On Glauconite from the Greensand near Lewes, Sussex; the constitution of Glauconite.[1]

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A BORING made at Iford Manor, $1\frac{1}{2}$ miles S.E. of Lewes, Sussex, yielded the following section :

Gault	...	...to 325 ft. 0 ins.
Glauconite sand	...	5 0
Sand, to bottom of boring,		4 0

The lower sand contained numerous grains of glauconite, while the upper bed was black when wet and consisted almost entirely of dark-green glauconite, with a few shell fragments and large quartz grains. The glauconite grains were small and were separated in an almost pure state by sieving; the portion coarser than 76 [wires to the inch] mesh contained the shell fragments, &c., while that below was nearly all glauconite, with a few very small grains of magnetite present in the sand. The mean size of the grains was thus about 0·25 mm., and they had the typical irregular rounded form, but there was no evidence of casts after forminifera. The material between 76 and 100 mesh was taken as pure for analysis. As is usual in fresh glauconite, both recent and in the sedimentary rocks, the grains consisted of a felted mass of minute birefringent flakes. The mean refractive index was 1·62, the specific gravity 2·70.

Mr. E. G. Radley has very kindly supplied the following analysis of this mineral :

SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	K_2O.	Na_2O.	H_2O at 105°.	H_2O > 105°.	Total.
48·12	9·16	19·10	3·47	0·76	2·36	7·08	0·22	4·78	5·28	100·33

This analysis agrees very closely with others in Table I, and it is of

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interest to note the occurrence of a greensand glauconite with a percentage of ferric iron comparable with that in recent oceanic material.

The constitution of Glauconite.

A list of forty-five analyses of this mineral has been tabulated by C. K. Leith (Monogr. U.S. Geol. Surv., 1903, vol. 43, p. 240). The results vary greatly in value, for the early analyses were often made on 'greensand' insufficiently purified. Again, chamosite is a common associate of glauconite, and its presence has rarely been recognized; the high content of FeO in many analyses is no doubt due in part to this and similar minerals. In order to obtain analyses suitable for comparison it is necessary to exclude carefully all doubtful material. In the list given by Leith, it seems best to exclude all analyses of date earlier than 1870, together with all analyses in which FeO is not separately determined. The early 'Challenger' analyses have now been superseded by the later work of Collet, Lee, and Caspari (Table I). The long series by Glinka in 1899 was made on material separated in Thoulet's solution; the results are variable in every respect, and the potash content is often unusually high. The material is regarded by that author as being in many cases altered, while it seems possible that the high potash values may be due to the difficulty of removing the Thoulet's solution from the mineral. These analyses have therefore also been omitted.

The remaining analyses in Leith's list, together with other recent analyses, are given in the following table:

Table I. Percentage composition of Glauconite.

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	K_2O.	Na_2O.	H_2O.	Total.
1.	49.76	8.18	16.00	3.77	0.41	3.97	7.57	0.52	9.82	100.00
2.	49.42	10.23	16.01	3.00	0.31	3.78	7.91	0.26	8.08	99.00
3.	51.24	12.22	13.44	3.06	0.10	3.93	7.50	0.31	8.20	100.00
4.	50.42	4.79	19.90	5.96	3.21	2.28	7.87	0.21	5.28	99.92
5.	49.09	15.21	10.56	3.06	0.55	2.65	6.05	1.21	11.64	100.02
6.	46.90	4.06	27.09	8.60	0.20	0.70	6.16	1.28	9.25	99.24
7.	46.91	7.04	23.06	2.64	2.95	4.40	7.31	0.91	4.71	99.93
8.	47.46	1.53	30.83	3.10	—	2.41	7.76	—	7.00	100.09
9.	49.67	9.29	19.88	1.28	1.95	4.03	3.68	3.00	7.88	100.66
10.	49.12	7.09	25.95	0.89	—	3.10	7.02	—	7.12	100.29
11.	51.15	7.61	18.83	2.78	—	4.54	7.80	—	7.56	100.27
12.	48.12	9.16	19.10	3.47	0.76	2.36	7.08	0.22	10.06	100.33

1. Grodno, Poland. A. Kupffer, Archiv Naturk. Liv-, Ehst- und Kurlands, Ser. I, Min. Wiss. Dorpat, 1870, vol. 5, p. 123.

2. Svir river, Olonets, Russia. (Also quartz 0.80). Ibid.

3. Karya-Oro, Ontika, Esthonia. Ibid.

4. Antwerp, Belgium. F. Dewalque, Ann. Soc. Géol. Belgique, 1875, vol. 2, p. 8.

5. Ashgrove, Elgin, Scotland. M. F. Heddle, Trans. R. Soc. Edinburgh, 1879, vol. 29, p. 79.

6. Agulhas Bank, South Africa. C. W. von Gümbel, Sitzungsber. math.-physik. Cl. Akad. Wiss. München, 1886, vol. 16, pp. 417–449.

7. Gozo, Maltese Islands. E. von Bamberger, Tschermak's Min. Mitth., 1877, p. 271.

8. Pacific Ocean, off California. L. W. Collet and G. W. Lee, Proc. R. Soc., Edinburgh, 1906, vol. 26, pp. 238–278; Compt. Rend. Acad. Sci. Paris, 1906, vol. 142, pp. 999 1001.

9. Kurische Nehrung, East Prussia. A. Johnsen, Schrift. physik. Ges. Königsberg, 1908, vol. 49, pp. 51–60.

10. Pacific Ocean, off Panama, at depth of 556 fathoms. W. A. Caspari, Proc. R. Soc. Edinburgh, 1910, vol. 30, pp. 364–373.

11. Agulhas Bank, South Africa, at 110 fathoms. Ibid.

12. Lewes, Sussex. E. G. Radley, this paper.

In order to examine the constitution of the mineral, the above analyses have been recalculated in molecular proportions, the amount of silica being represented as 1,000 in each case. This was chosen as the common 'datum' since silica is a constituent which does not appear to be affected by substitution, and the results so presented are simpler in form than the 'molecular percentages' as usually calculated. The lime present in a few analyses has been omitted, as probably due to impurities.

Table II. Molecular proportions.

	SiO_2.	$Al_2O_3 + Fe_2O_3$.	$FeO + MgO$.	$K_2O + Na_2O$.	$R_2O_3 + RO$.
1.	1,000	218	182	107	400
2.	,,	243	164	107	407
3.	,,	238	163	99	401
4.	,,	201	166	105	367
5.	,,	263	132	102	395
6.	,,	267	87	110	354
7.	,,	272	188	117	460
8.	,,	263	130	103	393
9.	,,	261	144	106	405
10.	,,	283	106	98	389
11.	,,	225	179	97	404
12.	,,	262	133	98	395

The proportion of alkalis is remarkably constant, and there is clearly no evidence of the substitution of these by water, or, as was assumed by Clarke (Leith, l. c.), by the magnesia group. There is, however, considerable replacement of potash by soda, greatest in analysis 9, and

it may be suggested that the name 'soda-glauconite' should be used to distinguish these varieties.

In the groups R_2O_3 and RO the molecular proportions are not constant and do not stand in any simple ratio to the silica and alkalis; the ordinary substitutions of alumina for ferric iron and magnesia for ferrous iron are therefore insufficient to explain the analyses. If, however, the $(Fe,Mg)O$ and $(Fe,Al)_2O_3$ are treated as mutually replaceable, considerable improvement can be brought about. The total for these two groups combined is given in the last column of Table II, and it will be seen that, with the exception of nos. 4, 6, and 7, the total is constant and in simple ratio to the silica. The ratios so obtained lead to the simple formula

$$R_2O \cdot 4(R_2O_3,RO) \cdot 10 \, SiO_2 \cdot nH_2O,$$
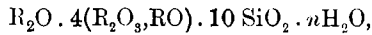
the ratio of bases to silica being $1:2$.

There exists a certain justification for regarding the above substitution as possible, for the only definite hydrate of Fe_2O_3 known to exist is the monohydrate, which may be written $OFeOFe(OH)_2$ resembling $Fe(OH)_2$. The extent of this substitution is not great, the ratio of R_2O_3 to RO lying between the limits $3:1$ and $1:1$.

As regards the water, apart from the observation that it does not substitute the solid constituents, there is no information as to the extent to which it is present in definite combination; detailed work on the dehydration would be necessary to throw light on this question, and it has been thought best to omit this from the present paper.