

3. On the Fossil Plants in the Ravenhead Collection in the Liverpool Museum. By R. Kidston, Esq.

4. On the Action of Carbonic Acid Water on Olivine. By Alexander Johnstone, F.G.S., Assistant to the Professor of Geology, Edinburgh University.

In a paper, entitled "On the Action of Carbonic Acid Water on Minerals and Rocks," read before the Edinburgh Geological Society on the 18th February 1886, and subsequently published in their *Transactions* for that year (vol. v. part ii. p. 282), I gave some account of the simple experiments made with a view to elucidate the action of carbonated water on various minerals, which up to that period I had been able to carry through. The minerals which I had at that time submitted to the action of carbonic acid water were the commonest rock-forming felspars, viz., orthoclase, oligoclase, and labradorite; the micas,—muscovite and biotite; *black* amphiboles and pyroxenes,—hornblende and augite; the anhydrous iron oxides,—magnetic and hæmatite; and the rhombohedral carbonates,—calcite and siderite.

On a certain quantity of each of those mineral substances, I allowed a litre of distilled water, saturated with carbonic acid gas, and kept at a nearly constant equal temperature (about 4° C.), to act for a certain time. In some cases I permitted fresh air to come repeatedly into contact with the moist mineral, in other cases I carefully excluded atmospheric air. As the result of these experiments, I found that in nearly every instance the mineral which repeatedly encountered air *plus* carbonic acid water, changed and disintegrated far more rapidly than its neighbour which was carefully protected from the atmospheric contact. I have since the beginning of the year 1886, continued, with occasional interruptions, my investigations into this important matter, and have found that almost every rock-forming mineral and rock which I have submitted to the action of the carbonated water, has become, in a comparatively short period, altered chemically and mechanically, and also in a greater or less degree disintegrated. I have paid

special attention to the action of the carbonic acid water on the mineral olivine, and believing that the results obtained in this case, along with those previously recorded, may yet throw considerable light on the nature and extent of the chemical alteration and disintegration of rocks, and in the meantime prove to possess some little interest for geologists generally, I venture to bring this paper before the Royal Society of Edinburgh.

Olivine, chrysolite, or peridot is in its original state a double silicate of magnesia and protoxide of iron, with traces of other bases. It usually occurs in small transparent to translucent rectangular prisms of the Trimetric System, embedded in basalts and basaltic lavas, and looks like pale olive-green glass, differing, however, from glass in having cleavage.*

Its normal hardness when fresh is close on 7. Its specific gravity varies from 3·3 to 3·5. It is one of the least fusible of minerals; in fact, in the ordinary blowpipe laboratory it is considered to be practically infusible, its fusibility, according to Von Kobell's scale, being at least as high as 6.

It is when finely powdered, decomposed and gelatinised when treated for some time with warm concentrated hydrochloric acid.

Under the microscope, fresh olivine appears colourless when in thin sections, and its surface, especially when viewed by oblique illumination, is seen to be rough, like ground glass, and minutely pitted. It is doubly refractive, polarising in fairly strong tints, and numerous irregular cracks can be seen traversing it in all directions.

I took a certain amount of olivine having all the characters and properties of the typical mineral as described above, and placed it in a flask containing a litre of pure distilled water saturated with carbonic acid gas, and allowed this liquid to act on it undisturbed for two months. I tested the solution with litmus paper at the time I put the mineral into it, and found it to be distinctly acid. About every two days or so after this, I again tested the water, and observed that it gradually became less and less acid in nature, until in about six weeks' time it was quite neutral to test papers.

* There are two cleavages—the macropinacoid and brachypinacoid; the latter is the more distinct, but neither as a rule are at all strongly marked, at least in fresh specimens.

By chemical and microscopical investigations afterwards I found that this disappearance of the acid reaction was undoubtedly due to the absorption and combination of the carbonic acid gas held in solution by and with the magnesia especially, but also, although in a much less degree, with the protoxide of iron.

After the olivine had lain undisturbed in the carbonated water for two months, I took a small portion of the liquid and tested it directly for magnesia as follows:—I added to it first about a fourth of its bulk of ammonium chloride, and after thoroughly mixing saw that the liquid remained perfectly clear; I then poured in a sufficient quantity of ammonium hydrate to make the whole fluid, after again mixing properly, distinctly alkaline. To the still perfectly clear liquid I now added ammonium phosphate, and shook up the mixture very briskly for two or three minutes. A very distinct white crystalline precipitate of the double phosphate of ammonium and magnesium formed almost at once, proving the presence of magnesium, and showing that that metal had been removed from the olivine crystals by the action of the carbonic acid water.

I tested another small portion of the water in which the crystals had lain, for iron, by the following methods:—(1) I poured in a little rather strong pure hydrochloric acid (free from even a trace of iron) heated gently, and then added in small quantities at a time a little solid chlorate of potash,* and continued heating for four or five minutes. By this operation any iron present in the ferrous state was changed into the ferric condition, and rendered fit for testing. To one part of this ferric-ised solution I now added thiocyanate of potassium, when a *pale* but distinct blood-red coloration was produced, showing that a *trace* of iron had been removed from the olivine, and held in solution by the carbonated water. (2) I also converted, in another portion of the original solution, the ferrous salt present into ferric, by boiling it for some time with *pure* concentrated nitric acid (absolutely free from iron), and tested the liquid so treated by the methods detailed above for magnesia and iron, with precisely the same results.

After removing the crystals I evaporated off the remainder of the liquid, in which they had been placed, over the water-bath, and

* I used the chlorate of potassium, but am now aware that potassium permanganate would have served the purpose better.

procured a decided residue, which after chemical examination I found to be almost entirely magnesium carbonate; there was, however, a trace but only a trace of *ferrous carbonate*.

In order to make certain that the solvent action was due to the presence of the carbonic gas in the water, I allowed a litre of carefully distilled water to act for two months on the same weight of the same variety of olivine crystals which I had used in the above experiment, and at the expiration of that time I tested a portion of the liquid by the methods already stated for magnesia and iron; I could not detect even the faintest trace of those substances, and after evaporating the rest of the liquid to dryness, I was equally unsuccessful—observing no indication of any residue whatever.

I analysed a variety of practically fresh olivine similar to that taken for the above experimental investigation, and I also submitted to analysis the crystals of olivine which had been subjected to the action of the carbonic acid water as described. The two analyses I give below:—

I. *Analysis of practically Fresh Olivine.*

Silica,	.	.	.	41·25	per cent.
Magnesia,	.	.	.	50·74	„
Protoxide of iron,	.	.	.	7·88	„
Alumina,	}	.	.		Traces
Calcium,					
Manganese,					
Nickel?					
Chromium,					
Total,				99·87	per cent.

II. *Analysis of Olivine (originally of the same quantitative composition as I.) which had lain for two months in distilled water saturated with carbonic acid gas:—*

Silica,	.	.	.	41·989	per cent.
Magnesia,	.	.	.	50·008	„
Protoxide of iron, and Ferric Oxide,	}	.	.	7·879	„
Total,				99·876	per cent.

When the olivine crystals were removed from the liquid their physical characters were observed to have changed slightly. Originally of a *pale* olive-green colour, and transparent to semi-

transparent, they exhibited now more of a yellowish-green tint, and their diaphaneity was rather translucent than transparent. Their hardness was also reduced to about 6.5.

I noticed also that crystals naturally aggregated together, when put into the water, tended to separate from one another after a month or two's exposure to the carbonated liquid.

Being curious to learn the effects of the action of the carbonic acid water on the microscopic character of olivine, I got two specimens sliced, one of which was a fresh crystal, and the other a crystal originally identical with the former, but which had lain for two months immersed in the carbonated fluid. Fig. 1 shows the fresh specimen as observed under the microscope, and fig. 2 shows the same variety of mineral after its two months' treatment.

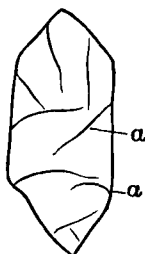


FIG. 1.—A fresh Crystal of Olivine. *a a*, fissures. Magnified about 60 diameters.

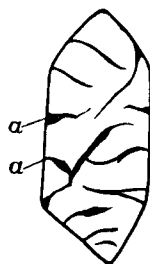


FIG. 2.—A Crystal of Olivine which had been subjected to two months' immersion in water saturated with Carbonic Acid Gas. *a a*, fissures. Magnified about 60 diameters.

In the unaltered crystal (fig. 1) the irregularly distributed cracks are much finer than those shown in the altered crystal in fig. 2, where they have evidently been widened considerably by the solvent action of the carbonic acid water.

In fig. 2 there is also a very distinct serpentinous formation about the cracks of the mineral, which is only very slightly developed in the fresh specimen, and in addition several faint red spots or patches of ferric oxide can be observed on the edges of the fissures; these are wholly wanting in the fresh crystal figured (fig. 1).

I have noticed also, that whereas in the freshest olivine neither of the cleavages are visible, or if visible not at all well marked, in

the weathered varieties, *i.e.*, varieties which have been altered in consequence of exposure to water plus carbonic acid and air, the cracks of the brachydiagonal cleavage, at least, are usually tolerably distinct.

5. Is the Law of Talbot true for very rapidly Intermittent Light? By George N. Stewart, Esq., *Senior Demonstrator of Physiology, Owens College, Manchester*.

The law which is sometimes associated with the name of Talbot is generally stated thus:—Once complete fusion has been reached, no alteration in the intensity of the resultant impression produced by a series of flashes takes place, however short the time during which each flash acts may be, provided that the number of flashes in a given time and the length of each stimulation be always kept inversely proportional. Complete fusion of stimuli here is analogous to complete tetanus of muscle. And, as in the latter case, it has been discussed as to where the upper limit of frequency lies, or whether there be an upper limit, so in the former case are like questions in place. With the various answers which have been given in regard to muscle tetanus we are not here concerned; except that it may be noticed that the later investigators, where they have at all admitted the probability of a limit, have had a tendency to shorten the time between each stimulus which they regarded as the minimum.

The analogous question for retinal stimulation may be stated a little more fully. It is this: Granting that so long as the individual stimuli are effective the law of Talbot is true, is there any limit of time below which the individual stimuli cease to affect the retina at all, even when the frequency of repetition increases in proportion to the diminution of the time during which each acts? In other words, is the retinal tetanus a complete tetanus, however short the duration of each stimulus? This is not the same thing as to ask whether there is a minimum time during which a single isolated stimulus must act in order to call forth a sensation. There is certainly such a minimum. It lies lower the stronger the light, and above this limit and below another the physiological intensity