SORPTION OF GAS BY MINERAL. II. LAUMONTITE.

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The results of observations on the sorption of gases by heulandite and chabazite were already reported.(1) In this paper, the sorption of gases by laumontite is described.

The composition of laumontite is $CaAl_2Si_4O_{12}.4H_2O$.(2) The mineral from Takashima, Hokkaido has been used in the present experiment. It is white crystal of silky lustre.

The method of observation is quite the same with that in the previous experiments. Before the measurement, the mineral is evacuated and heated to a certain temperature for certain length of time. Then, keeping the temperature of the dehydrated mineral to be constant by a thermostat, the gas is put in contact with the mineral and decrease of volume of the gas is measured. The gases tested are carbon dioxide and ammonia.

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(1) Sameshima, this Bulletin, **4** (1929), 96.

(2) Doelter, "Handbuch der Mineralchemie." Bd. II, 3 Teil, 43.

The result obtained on carbon dioxide is shown in Table 1.

Table 1.

Sorption of Carbon Dioxide by Laumontite at 25°C.

Time in min.	Vol. of CO_2 sorbed by 1 gr. of mineral in c.c.	Pressure of gas in mm. Hg.
0.5	0.52	751.4
45.	0.71	751.0
1355.	1.01	751.9

In the above experiment, the mineral is dehydrated at 300°C. for 30 minutes. Laumontite, thus, does not noticeably sorbs carbon dioxide. The same order of amount of this gas is sorbed by laumontite with heulandite.[1] Such a small amount of carbon dioxide will be sorbed by the lime or other substances which may be admixed as impurity. We can say, therefore, that laumontite sorbs practically no carbon dioxide.

A rather interesting result has been obtained on ammonia. At first the bulb containing laumontite is evacuated and heated to 300°C. until no evolution of gas (water vapour) is perceptible. By this treatment the decrease in weight of laumontite was 10.0%. Then the dehydrated mineral was kept to 25.0°C. and the sorption velocity and amount of ammonia was measured. The result is as follows:

Table 2. First Sorption.

Time in min.	Vol. of NH_3 sorbed by 1 gr. of mineral at 25.0°C. in c.c.	Pressure of gas in mm. Hg.
0.5	7.76	751.6
4.25	14 27	751.6
9.5	17.86	751.5
28.	23.36	751.3
90.	30.25	750.3
210.	33.48	749.8
1420.	38.69	751.3

(1) This Bulletin, **4** (1929), 99.

In this table, the first column shows the time in minutes after the contact of mineral to ammonia, the second column the volume of ammonia sorbed by the material which is obtained by dehydrating 1 gram of air dry laumontite, and the third column the pressure of ammonia gas.

The material which has sorbed ammonia is now evacuated and heated to 300°C. and then second sorption is undertaken on this desorbed material. The result was as follows.

Table 3. Second Sorption.

Time in min.	Vol. of NH_3 sorbed by 1 gr. of mineral at 25.0°C. in c.c.	Pressure of gas in mm. Hg.
0.5	5.11	750.8
5.	7.37	750.8
9.5	8.04	750.8
26.	9.45	750.8
72.	11.21	750.6

The material was evacuated and heated to 300°C. and third sorption was observed.

Table 4. Third Sorption.

Time in min.	Vol. of NH_3 sorbed by 1 gr. of mineral at 25.0°C. in c.c.	Pressure of gas in mm. Hg.
0.5	1.46	750.6
5.	1.94	750.6
10.	2.06	750.6
50.	2.62	750.6
1220.	4.00	754.6
2665.	4.47	751.8

These three series of observations are depicted in Fig. 1.

From these results, it is known that the sorption amount of ammonia by laumontite decreases rapidly by either repeating sorption or prolonged heating. Now the sorption amount was measured changing the heating time and the temperature of dehydration.

The glass bulb containing the mineral was evacuated and an electric furnace was put around the bulb. The temperature of bulb was now raised and after 5 minutes it reached 300°C. Then this temperature is

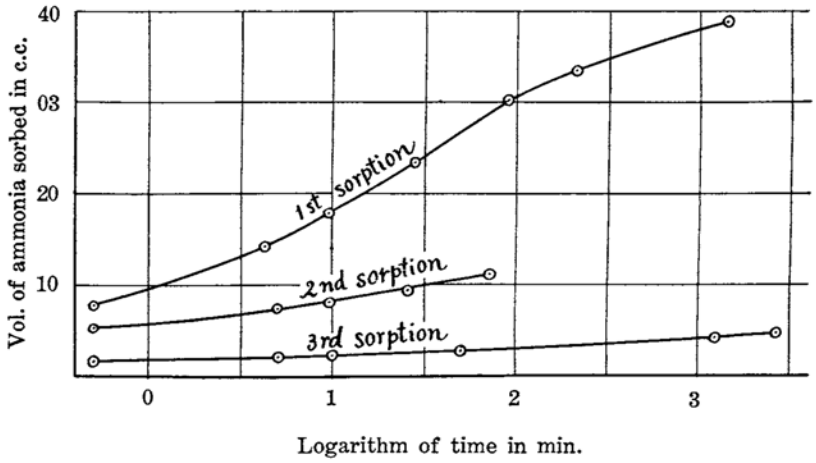

Fig. 1.

maintained for 30, 20, 10 or 1 minute in the following four series of observations respectively (Tables 5, 6, 7 and 8). In Table 9 the results are shown in the case where the mineral was dehydrated at 150°C. for 15 minutes.

Table 5.

The mineral was dehydrated by evacuating and heating to 300°C. for 30 minutes.

Time in min.	Vol. of NH_3 sorbed by 1 gr. of mineral at 25.0°C. in c.c.	Pressure of gas in mm. Hg.
0.5	2.14	751.8
5.	3.00	751.8
13.	3.52	751.8
68.	4.70	751.8
159.	5.55	751.2
1415.	8.08	752.6
4265.	10.01	756.6

Table 6.

The mineral was dehydrated by evacuating and heating to 300°C. for 20 minutes.

Time in min.	Vol. of NH_3 sorbed by 1 gr. of mineral at 25.0°C. in c.c.	Pressure of gas in mm. Hg.
0.5	6.92	757.0
5.	10.46	757.0
10.	11.98	756.9
50.	15.98	756.6
120.	17.90	756.0
1350.	22.54	754.3
2815.	23.72	751.2

Table 7.

The mineral was dehydrated by evacuating and heating to 300°C. for 10 minutes.

Time in min.	Vol. of NH_3 sorbed by 1 gr. of mineral at 25.0°C. in c.c.	Pressure of gas in mm. Hg.
0.5	19.59	757.4
5.	33.94	757.4
10.	37.59	757.3
45.	46.91	757.0
155.	54.35	756.5
1335.	63.54	757.9
2810.	65.45	757.4

Table 8.

The mineral was dehydrated by evacuating and heating to 300°C. for 1 minute.

Time in min.	Vol. of NH_3 sorbed by 1 gr. of mineral at 25.0°C. in c.c.	Pressure of gas in mm. Hg.
0.5	21.76	750.9
5.	37.44	750.9
10.	40.82	750.9
30.	47.38	750.7
160.	57.58	750.3
2830.	68.46	756.5

Table 9.

The mineral was dehydrated by evacuating and heating to 150°C. for 15 minutes.

Time in min.	Vol. of NH_3 sorbed by 1 gr. of mineral at 25.0°C. in c.c.	Pressure of gas in mm. Hg.
0.5	5.46	759.4
1.5	9.08	759.4
5.	15.34	759.4
10.	20.68	759.3
20.	26.29	759.2
60.	34.87	759.1
125.	38.92	758.7
300.	41.62	758.1
2965.	45.16	754.2

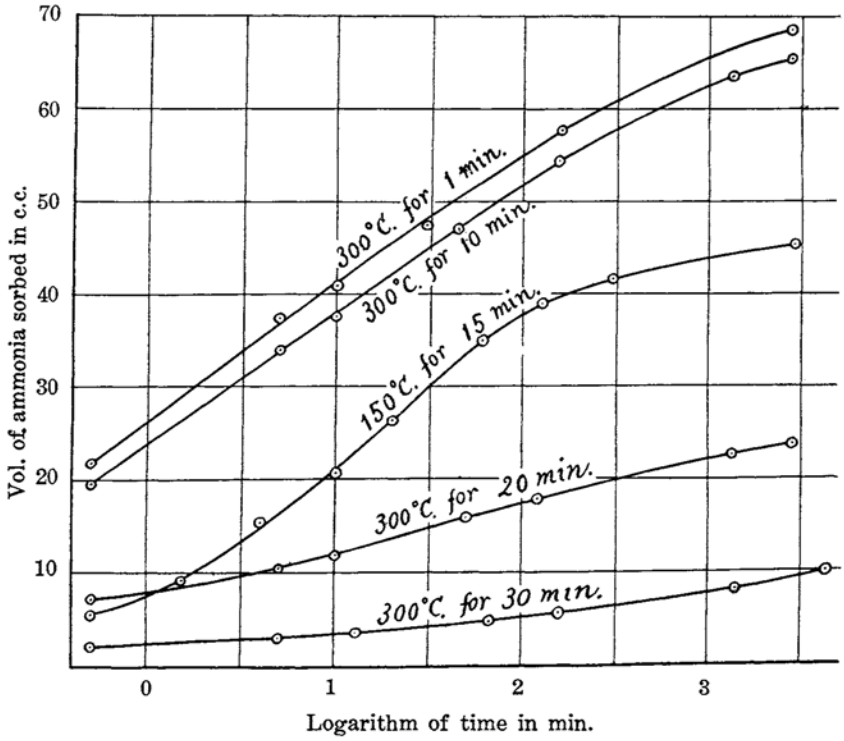

Fig. 2.

By evacuating and heating to 150°C. for 15 minutes the mineral decreases its weight 4.6%.

The data of Tables 5, 6, 7, 8 and 9 are plotted in Fig. 2.

The sorption amount by laumontite of ammonia is, thus, markedly effected by the heat treatment of the mineral at comparatively low temperature such as 300°C.

For the purpose of deciding whether ammonia combines chemically with dehydrated mineral or it is "sorbed" into the pores of the material,[1] an experiment was undertaken at 0°C. intead of 25°C. The material which had been dehydrated in the exactly same conditions as that in Table 9, was tested at 0.0°C. The material was kept at 0.0°C. by using a bath of melting ice during the whole observations, namely ca. 48 hours. The result is shown in Table 10.

Table 10.

The material was dehydrated by evacuating and heating to 150°C. for 15 minutes.

Time in min.	Vol. of NH_3 sorbed by 1 gr. of mineral at 0.0°C. in c.c.	Pressure of gas in mm. Hg.
0.5	4.65	757.3
1.	5.70	757.3
5.	8.62	757.3
15.	12.12	757.3
30.	15.57	757.3
60.	20.12	757.3
120.	25.65	757.1
320.	33.51	756.3
1270.	41.95	759.5
2830.	45.35	761.1

The data in Table 9 and Table 10 are plotted in Fig. 3.

From Fig. 3 it can be noticed that the amount of sorption of ammonia is nearly the same in both cases, while the velocity of sorption is considerably different.

In general, the sorption amount of gases by porous matters such as charcoal, dehydrated silica or chabazite increase by the lowering of temperature. Thus charcoal sorbs greater amount of ammonia at 0°C. than 25°C. In the case of a chemical combination between gas and solid, however, the sorption amount must remain constant at any temperature. Therefore, it is known that the ammonia sorbed by laumontite combines

(1) Sameshima, this Bulletin, **4** (1929), 125; *Chem. News*, **139** (1929), 61.

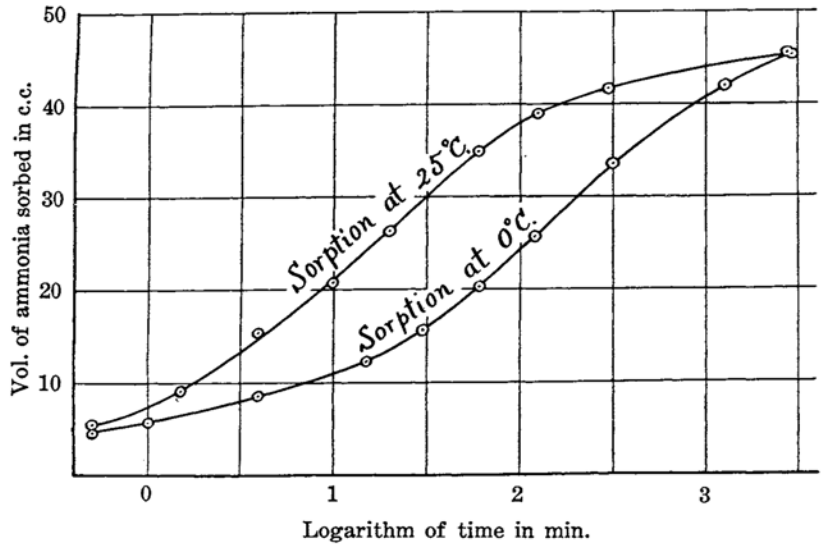

Fig. 3.

chemically with the dehydrated mineral. The retardation of the combination velocity by the lowering of temperature is the general rule in chemical kinetics.

The relation between the number of mols of ammonia sorbed and that of water evaporated is not exactly known by the present experiments, for the sorption amount varies by the heat treatment of the material. It is probable, however, that one molecule of ammonia enters in place of one molecule of water, just as the case of heulandite.[1]

The structures of zeolite minerals are considered to be rather complicated, and the constitution or crystal form of a mineral as laumontite is liable to change by a slight heat treatment. Accordingly, the sorption amount of ammonia will change also.

Summary.

Dehydrated laumontite sorbs ammonia but not carbon dioxide. The sorption amount of ammonia varies markedly by the conditions of the dehydration. Same amount of ammonia is sorbed at 25°C. and at 0°C. by a sample. The ammonia combines chemically with dehydrated mineral.

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(1) Sameshima, this Bulletin, **4** (1929), 96.