

Atlas. It is a very important work, namely, the Geology of the County of York, in four sheets. This is one of the finest of Smith's works. It is full of admirably worked out details. In the West Riding, the outcrops of the chief of the grit-beds are represented on the map with their relations to the coal-seams, and a fine vertical section of them is given; and in the north-east of the county, Smith clearly defines the estuarine strata of the Lower Oolites as follows: "Sand Rock and Grit Freestone of the Moors, lying over the Alum Shale" (Upper Lias), "and, in Scarborough Castle Hill, under the Oolite or Calcareous Freestone. A thin coal in the cliffs is worked on the Moors at Danby and other places." In this work we see the fruits of Smith's residence at Scarborough, which commenced in the year 1820.

The maps of Part V of the Atlas (Leicester, Nottingham, Huntingdon, and Rutland) were printed in 1821, but the part, according to Phillips, did not make its appearance till 1822. Two years later Part VI, with the Maps of Northumberland, Cumberland, Durham, and Westmoreland, was issued, and this was the end of this very important undertaking, though Phillips informs us that "other parts to complete this work were left in a state of forwardness." With the exception of a little "Synopsis of Geological Phenomena," a single folio sheet printed at Oxford in 1832 at the Meeting of the British Association, the Geological Atlas of England and Wales was the last of William Smith's published works. It is perhaps not generally known that the plates of Smith's Atlas seem to have been acquired from Cary by the well-known map-publishers Messrs. Crutchley, and the sixpenny County Maps for many years issued by that firm contain the lines and legends of William Smith's maps.

In attempting to solve various questions that have arisen in connection with the history of these early geological maps of the British Islands, I have received much valuable assistance from Mr. F. W. Rudler, F.G.S., the Curator and Librarian of the Jermyn Street Museum. And to the same gentleman the Department of Science and Art is indebted for the gift of a number of maps which have proved to be of great value in making more complete the series exhibited in the Science Museum.

II.—ON THE FLAME-REACTION OF POTASSIUM IN SILICATES.

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WHEN recently examining a series of igneous rocks for the Geological Survey of the United Kingdom, I required a ready method for the determination of potassium in the felspars, whether they occurred as porphyritic crystals or as microlites in the ground-mass. The ordinary flame-reaction has always been recognized as unsatisfactory in the presence of sodium, and the use of blue glass has been long recommended, of a sufficient thickness to cut off a sodium flame, the potassium flame then coming through alone.

The blue glass usually supplied with blowpipe-cabinets is far too thin, and any strong sodium flame will appear through it as a violet one. On using blue glass 5 mm. thick, all but the strongest light of an intense sodium flame is cut off, and the column or band of flame that does reach the eye appears blue and not violet. On securing, after experiment, a blue glass, or combination of glasses, which gives only this effect, potassium may be safely looked for, and will readily be recognized, even alongside the blue flame due to the presence of an unusual proportion of sodium.

Lithium, it may be observed, is cut off by a much less thickness of blue glass, and can generally, as in lepidolite and spodumene, be recognized by the eye alone, when the assay is held in the very outermost sheath of the Bunsen flame, or barely touching the flame at all.

The difficulty, however, in the case of potassium is that the flame is often so feeble that some doubt exists as to its occurrence when viewed through 5 mm. of blue glass. Hence intensification has been sought, in the case of silicates, by mixing the assay with powdered gypsum, a method recommended by Bunsen. On thorough heating, even 3 or 4 per cent. of potash reveals itself in this manner; and Professor Szabó¹ was confident that he could detect even 1 per cent.

The great value of Szabó's results to geologists is their quantitative character; but his determinations of potassium involve the dipping of the assay into powdered gypsum, instead of its complete powdering together with the gypsum. The latter method I have found to be far more certain; but it is obviously impossible to pick up again on the platinum loop, after powdering, the whole of the assay selected, or a known bulk of it. Hence even the results with gypsum have given little satisfaction in practice.

It seemed, however, that decomposition of the assay in a bead of sodium carbonate might get rid of the difficulties surrounding the reaction. We should always have the satisfaction of knowing that what we saw could not be due to sodium, for this flame would be eliminated by testing our blue glass in each case on the bead alone. Moreover, the most refractory silicates would be dealt with even more completely than when intimately powdered up with gypsum.

Since the simple support used in testing this reaction, and in all such work in the laboratory of the Royal College of Science for Ireland, was described in the *GEOLOGICAL MAGAZINE*,² it may seem appropriate to furnish the details of this later process here.

The ordinary observations, as arranged by Szabó, may be gone through first, on an assay of the dimensions used by that author. In place of the observation with gypsum, I would venture to substitute the following. In many cases, such as the determination of the presence of potassium in the groundmass of a lava, it may suffice as the only observation to be made.

¹ "Ueber eine neue Methode die Feldspathe zu bestimmen," p. 34; Budapest, 1876.

² G. Cole, "A Simple Apparatus for Flame-Reactions": *GEOL. MAG.*, 1888, p. 314.

(i) From a crushed and pure sample of the silicate or groundmass, select a bulk of about two cubic millimetres. This is about twice the bulk used in the ordinary Szabó reactions.

(ii) Place the cone on the star-support round the lower part of the Bunsen-burner, the flame rising some 15 cm. above it.

(iii) On the end of the platinum wire make a loop about 2 mm. in outer diameter; dip it into water—all ordinary waters are sufficiently free from potassium—and pick up on it powdered sodium carbonate. Fuse this into a bead covering the loop.

(iv) Examine the flame produced by this bead through 5 mm. of blue glass, and note that the blue column in the flame has no violet fringe.

(v) Remove the bead from the flame, dip it into water, and pick up the selected particle or particles of the assay.

(vi) Fix the wire on the support, so that its loop falls in Szabó's position, in the edge of and enveloped by the flame, and 5 mm. above the top of the cone. Leave it for two minutes, noted by the watch.

(vii) Then examine the resulting flame edgewise, i.e. with the plane of the blue glass upright and parallel to the length of the wire. If potassium is present, a violet flame will be seen, on the inner side of the blue column produced by the intense sodium. The *intensity of colouration* is as important quantitatively as the extent of the flame. This flame is persistent for ten minutes or more, and may thus be examined at leisure.

(viii) In some few cases, a further intensification may be required. Remove the bead, dip it into a drop of strong hydrochloric acid, and insert again in the flame. The flames from the chlorides thus formed rival those produced by the sulphates under the best conditions of the experiment with gypsum.

I find it sufficient to tabulate the results obtained by the method described in paragraph vii under three grades:—

Grade 1 = about 4 per cent. of potash.

“ 2 = “ 8 “ “

“ 3 = “ 12 “ “

I would advise each worker, however, to establish these grades for his own eye and his own blue glass, upon specimens of known and analyzed minerals.

Where only the qualitative result is required, the flame may be viewed from the back, i.e. along the platinum wire, when a violet flame of varied intensity will easily be detected, occupying almost all the region covered by the flame rising from the bead.

As examples of the use of the scale above suggested, the following results may be quoted. The burner used was 9 mm. in inner diameter; the cone was 5 cm. high, and its top was 35 mm. above that of the burner; the flame was 18 cm. high, and 145 mm. above the top of the cone.

Grade less than 1.—Oligoclase, Ytterby. Flame just perceptible in some experiments. Average of six published analyses gives $K_2O = .62$ per cent.

Albite, Amelia Court House, Virginia. No result. $K_2O = .43$.
 Albite, Zöptau, Moravia. No result.

Grade 1.—Apophyllite, Squire's Hill, near Belfast. K_2O probably = 4 or 5 per cent. Analyses of other apophyllites give 3.10–6.30.

Biotite, Miask. This is a low result, but one analysis gives K_2O as low as 5.61, while the potash in biotite from other localities may sink to less than 1 per cent.

Grade between 1 and 2 (1.5).—Elæolite, Brevig. $K_2O = 5.17$.

Elæolite, Magnet Cove, Arkansas. $K_2O = 5.91$.

Anorthoclase, Pantelleria. K_2O varies from 2.53 to 5.45.

Obsidian, Lipari. $K_2O = 5.1$.

Pitchstone, Corriegills. $K_2O = 4.7$.

Groundmass of Phonolite of the Schlossberg, Teplitz. The bulk-analysis of the rock has $K_2O = 6.57$.

Groundmass of Phonolite of the Schlossberg, Brüx. This is full of small nepheline crystals.

Grade 2.—Muscovite (probably Russian). K_2O probably = 9 or 10 per cent.

Biotite, Burgess, Canada. Intensified to 2.5 by HCl. K_2O probably about 8 per cent.

Grade between 2 and 3 (2.5).—Porphyritic Orthoclase (Sanidine) in trachyte of the Drachenfels, near Bonn. Average of five analyses gives $K_2O = 9.7$.

Groundmass of Phonolite, Schloss Olbrück, Eifel. Rich in minute leucite crystals. Compare with the figures above given for phonolites rich in nepheline or nosean.

Grade 3.—Microcline, Pike's Peak.

Orthoclase from drusy cavity in granite, Slieve Donard, Mourne Mountains.

Orthoclase (Adularia), Schwarzenstein, Zillerthal.

Leucite. $K_2O =$ about 20 per cent.

Evidently all true orthoclases, with their $K_2O =$ about 13 per cent. (theoretical 17 per cent.), come in grade 3. Soda-orthoclase will give 2.5, and anorthoclase 1.5 or even lower.

Spodumene, with its good lithium flame visible to the naked eye, gives no result through the blue glass used in these experiments.

Lastly, the advantages claimed for the employment of sodium carbonate in place of gypsum are:—(1) The certainty in each case that the sodium flame is clearly differentiated from that of potassium; we have a large quantity of sodium present, and we have eliminated its effects. (2) Complete decomposition of the assay. (3) Security against loss of the assay when picked up on the moistened bead and inserted in the flame. It is quickly fused in and absorbed. (4) Since the operation is always performed in the presence of sodium, there is no need for elaborate cleaning of the wire after each experiment, or for the use of distilled water.