

XVIII.—*On the Action of Carbonic Acid Water on Minerals and Rocks.* By A. JOHNSTONE.

(Read 18th February 1886.)

HAVING for the last two years been engaged more or less continuously in investigating the nature of chemical disintegration of mineral and rocky substances, I propose to submit to the Society some account of the simple experiments which, up to the present time, I have been enabled to carry through.

The minerals which I subjected to experimental examination, were those that enter most largely into the composition of the principal rocks of the earth's crust, and the rocks studied were those which occur most abundantly in the British Isles.

On these mineral and rock substances I allowed water, saturated with carbonic acid gas, to act for a certain time. The amount of carbonic acid water taken for all my experiments was one litre, and the temperature of the water was always kept at nearly 4° C.

At present I can only give you the results of my experiments on Orthoclase, Oligoclase, Labradorite, Muscovite, Biotite, Hornblende, Augite, Magnetite, Hæmatite, Calcite, and Crystalline Limestone.

Three pieces of Orthoclase felspar, which I will call A, B, and C respectively, after having been carefully weighed, were placed in separate portions of distilled water saturated with carbonic acid gas, and allowed to remain for three months.

A, with its carbonic acid water, was placed in a flask which was corked and put away on a shelf, and was never touched or moved in any way for three months, so that the water in which this specimen was suspended and completely immersed was always during that period in a motionless state.

B was suspended and entirely immersed in its portion of carbonic acid water which was put into a beaker, and the liquid was gently agitated for about ten minutes every day for three months. The mouth of the beaker was always left uncovered.

C was placed in a large shallow dish, and the carbonic acid water poured over it. There was just sufficient water to barely cover it, so that its upper surface was nearly in close contact with the atmosphere. Of course, the mouth of the dish in this case also was left uncovered. The water was gently shaken about for ten minutes every day.

At the end of three months A and B were taken out, dried in

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a hot air-bath, and weighed. A was found to have only very, very slightly decreased in weight; B was, however, distinctly lighter. A was a very little softer than it was before it was placed in the solution. It could be scratched a little easier by a good knife. B was decidedly softer; originally B was nearly 6.5 in Mohs' scale of hardness. When taken out of the water and again tested, one of its faces was found to have sunk to nearly 5.5. The solutions in which A and B had been suspended were evaporated down. A's left scarcely any residue; B's left sufficient to enable me to find in it Potash and Carbonic Acid, with a mere trace of Lime and Soda.

When C was removed from its vessel, it was seen to have altered its appearance; originally subtranslucent on the edges, these were now quite opaque, and the face of the crystal, which had been during the three months constantly kept in almost direct contact with the air, was noticed to have acquired a very thin dusty-like crust of Kaolin. The other faces of the mineral were also considerably softer since the date of their immersion. The carbonic acid water in which C had lain left behind it, after having been evaporated off, a considerably larger residue than B's liquid had done. This residue consisted of Potash, Soda, and Carbonic Acid, with a trace of Lime and Silica.

These very simple experiments, I think, prove, first, that Orthoclase kept in motionless carbonic acid water, away from air, is only very, very slightly altered indeed; second, that Orthoclase kept in moving carbonic acid water, and in ready contact with air, is disintegrated more rapidly. The more air, in fact—along with water—the more rapidly disintegration proceeds.

I subjected Oligoclase and Labradorite to the same conditions, and found that, like Orthoclase, they were most rapidly decomposed when kept in moving water, and also in contact with air. Of these three feldspars, viz., Orthoclase, Oligoclase, and Labradorite, I noticed that Orthoclase was the least liable to change, and Labradorite the most ready to disintegrate chemically. Oligoclase occupied an intermediate position. The products of the decomposition of Labradorite were Lime, Soda, Iron, Silica, and Alumina. Oligoclase yielded Soda, Lime, Silica, and Alumina. The white or grey varieties of Orthoclase and Oligoclase resisted the action of the carbonic acid water much better than those of a red or yellow colour.

After having exposed Oligoclase to the action of carbonic acid water and air for three months, I found on taking it out of the solution that two of its faces felt quite greasy; in fact, exposure to the solution and air had altered these external portions into steatites. It is probable, therefore, that at least some talcs and steatite are nothing more nor less than chemically altered feldspars.

The next mineral I experimented with was Muscovite, or common Mica. This mineral, as you are aware, exists in plates or scales, which cleave up into very thin laminæ. These laminæ are tough and very elastic, and possess a hardness equal to 2 or 2·5, according to Mohs' scale. It is practically an *anhydrous* silicate of Alumina and Potash. I took a strong piece of this mineral, about a quarter of an inch in thickness, and kept it suspended in water saturated with carbonic acid for four months. I agitated the water during that period nearly every day for about ten minutes. At the end of the four months, the originally thick piece of Muscovite had partially broken up into innumerable thin plates, the majority of which were of an exceedingly small size. I subjected all the larger plates to a careful examination. Some, I observed, had lost most of their elasticity, and all of them a great deal of their toughness; I could now crush a Mica plate between my finger and thumb into small soft pieces with the greatest ease. The lustre of the mineral had also changed during the time of its immersion from its original bright pearly sheen to *dull* pearly. I afterwards filtered the water in which the Mica had been suspended, and evaporated it down. There was no residue left. In fact, all the chemical change effected was hydration.

Biotite Mica, exposed to the same conditions, was, however, to a small extent chemically decomposed; some of its Magnesia and Ferric Oxide was dissolved out by the carbonic acid water. Like Muscovite, its folia also lost a good deal of their toughness and elasticity and original bright pearly lustre.

Hornblende and Augite kept in carbonic acid water, agitated frequently, were decomposed at about the same rate. They chemically disintegrated more rapidly than any of the felspars I subjected to the same test. They became hydrous and lost by solution Magnesia, Lime, and Iron, and a mere trace of Manganese. I am still experimenting with these two minerals, and hope soon to be able to give much fuller details.

I exposed Magnetite for two months to a strong solution of carbonic acid in water, and found that it did not alter in the very least.

Hæmatite (*Anhydrous* Ferric Oxide), placed in a shallow dish, and just barely covered with carbonic acid water (agitated frequently), became partially converted on its surface into an earthy variety of Limonite (*Hydrated* Ferric Oxide).

About three years ago I first began to try the effect of carbonic acid water on Limestone and Calcite. I will give you briefly the result of my latest effort.

A litre of distilled water (at about 4° C.) was saturated with carbonic acid gas. Into this was suspended a piece of white homogeneous statuary marble weighing 44·52 grms. It was

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allowed to remain in the water twenty-eight days. The water was gently shaken about for three or four minutes every day. After the marble had been immersed for a few days, Mr Murphy, a Glasgow chemist who aided me greatly with this experiment, called my attention to the fact that small crystals had fallen off from the suspended piece, and had congregated at the bottom of the vessel. Minute crystals could also be seen now and then breaking off from the original piece, and sinking to the bottom of the vessel. These very small crystals were examined by a good lens, and seen to be almost perfectly rhombohedral in form. After having been filtered off and carefully dried, they were found to weigh '0341 gramme.

The solution in which the marble had remained for one month was found to contain dissolved in it '699 gramme of carbonate of lime.

Calcite dissolved at about the same rate as marble, and, like it, partially broke up into minute rhombohedral crystals.¹

I am sorry that I cannot yet give you a satisfactory account of the action of carbonic acid water on Granite, Syenite, Gneiss, Mica, Schist, &c. The qualitative results I could indeed lay before you, but I think it better to wait until I can produce in their case sound quantitative results along with qualitative.

¹ Since writing the above, I have ascertained, by experiment, that Siderite (Carbonate of Iron), after exposure to carbonated water, also breaks up into minute crystals, having distinct rhombohedral shapes.—A. J.