

*The leaching of granite and some other rocks.*

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IN 1913 the late Mr. J. J. Beringer suggested that it would be of interest to determine the solubility of crushed felspar (*a*) in distilled water free of carbon dioxide, and (*b*) in distilled water saturated with carbon dioxide. For this purpose crushed felspar (orthoclase) was covered with water in a silica basin (i) in a desiccator containing potassium hydroxide solution, and (ii) in a desiccator connected with a carbon dioxide Kipp's apparatus. These were allowed to stand for a fortnight and the alkalinity of the water was then determined by *N*/100 hydrochloric acid. This experiment was continued until the end of July, 1914. A definite solubility was determined in each case and the solubility in the carbon dioxide water was only slightly more than in the water free from carbon dioxide. Unfortunately Mr. Beringer died early in 1915, and the records of his experiment could not be found.

In 1934 I began the experiments to be described below. It seemed advisable to reproduce the conditions under which superficial granite is percolated by rain-water but, at the same time, to stimulate the action by using crushed granite so as to expose a greater surface to the percolating water. The experiment was therefore set up as follows.

A sample of fresh, unaltered muscovite-biotite-granite from Long Downs, near Penryn, Cornwall, was crushed to pass a 30-mesh sieve and lie on a 50-mesh sieve; 450 grams of the crushed rock was placed in a glass separating funnel (fig. 1) with a plug of glass-wool at the bottom to prevent choking of the glass tap. A flask fitted with a rubber cork and two tubes, one of which extended from about half-way up the neck of the flask to 4 inches below the cork, its upper end being drawn out to a fine jet; the second tube extended from the bottom of the neck of the flask to outside the cork where it was bent at 30° and its outer end fitted with a rubber tube and screw pinch-cock, while its upper end was drawn out to a fine jet. This flask was filled with 800 c.c. of distilled water and inverted over the separating funnel, the pinch-cock being so adjusted that air bubbled slowly into the flask, while water dripped into

the funnel. In this way the water was thoroughly aerated. The outflow from the separating funnel was delivered into a glass funnel, fitted with filter-paper, which was placed in the neck of an empty flask.

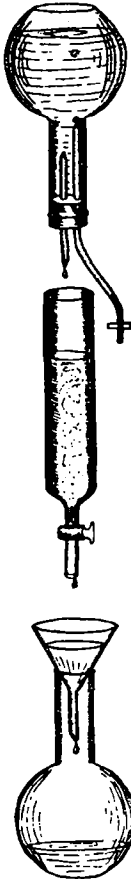


FIG. 1. Leaching apparatus.

After the first 800 c.c. of water had passed through it was returned to the upper flask and allowed to drip through again. This was repeated until the water had dripped through the funnel five times. The water was then transferred to a porcelain dish, evaporated to a small volume, transferred to a weighed silica crucible, evaporated to dryness, and weighed. A fresh 800 c.c. of distilled water was then placed in the upper flask and the leaching repeated.

This experiment was repeated until fifteen lots of water had been evaporated, when an accident brought the experiment to a close. The results are given in table I (column 1). A new experiment was started in 1936 and was carried on until 25 lots of water had been evaporated, and the results are given in column 2.

The time taken for the water to pass through five times varied somewhat, especially as the experiment was stopped on Sundays, but neglecting this interruption, the average time was 5 to 6 days. It was observed that, after the water had passed through the funnel twice, rusty-red haloes appeared round the flakes of biotite. The sediment collected in the filter-paper was very little, its total weight after 25 leachings being only 0.008 gram. The dried soluble portion was rusty-brown in colour.

To determine the solubility of the apparatus, three blank experiments were carried out with a separating funnel filled with glass-wool. The solubles recovered after evaporation were, 0.00056, 0.00071, and 0.00062

gram. In 1936 a similar experiment was begun using oolitic limestone of the Oolite formation from Corsham quarry, near Bath, crushed to pass a 30-mesh sieve and lie on a 50-mesh sieve. The experiment was carried out in exactly the same way as in the case of the granite and was continued until 25 lots of water had been evaporated (table I, column 3). The dried material was dark cream-coloured. It was observed that after five leachings, calcium carbonate was deposited

between the grains of the oolite; also, the effluent water was sometimes cloudy with calcium carbonate. The sediment caught in the filter-paper was larger than in the case of the granite and gave a total weight of 0.12 gram.

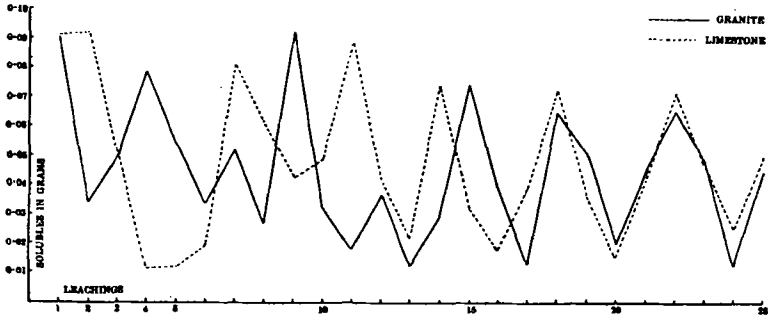


FIG. 2. Leaching of granite (2) and limestone, plotted from Table I.

TABLE I. Leaching of granite, limestone, and gabbro.

Weight in grams of solubles, each number being for five leachings.  
(Temperatures: maximum 71°, minimum 57°, average 68° F.)

	Granite (1).	Granite (2).	Limestone.	Gabbro.
1.	0.071	0.090	0.091	0.048
2.	0.050	0.034	0.092	0.0201
3.	0.017	0.0498	0.051	0.027
4.	0.042	0.079	0.0113	0.0582
5.	0.0825	0.054	0.0118	0.0242
6.	0.0481	0.0335	0.019	0.036
7.	0.018	0.0518	0.081	0.0302
8.	0.021	0.027	0.061	0.048
9.	0.052	0.092	0.0428	0.031
10.	0.079	0.033	0.049	0.3227
11.	0.0611	0.0181	0.089	
12.	0.0287	0.037	0.0415	
13.	0.045	0.012	0.0219	
14.	0.0829	0.0288	0.074	
15.	0.057	0.074	0.032	
Total	0.7553			
16.		0.0388	0.0157	
17.		0.013	0.039	
18.		0.075	0.072	
19.		0.050	0.037	
20.		0.020	0.0153	
21.		0.046	0.042	
22.		0.075	0.071	
23.		0.048	0.047	
24.		0.0118	0.025	
25.		0.0451	0.050	
Total		1.1367	1.1823	

Quite recently a third experiment has been started in which the rock leached was gabbro. The results of this experiment, to date, are given in column 4.

The total solubles obtained in the second leaching of granite and in the leaching of oolitic limestone were analysed by Dr. F. W. Rixon of Bristol University, and the results are given in table II.

TABLE II. Chemical analyses of solubles.  
(Materials dried at 110° C.)

	Granite (2).	Limestone.
SiO <sub>2</sub> ... ..	6.36%	5.25%
Al <sub>2</sub> O <sub>3</sub> ... ..	1.01	—
Fe <sub>2</sub> O <sub>3</sub> ... ..	3.50	0.95
MgO ... ..	10.85	trace
CaO ... ..	45.10	44.35
Na <sub>2</sub> O ... ..	3.64	8.84
K <sub>2</sub> O ... ..	3.18	trace
CO <sub>2</sub> ... ..	n.d.*	n.d.†
Cl ... ..	—	9.34
I ... ..	—	trace
SO <sub>2</sub> ... ..	—	15.20
H <sub>2</sub> O ... ..	n.d.	n.d.
Organic matter ... ..	—	1.90
	73.64	85.83

\* Slight effervescence with HCl.

† Strong effervescence with HCl.

The graphs (fig. 2) emphasize the fact that the amounts dissolved in leaching both the granite and oolite show a fairly regular rise and fall. This variation is not due to change of temperature, as it persists when the temperature is constant. It seems to the author that some type of delayed action takes place, due possibly to the formation of intermediate hydrated compounds.

The leaching experiments will be continued, and it is intended to use water which has stood over peat.