D, serpentine derived from the same pyroxene.

	A.	B.	C.	D.
SiO_2	39.96	2.60	55.36	42.17
Al_2O_3	1.07	.09	.22	.30
Fe_2O_3	3.53	none	.18	1.57
FeO	3.85	.80	.57	.64
MgO	37.61	2.49	19.53	41.33
CaO	none	52.38	24.48	none
CO_2	none	41.77	....	none
MnO	trace	.04	trace	trace
H_2O	13.65	....	....	13.72
	99.67	100.17	100.34	99.73

Chromium and nickel sought for, but absent.

Serpentine from the aqueduct shaft, New York City.—Analyzed by Mr. Catlett:

SiO_2	39.92
Al_2O_3	.08
Fe_2O_3	.50
FeO	none
MgO	42.52
CO_2	1.64
CaO	.90
H_2O at 105°	1.36
Ignition	13.26
	100.18

From Montville, New Jersey.—A, very pale serpentine, somewhat resembling deweylite in appearance. B, mineral, resembling actinolite. C, brown mica, first zone above pyroxene. D, yellowish mica, second zone above the pyroxene. E, white mica, associated with pyroxene. Analyses A and B, by L. G. Eakins; C, D, and E, by Charles Catlett. In D and E the ferrous oxide was not separately estimated for want of sufficient material.

	A.	B.	C.	D.	E.
H_2O	14.73	1.17	5.07	10.88	10.20
CO_2	....	....	.30	1.80	....
SiO_2	40.64	43.31	39.38	32.52	39.14
Al_2O_3	2.74	17.41	15.92	18.14	15.70
Fe_2O_3	.81	.71	.71	2.30	1.68
FeO	.28	.59	.80		
MnO	trace	.14	trace	trace	trace
CaO	trace	12.84	.28	1.44	5.24
MgO	40.93	19.39	26.85	29.26	25.44
Na_2O	....	2.23	.62	1.38	.64
K_2O	....	1.36	9.84	2.78	2.06
F	....	....	.62	....	....
	100.13	99.15	100.39	100.50	100.10
Less O	....	....	.26		
			100.13		

Associates of serpentine from Easton, Pennsylvania.—A, vermiculite, analyzed by C. Catlett; B, tremolite; C, so-called "nephrite." Analyses B and C by L. G. Eakins.

	A.	B.	C.
SiO_2	42.21	58.27	60.29
Al_2O_3	9.37	.33	20.83
Fe_2O_3	.68	trace	trace
FeO	none	....	....
MnO	none	.08	....
CaO	none	11.90	.16
MgO	34.80	25.93	6.44
Na_2O	1.25	1.25	1.97
K_2O	1.34	.42	8.41
H_2O	10.70	1.22	1.13
	100.35	99.40	99.23

All of the foregoing minerals were collected by Mr. G. P. Merrill.

6. GEYSERITES FROM ROTORUA, NEW ZEALAND.

Received from the museum at Auckland. Analyzed by J. E. Whitfield for comparison with the geyserites of the Yellowstone Park, which they closely resemble. Three samples:

	1.	2.	3.
SiO_2	92.47	90.28	74.63
Al_2O_3	2.54	3.00	15.59
CaO	.79	.44	1.00
MgO	.15	trace	trace
Na_2O	....	....	.30
K_2O	....	....	1.02
Ignition	3.99	6.24	7.43
	99.94	99.96	99.97

7. MISCELLANEOUS ROCKS.

Sandstone from Buena Vista, Ohio.—A yellowish building stone. Partial analysis by F. W. Clarke.

Moisture	2.51
SiO_2	88.27
$Al_2O_3+Fe_2O_3$	9.09
MgO	trace
	99.87
Insoluble in HCl	96.47
Soluble Fe_2O_3	.77

Sandstone from near Portsmouth, Ohio.—The "Peebles-Henley" or "Otway" building stone. Three samples, analyzed by T. M. Chatard. In B and C the iron was mainly ferrous, though weighed as Fe_2O_3.

	A.	B.	C.
Ignition	1.08	1.46	1.95
Insoluble in HCl	98.31	97.20	95.83
Soluble	.61	1.40	2.42
	100.00	100.06	100.20
Soluble Fe_2O_3	.61	1.04	1.65
Soluble CaO	trace	.36	.77
Soluble MgO	trace	little	trace

Limestone from Silverdale, Kansas.—Analyzed by Charles Catlett.

SiO_2	5.27
Al_2O_3	1.07
Fe_2O_3	.71
FeO	.32
CaO	50.36
MgO	.56
Na_2O	.20
K_2O	.10
CO_2	40.34
SO_3	.07
P_2O_5	.06
H_2O	.78
	99.84

Metamorphic rock from Marion, Kentucky.—Analyzed by L. G. Eakins.

SiO_2	34.50
Al_2O_3	14.37
Fe_2O_3	2.85
FeO	4.46
CaO	11.43
MgO	21.81
K_2O	1.50
Na_2O	.51
H_2O	7.14
P_2O_5	.77
SO_3	.60
CO_2	.21
	100.15

From Pigeon Point, Michigan.—Analyses by L. G. Eakins. A, red porphyry from Brick Island, Lake Superior, near Pigeon Point. B, green mottlings from Pigeon Point. Van Hise's rock, No. 11908.

	A.	B.
SiO_2	73.70	83.27
TiO_2	.12	trace
Al_2O_3	12.87	7.81
Fe_2O_3	3.76	1.99
FeO	.31	1.81
MnO	.07	......
CaO	.14	.20
MgO	.11	1.59
K_2O	4.56	1.11
Na_2O	3.63	.19
H_2O	.57	2.32
P_2O_5	trace	trace
	99.84	100.29

Diabase, Penokee-Gogebic Range, Michigan.—Analyses by T. M. Chatard. A, from near SE. corner of Sec. 13, T. 47 N., R. 46 W. B, altered diabase, same locality. C, altered diabase, Aurora Mine, NE. ¼ of SW. ¼ Sec., T. 47 N., R. 47 W. D, feldspar separated from A.

	A.	B.	C.	D.
H_2O, at 105°	.15	3.12	.29	1.19
H_2O, at red heat	2.34	8.25	13.54	
CO_2	.38	1.89	.38	1.89
P_2O_5	.13	.16	.14	....
SiO_2	47.90	46.85	41.60	51.18
TiO_2	.82	1.12	3.79	....
Al_2O_3	15.60	22.62	37.20	27.00
Fe_2O_3	3.69	5.12	3.21	3.19
Cr_2O_3	trace	....	....	....
FeO	8.41	1.58	.30	undet.
NiO	.10	.08	....	....
MnO	.17	2.54	.08	.17
BaO	.05	.10	trace	....
CaO	9.99	1.25	.23	11.70
MgO	8.11	2.01	.02	1.92
K_2O	.23	2.66	....	.41
Na_2O	2.05	.80	.07	3.48
	100.12	100.15	100.85	100.24

Penokee-Gogebic rocks from Wisconsin.—A, B, C, three slates, analyzed by L. G. Eakins. A, from Sec. 6, T. 45 N., R. 2 E. B, from Sec. 1, T. 45 N., R. 1 E. C, from Sec. 4, T. 44 N., R. 2 W.

	A.	B.	C.
SiO_2	53.44	59.73	52.58
Al_2O_3	19.62	22.78	20.76
Fe_2O_3	11.38	.11	12.17
FeO	5.35	5.98	4.08
MnO	trace	.09	.21
CaO	.42	.53	.30
MgO	1.58	2.94	1.33
K_2O	1.73	3.48	4.87
Na_2O	2.61	1.41	.37
Li_2O	trace	....	trace
H_2O	4.07	3.28	3.43
P_2O_5	trace	....	....
	100.20	100.33	100.10

D, E, F, three feldspars, analyzed by T. M. Chatard. D, from gabbro, center of Sec. 14, T. 44 N., R. 4 W. E, F, from olivine diabase, NE. ¼ Sec. 13, T. 45 N., R. 1 W.

	D.	E.	F.
H_2O, at 105°	.03	.95	.13
H_2O, at red heat	.54		.64
SiO_2	51.99	61.65	56.15
Al_2O_3	29.32	19.91	26.05
Fe_2O_3	1.23	2.28	1.98
FeO	undet.	undet.	undet.
MnO	trace	trace	.13
CaO	12.60	4.12	8.70
MgO	.63	.61	.54
K_2O	.28	5.72	1.56
Na_2O	2.91	4.74	4.79
	99.53	99.98	100.67

Eruptive rock from four miles southwest of Hot Springs, Arkansas.—Analyzed by L. G. Eakins.

SiO_2	36.40
TiO_2	.42
Al_2O_3	12.94
Fe_2O_3	8.27
FeO	4.59
CaO	14.46
MgO	11.44
K_2O	3.01
Na_2O	.97
H_2O	2.36
CO_2	3.94
P_2O_5	1.04
	99.84

Recent lava from two miles south of Mount Trumbull, Arizona.—Analyzed by L. G. Eakins.

SiO_2	45.30
TiO_2	2.66
Al_2O_3	14.95
Fe_2O_3	1.98
FeO	9.32
MnO	trace
CaO	8.87
MgO	8.29
K_2O	1.27
Na_2O	4.27
H_2O	.85
P_2O_5	2.23
	99.99

Eruptive rock from Castle Mountain, Montana.—Analyzed by L. G. Eakins.

SiO_2	44.66
TiO_2	1.02
Al_2O_3	12.12
Fe_2O_3	5.81
FeO	3.20
MnO	.21
CaO	8.14
MgO	8.77
K_2O	2.75
Na_2O	4.47
H_2O	4.33
CO_2	2.19
P_2O_5	2.02
	99.69

Rocks from Northern California.—Collected by J. S. Diller. A, B, porphyritic rocks from Shasta County; analyzed by J. E. Whitfield. A, east fork of Clear Creek, nine miles from French Gulch. B, Smith's Gulch, six miles up Clear Creek from French Gulch.

	A.	B.
SiO_2	66.30	64.24
TiO_2	trace	.76
SO_3	.28	.22
Cl	none	.25
P_2O_5	.15	.08
Al_2O_3	17.55	18.67
Fe_2O_3	2.19	1.40
FeO	.55	1.96
MnO	trace	trace
CaO	3.12	4.11
MgO	.97	1.48
Na_2O	5.15	4.14
K_2O	2.45	1.71
H_2O	1.25	1.18
	99.96	100.20

C, D, two rocks from three-fourths of a mile below John Allen's, Dry Creek, Shasta County. E, from John Allen's. F, from two and one-half miles above John Allen's. Analyses by Whitfield.

	C.	D.	E.	F.
SiO_2	59.10	61.60	54.55	60.74
TiO_2	.70	trace	trace	.86
SO_3	trace	.27	.10	.40
Cl	trace	trace	.12	trace
P_2O_5	trace	.08	.10	trace
Al_2O_3	14.02	12.15	10.64	10.25
Fe_2O_3	3.16	2.09	1.59	4.31
FeO	1.42	3.30	1.16	6.21
MnO	trace	trace	1.53	trace
CaO	9.35	6.92	14.30	4.97
MgO	1.72	2.33	1.29	3.69
Na_2O	2.21	2.16	2.60	1.83
K_2O	1.49	1.41	1.68	.52
CO_2	4.65	5.05	9.05	2.29
H_2O	2.63	3.10	1.60	4.36
	100.45	100.46	100.31	100.43

G, eruptive rock, Great Bend of Pit River. H, black obsidian, Medicine Lake, Modoc County; analyses by L. G. Eakins.

	G.	H.
SiO_2	44.77	73.51
TiO_2	.53	....
P_2O_5	.72	.04
Al_2O_3	17.82	14.42
Fe_2O_3	5.05	.46
FeO	6.95	1.49
MnO	trace	trace
CaO	10.36	1.26
MgO	8.22	.33
Na_2O	2.13	4.03
K_2O	.92	4.29
H_2O	2.64	.40
	100.11	100.23

8. SOILS AND CLAYS.

A, kaolin from Talladega, Alabama. B, clay from Richfield Springs, New York; partial analysis. C, D, two clays from Northumberland County, Pennsylvania; analyses by Charles Catlett.

	A.	B.	C.	D.
H_2O, at 120°	5.02	16.18	6.28	6.87
H_2O, at red heat	13.48			
SiO_2	43.21	49.65	65.97	59.16
Al_2O_3	37.27	23.82	20.37	18.68
Fe_2O_3	trace		2.75	10.32
CaO	.11	6.48	.64	.52
MgO	.10	trace	.52	.67
K_2O	.28	undet.	3.32	3.35
Na_2O	.40	undet.	.05	.11
	99.87	96.13	99.90	99.68

E, F, G, H, adobe soils. E, from Santa Fé, New Mexico. F, Fort Wingate, New Mexico. G, Humboldt City, Nevada. H, Salt Lake City, Utah. Analyses by L. G. Eakins.

	E.	F.	G.	H.
SiO_2	66.69	26.67	44.64	19.24
Al_2O_3	14.16	.91	13.19	3.26
Fe_2O_3	4.38	.64	5.12	1.09
MnO	.09	trace	.13	trace
CaO	2.49	36.40	13.91	38.94
MgO	1.28	.51	2.96	2.75
K_2O	1.21	trace	1.71	trace
Na_2O	.67	trace	.59	trace
CO_2	.77	25.84	8.55	29.57
P_2O_5	.29	.75	.94	.23
SO_3	.41	.82	.64	.53
Cl	.34	.07	.14	.11
H_2O	4.94	2.26	3.89	1.67
Organic matter	2.00	5.10	3.43	2.96
	99.72	99.97	99.84	100.35

9. ORES OF IRON AND MANGANESE.

Manganese ore, Powell's Fort, east end of Massanutten Mountain. Warren County, Virginia. Analysis by Charles Catlett.

SiO_2	9.20
Fe	3.07
Mn	48.59
P	.349
S	.12

Iron and manganese ores, Montebello, Nelson County, Virginia. Analyses by Catlett.

	Iron.	Manganese.
SiO_2	16.47	1.68
Fe	51.10	2.60
Mn	.65	46.99
P	.152	.464
S	.11	.21

Ores from Rockbridge County, Virginia; analyzed by T. M. Chatard. A, top of hill above Hart's Bottom, one and three-fourths miles southwest of Green Forest Station, near Lockland Station. B, Moorman Quarry, Green Forest. C, new opening, No. 2, Buena Vista. D, opening, No. 3, 40-foot vein, Buena Vista. E, Chalk Mine Branch. F, Old Colonial opening, Buena Vista.

	A.	B.	C.	D.	E.	F.
H_2O, 105°	.72	.15	.39	.60	.45	.48
Insoluble	20.40	13.47	22.55	16.60	8.05	5.43
Soluble Al_2O_3	1.67		.37	1.81	.46	
TiO_2	.16					
Fe_2O_3	3.11	76.19	66.58	71.16	78.24	82.15
NiO			.27			
MnO	53.91	.45	.22	.11	.66	.19
BaO	.23					
SO_3	.32	.14	.09	.37	trace	.08
P_2O_5	.50	.26	.42	.50	.88	1.04
Fe	2.18	53.33	46.60	49.81	54.76	57.50
Mn	41.59					
P	.22	.11	.18	.22	.38	.45
S	.12	.06	.03	.14		.02

Two manganese ores. Cripple Creek, eight miles from Wytheville, Virginia. Analyses by C. Catlett.

	1.	2.
SiO_2	47.30	27.86
Fe	2.72	3.61
Mn	24.85	32.55
P	.05	.097
S	trace	.030

Iron ore from Shanghai, West Virginia. Analyzed by C. Catlett.

SiO_2	45.24
Fe	26.02
Mn	.43

Two iron ores from Kentucky; analyzed by J. E. Whitfield. A, Cloverport Road, two miles north of Fordsville, Ohio County. B, north slope of Pine Mountain, three miles east of Pineville, Bell County.

	A.	B.
SiO_2	35.67	17.28
TiO_2	trace	trace
Cl	trace	....
SO_3	.42	.40
P_2O_5	1.42	trace
Al_2O_3	6.15	.35
Fe_2O_3	42.31	68.24
FeO	.35	trace
MnO	.84	.95
CaO	1.90	.83
MgO	1.07	.92
Ignition	9.69	11.60
	99.82	100.57
Fe	29.86	47.77
P	.71	....
S	.16	.15

Iron ore. Douglass Mine, Clinton Horizon, one mile west of Big Creek Gap, Campbell County, Tennessee. Analyzed by W. F. Hillebrand.

SiO_2	10.51
Fe	54.29
Mn	.20
P	.355
S	.043

Two iron ores; analyzed by C. Catlett. A, from Edgefield County, South Carolina. B, north part of Howard County, Arkansas.

	A.	B.
SiO_2	9.40	28.10
Fe	52.40	29.57
Mn	trace	2.19
P	.664	.483
S	.08	.04

10. COAL AND COKE.

Three coals. Raccoon Fork of Cabin Creek, Kanawha County, West Virginia. Analyzed by E. L. Howard.

	1.	2.	3.
Moisture	1.93	2.15	1.67
Volatile matter	37.09	23.95	41.36
Fixed carbon	57.90	61.85	53.22
Ash	3.08	12.05	3.75
	100.00	100.00	100.00
Sulphur	.62	.46	.80
Ash	dirty white	light gray	reddish

Coal and coke. Davis Mine No. 1, near North Fork of Blackwater, Tucker County, West Virginia. Analyzed by Charles Catlett.

	Coal.	Coke.
Moisture	.80	.18
Volatile matter	26.84	1.49
Fixed carbon	67.18	90.60
Ash	5.18	7.73
	100.00	100.00
Sulphur	1.68	.771
Ash	very light red	light red

Five coals. Campbell County, Tennessee; A, B, C analyzed by W. F. Hillebrand; D, E by Charles Catlett. A, Douglass Bank, Middle Fork of Big Creek, one and one-half miles from Gap, lower coal-measures. B, Walnut Mountain, head of Hickory Creek, Clear Fork of Cumberland River, 2,850 feet above sea-level, upper coal-measures. C, Middle Fork of Big Creek, lower coal-measures. D, East Fork of Big Creek. E, Middle Fork of Big Creek, three miles from Big Creek Gap.

	A.	B.	C.	D.	E.
Moisture	1.49	2.95	1.11	1.70	7.60
Volatile matter	39.00	38.51	35.59	39.41	34.89
Fixed carbon	53.30	55.42	23.99	55.36	53.14
Ash	6.21	3.12	39.31	3.53	4.37
	100.00	100.00	100.00	100.00	100.00
S	1.53	.87	2.78	1.07	.64
P	.041	....	....	....	....

A rough test on C showed that one ton of coal should yield 40,000 cubic feet of gas.

Also two cokes, analyzed by C. Catlett. F, Walnut Mountain, Hickory Creek. G, from Sharp coal, Left Fork of Big Creek.

	F.	G.
Moisture	.20	.50
Volatile matter	2.01	1.95
Fixed carbon	85.56	91.71
Ash	12.23	5.84
	100.00	100.00
S	.886	.705
P	.040	undet.

Thirty-two coals from Gunnison County, Colorado. Collected by G. H. Eldridge, and analyzed by L. G. Eakins.

From Anthracite Creek Mines.

Moisture	3.95
Volatile matter	4.65
Fixed carbon	82.34
Ash	9.06
	100.00
S	.63
P. in ash	.07
Specific gravity	1.644—24.4°

Ash, light red; no coke.

From Green Mountain, Denver Beds.

Moisture	8.91
Volatile matter	46.16
Fixed carbon	44.46
Ash	.47
	100.00
S	.47
Specific gravity	1.381—22.5°

Ash, light red; coke moderately coherent.

From Ohio Creek Mines, Nos. 1 to 11.

	1.	2.	3.	4.	5.
Moisture	7.39	8.46	8.26	1.61	1.34
Volatile matter	39.43	39.01	39.96	13.05	30.25
Fixed carbon	47.83	46.68	46.36	80.29	62.38
Ash	5.35	5.85	5.42	5.05	6.03
	100.00	100.00	100.00	100.00	100.00
S	1.47	.76	.68	.59	.44
P. in ash			.06		.07
Specific gravity	1.328, 23°	1.334, 21.6°	1.331, 25°	1.407, 23°	1.325, 22°
Ash	reddish gray	light red	light red	red	red
Coke	fairly coherent	cokes slightly	cokes slightly	none	firm, solid

	6.	7.	8.	9.	10.	11.
Moisture	6.28	6.37	6.39	1.07	1.23	.81
Volatile matter	40.92	38.06	39.26	26.22	26.65	9.96
Fixed carbon	46.35	49.75	48.41	68.36	68.27	82.33
Ash	6.45	5.82	5.94	4.35	3.85	6.90
	100.00	100.00	100.00	100.00	100.00	100.00
S	.47	.46	.46	.60	.61	1.06
P. in ash			.03	.05		
Specific gravity	1.324, 21°	1.345, 21.6°	1.337, 23°	1.319, 22°	1.317, 22°	1.426, 23.8°
Ash	reddish yellow	reddish yellow	red	red	red	pinkish gray
Coke	fair	slightly coherent	fair	fair	fair	none

From Slate Creek Mines, Nos. 12 to 21.

	12.	13.	14.	15.	16.
Moisture	1.29	1.36	1.86	1.35	1.30
Volatile matter	7.92	7.53	6.68	6.59	7.55
Fixed carbon	85.71	85.49	86.25	72.34	80.44
Ash	5.08	5.62	5.21	19.72	10.71
	100.00	100.00	100.00	100.00	100.00
S	.67	.54	.69	.66	.58
P. in ash		.05	.03		.32
Specific gravity	1.428, 23.4°	1.440, 21.8°	1.465, 26.4°	1.481, 22.2°	1.502, 22.8°
Ash	red	red	red	gray	light red
Coke	none	none	none	none	none

	17.	18.	19.	20.	21.
Moisture	1.58	1.22	1.27	.92	.81
Volatile matter	6.70	8.46	7.99	14.19	13.40
Fixed carbon	87.46	84.20	87.24	81.29	81.26
Ash	4.26	6.12	3.50	3.60	4.53
	100.00	100.00	100.00	100.00	100.00
S	.58	.76	.62	.52	.51
P. in ash				none	
Specific gravity	1.455, 22.8°	1.409, 22°	1.409, 23.3°	1.359, 20.4°	1.371, 20.8°
Ash	red	red	red	light red	red
Coke	none	none	none	cokes slightly	cokes slightly

From Crested Butte Mines, Nos. 22 to 30.

	22.	23.	24.	25.
Moisture	1. 36	1. 47	1. 94	2. 36
Volatile matter	37. 12	38. 09	41. 07	40. 82
Fixed carbon	57. 73	56. 68	51. 48	50. 49
Ash	3. 79	3. 76	5. 51	6. 33
	100. 00	100. 00	100. 00	100. 00
S	. 49	. 47	. 63	1. 04
P. in ash	....	. 07	trace	....
Specific gravity	1.288, 22.6°	1.276, 21°	1.311, 21.1°	1.332, 22°
Ash	light red...	light red..	red	red ....
Coke	good	good	good	good ......

	26.	27.	28.	29.	30.
Moisture	1. 88	2. 09	1. 76	3. 95	4. 83
Volatile matter	39. 51	41. 74	42. 00	37. 17	37. 86
Fixed carbon	54. 42	52. 07	51. 97	52. 34	51. 65
Ash	4. 19	4. 10	4. 27	6. 54	5. 66
	100. 00	100. 00	100. 00	100. 00	100. 00
S	. 63	. 65	. 75	. 42	. 68
P. in ash	....	trace	....	....	....
Specific gravity	1.288, 24.8°	1.289, 26.6°	1.286, 20°	1.328, 22.4°	1.349, 21.2°
Ash	red	red	light red..	red	red ....
Coke	good, solid	good	good	hard, compact.	fair ....

11. ANALYSES OF WATERS.

Analyzed by T. M. Chatard. A, from the Murray Well, one mile north of Frankfort, Kentucky. Slight odor of H_2S. Specific gravity, .99984, 22°.

	Found, grammes per liter.	Per cent. of total contents.		Combination.
SiO_2	. 0096	. 61	CO_2	. 0172
Fe	. 0014	. 08	NH_3	. 0015
Ca	. 0213	1. 35	KCl	. 0396
Sr?	. 0122	. 71	NaCl	. 8287
Mg	. 0189	1. 20	Na_2SO_4	. 2770
K	. 0207	1. 31	$FeH_2C_2O_6$	. 0045
Na	. 4604	29. 35	$CaH_2C_2O_6$	. 0862
Li	trace	....	$SrH_2C_2O_6$?	. 0269
SO_4	. 1873	11. 93	$MgH_2C_2O_6$	. 1150
Cl	. 5218	33. 23	$NaHCO_3$	. 1639
CO_3	. 2929	18. 74	SiO_2	. 0096
CO_2, free	. 0172	1. 09		
NH_3	. 0015	. 09		
H, in bicarbonates	. 0049	. 31		
	1. 5701	100. 00		1. 5701

The strontium is doubtful, and may be only a strong trace.

B, spring water from Mountain City, Tennessee. Statement like the preceding.

	Found.	Per cent. of total.		Combination.
SiO_2	.0219	21.26	SiO_2	.0219
Fe	.0008	.78	$FeH_2C_2O_6$	.0026
Al	trace	....	$CaH_2C_2O_6$	.0448
Ca	.0116	11.26	$MgH_2C_2O_6$	.0110
Mg	.0018	1.75	$CaSO_4$	.0018
Na	.0046	4.47	Na_2SO_4	.0142
K	.0032	3.11	K_2SO_4	.0042
Cl	.0012	1.16	KCl	.0025
SO_4	.0132	12.81		
CO_3	.0440	42.72		
H, bicarbonates	.0007	.68		
	.1030	100.00		.1030

C, the Grace Spring, seven miles north of Mountain City, Tennessee, on the road to Abingdon, Virginia, near Laurel Bloomery post-office. Specific gravity, 1.00038, 18.5°.

	Found.	Per cent. of total.		Combination.
SiO_2	.0125	1.09	SiO_2	.0125
Fe	trace	....	KCl	.0023
Ca	.2334	20.31	K_2SO_4	.0075
Mg	.0580	5.05	Na_2SO_4	.0145
K	.0046	.40	$MgSO_4$	.2900
Na	.0047	.41	$CaSO_4$	.6429
Cl	.0011	.09	$CaH_2C_2O_6$	.1794
SO_4	.6997	60.89		
CO_3	.1329	11.57		
H, bicarbonates	.0022	.19		
	1.1491	100.00		1.1491

D, drinking water, Savannah, Georgia. Stated in grammes per liter.

	Found.		Combination.
Suspended matter (organic)	.0020	Suspended matter	.0025
Suspended matter (inorganic)	.0005	SiO_2	.0624
SiO_2	.0624	Al_2O_3, Fe_2O_3	.0006
Al_2O_3, Fe_2O_3	.0006	NaCl	.0097
Ca	.0279	Na_2SO_4	.0120
Mg	.0085	$CaH_2C_2O_6$	.1129
Na	.0075	$MgH_2C_2O_6$	.0517
Cl	.0061		
SO_4	.0081		
CO_3	.1262		
NH_3, free	trace		
NH_3, albuminoid	none		
H, bicarbonates	.0020		
	.2518		.2518

E, two artesian well waters from St. Augustine, Florida. (*a*) six-inch well.

	Found.	Per cent. of total.		Combination.
Suspended matter	.0037	.24	Suspended matter	.0037
SiO_2	.0224	1.43	SiO_2	.0224
Al_2O_3	.0005	.03	Al_2O_3	.0005
Ca	.1276	8.16	NaCl	.6979
Mg	.0726	4.64	KCl	.0281
Sr	.0081	.52	$MgCl_2$	.1470
Na	.2743	17.54	$SrSO_4$	.0170
K	.0147	.94	$CaSO_4$	.4338
Cl	.5469	34.97	$MgSO_4$	.0127
SO_4	.3253	20.81	$MgH_2C_2O_6$	.2007
CO_3	.1650	10.55	$CaH_2C_2O_6$	none.
H, bicarbonates	.0027	.17		
	1.5638	100.00		1.5638

(*b*) twelve-inch well.

	Found.	Per cent. of total.		Combination.
Suspended matter	.0016	.05	Suspended matter	.0016
SiO_2	.0280	.88	SiO_2	.0280
Al_2O_3	.0012	.04	Al_2O_3	.0012
Ca	.1755	5.50	NaCl	1.9577
Mg	.1160	3.64	KCl	.0475
Sr	.0089	.28	$MgCl_2$	.3534
Na	.7695	24.12	$SrSO_4$	.0186
K	.0248	.77	$CaSO_4$	.4709
Cl	1.4750	46.22	$MgSO_4$	none.
SO_4	.3421	10.73	$MgH_2C_2O_6$	.1621
CO_3	.2442	7.64	$CaH_2C_2O_6$	.1499
H, bicarbonates	.0041	.13		
	3.1909	100.00		3.1909

F, from well four miles northwest of Clinton, Hinds County, Mississippi. No carbonates present.

	Found.	Per cent. of total.		Combination.
Suspended matter	.0028	.18	Suspended matter	.0028
SiO_2	.0750	4.82	SiO_2	.0750
Al_2O_3	.0077	.49	Al_2O_3	.0077
Fe_2O_3	trace.	....	$Al_2(SO_4)_3$	.0504
Al in sulphate	.0081	.52	$MnSO_4$	.0028
Mn	.0010	.06	$CaSO_4$	.6732
Ca	.1980	12.72	$MgSO_4$	.3695
Mg	.0739	4.78	Na_2SO_4	.2519
Na	.1234	7.92	NaCl	.1063
K	.0088	.56	KCl	.0167
SO_4	.9852	63.30		
Cl	.0724	4.65		
	1.5563	100.00		1.5563

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