The Structure of Adularia and Moonstone.

By Dr. A. E. H. Tutton, F.R.S.

A NEW and very promising scientific journal—Science Reports of the Tôhoku Imperial University, Sendai, Japan, vol 1, No. 1—printed in English at Tokio, has recently been issued (June, 1921). It contains the results of an investigation, commenced at Cambridge, by Mr. S. Kozu, who was assisted later in Japan by Y. Endo and M. Suzuki, on the X-ray analysis of adularia felspar from the St. Gotthard and the moonstone of Ceylon and Korea, and on the influence of temperature on their atomic arrangements. Adularia and moonstone are supposed by mineralogists to be solid solutions of varying proportions of orthoclase (monoclinic potash felspar, $KAlSi_3O_8$), albite (triclinic soda felspar, $NaAlSi_3O_8$), and anorthite (triclinic lime felspar, $CaAl_2Si_2O_8$), the moonstone of Ceylon being regarded as a variety of adularia exhibiting the property known as "schillerization," the exhibition of a pearly, sub-metallic, or bronze-like lustre. But determinations made in Cambridge of the refractive indices and optic axial angles of the monoclinic felspars by Mr. Kozu, the results of which were communicated to the Mineralogical Society in 1916, showed that these constants are much higher for moonstone than for adularia. This is due to different molecular structure corresponding to a different chemical composition, the optical constants always increasing with the presence of soda, of which moonstone contains nearly three times as much as adularia.

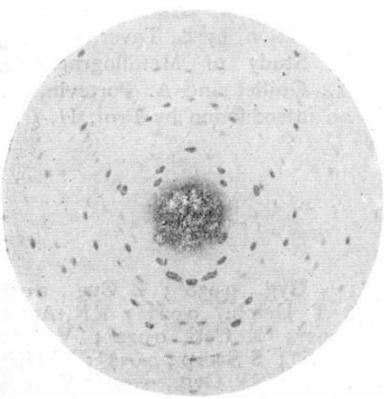

Fig. 1.—Adularia from St. Gotthard, plate parallel (001).

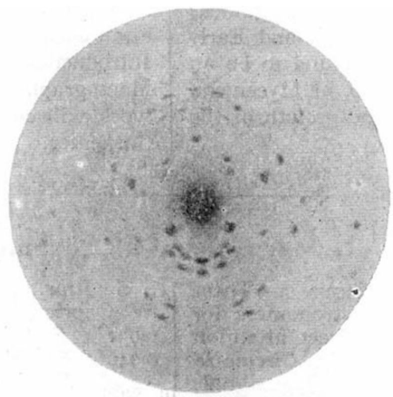

Fig. 2.—Moonstone from Ceylon, plate parallel (001).

When the crystals were submitted to X-ray analysis by the Laue radiographic method, and the radiograms compared, very remarkable differences were observed. In the case of adularia all the spots were arranged on single circles of the stereographic projection of the radiogram, or, in the case of the actual photograph, on ellipses, passing through the centre of the figure, while those of moonstone were in double circles, as will be clear from the two reproductions of the photographs themselves in Figs. 1 and 2, and of their stereographic projections in Figs. 3 and 4.

This indicates that adularia consists of a single kind of space-lattice and forms a homogeneous solid solution, while moonstone consists of two kinds of space-lattice, the atoms being distributed in two different arrangements. The two components of moonstone are not, however, pure potash felspar and pure soda felspar, but two kinds of solid solutions, both having monoclinic symmetry.

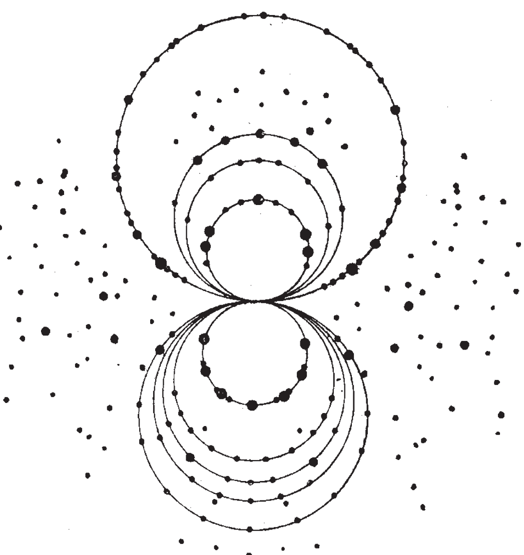

Fig. 3.—Stereographic projection of Laue spots of adularia (001).

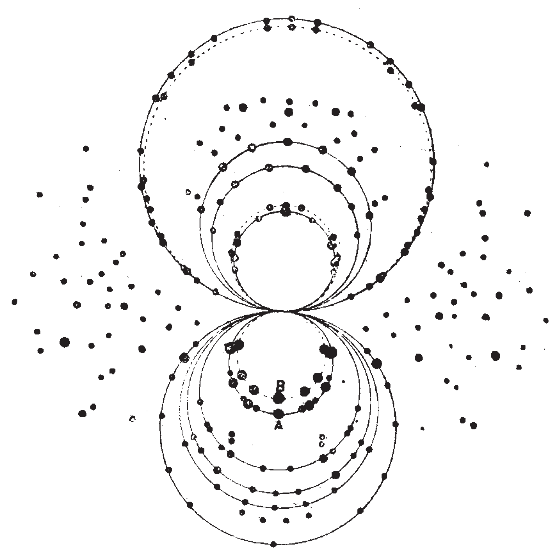

Fig. 4.—Stereographic projection of Laue spots of moonstone (001).

On heating the crystals a most interesting thing happens. Nothing occurs up to 500° C., but then the circles of spots corresponding to the structure richer in soda begin to decrease in intensity and also continuously approach in position those of the arrangement richer in potash, until at about 1060° C. the

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two series of circles overlie one another exactly and become identical with those of the latter arrangement and similar to those of adularia. At 1190° C. melting begins, and the spots disappear. Moreover, as the temperature approached 1000° C. the schillerization disappeared. Hence the schillerization of moonstone is due to the fact that interference of ordinary light rays is produced by the presence of the two different space-lattices corresponding to the two arrangements.

Similar investigation of the moonstone found ten years ago in Korea led to analogous and confirmatory results. This moonstone proves to be more sodic and calcic than the Cingalese variety, and the two sets of spots which its radiograms exhibit, corresponding to two distinct sets of space-lattice net-planes, are given by plates parallel to the side pinakoid faces, whereas in the case of the moonstone from Ceylon they were afforded by plates parallel to the basal plane. On heating the crystal the schillerization disappears, and the two systems of spots become coincident at a temperature of 790° C., very much below the melting-point of the crystal, which lies between 1100° and 1200° C.

These Japanese investigators would thus appear to have proved that in the cases of moonstone of Ceylon and Korea, the beautiful schillerization appearance is not due to the presence of inclusions and lucunæ, as formerly believed, but to the existence of two distinct, yet closely similar, space-lattices, which are so arranged with respect to each other as to cause the rays of ordinary light to interfere. It is very gratifying that the work commenced by Mr. Kozu in Cambridge has led to such interesting and important results.

Tissue Metabolism.

OXIDATION AND OXIDATIVE MECHANISMS IN LIVING TISSUES.

AT a joint meeting of the Sections of Chemistry and Physiology during the recent meeting of the British Association at Edinburgh a discussion on the above subject was opened by Prof. F. G. Hopkins, who commenced by pointing out that the essential task of biochemistry is dynamic. The task of investigation is difficult because the living structure is easily destroyed. In spite of this obstacle considerable progress has been made by various methods.

In the oxidation of fatty acids it is now recognised that the oxidation takes place in the β-position. Knoop investigated this problem by loading the fatty acid molecule with a non-oxidisable group, namely, a phenyl group. The side chain of fatty acid is oxidised so that all the substances administered reappeared as two substances. All those with an odd number of carbon atoms were oxidised to benzoic acid which was found in the urine combined with glycine as hippuric acid, whilst all those with an even number of carbon atoms were oxidised to phenylacetic acid, which was found combined with glycine as phenylaceturic acid. This result suggested that two carbon atoms were removed at each stage, thus there was no indication that by removal of one carbon atom the series with odd or even carbon atoms could be changed from one to the other.

Embden perfused fatty acids through the surviving liver, and found that all those with an even number of carbon atoms passed through the four-carbon stage whilst those with an odd number of carbon atoms did not pass through that stage. This, again, indicated that a single carbon atom was never removed, so that the odd and even carbon chains were not interconvertible.

The fate of the two carbon atoms that are split off has not yet been determined. It is interesting to remember that large quantities of material are dealt with in this manner, and that more than three thousand tons of fatty acid are oxidised daily in the human body in this country.

It is probable that carbohydrates are not oxidised directly, but that hexoses are converted into lactic acid. In the study of this problem isolated muscles are useful because the functional condition of muscle can be tested by its ability to contract. The change from hexose to lactic acid is probably associated with the presence of hexose phosphate, a fact which links up the metabolism of higher organisms with the fermentation of sugar by yeast, in which hexose phosphate is an important intermediate stage.

Surviving muscle, in anaerobic condition, loses carbohydrate with the formation of lactic acid; when oxygen is readmitted the lactic acid disappears. The removal of lactic acid is not due entirely to oxidation, but about one quarter of the acid is oxidised, and three quarters are reconverted into glycogen. Associated with these changes it can be shown that muscle contraction can be divided into at least two stages, one in which no oxidation occurs, and a later stage in which recovery is associated with the disappearance of oxygen.

The fate of proteins is that they are resolved into their constituent amino-acids, and the oxidation of these individual acids must be investigated. The result of disease, and of the administration of drugs, is to cause the appearance of intermediate products from which one learns that the amine group is removed by oxidation giving rise to keto-acids. The behaviour of acids with special groups in them furnishes further information. In dogs kynurenic acid is the end product of oxidation of tryptophane. If indole lactic acid is administered it is found to be toxic, and it does not give rise to kynurenic acid. The corresponding keto-acid is not toxic, and gives rise to kynurenic acid, showing that in this case the amine group is removed from tryptophane by oxidation giving rise to the keto-acid, and not by hydrolysis giving indole lactic acid as the intermediate substance.

It is the outstanding feature of oxidation in living organisms that they can take in molecular oxygen and combust material at a temperature of not more than 38° C. which are not combusted by molecular oxygen at moderate temperatures outside the body. All cells contain autoxidisable substances with the apparent formation of peroxides. Oxidising enzymes are found in many cells, some of which, however, need the presence of a peroxide whilst others apparently can form their own peroxide. In plants the peroxide-forming substances are probably something of a catechol nature. The oxidases are usually studied by the use of colour-forming indicators.

Hydrolytic oxidation and reduction may also occur. For instance, milk does not act by itself on acetaldehyde or on methylene-blue, but in a mixture of these two milk causes an oxidation of acetaldehyde and reduction of methylene-blue. This is analogous to the Cannizzaro reaction, where two molecules of benzaldehyde react, one being reduced to benzyl alcohol and the other oxidised to benzoic acid. For this type of reaction it is necessary to have an activation of hydrogen with a hydrogen acceptor, so that the oxygen of water is set free to produce oxidation of some other substance.

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