

Fergusonite from Ceylon.

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IN the appendix to the paper on the new mineral, baddeleyite, in the last number of the Magazine, Mr. Fletcher proves the identity of that mineral with the brazilite of Hussak, and explains the deviation in specific gravity and the original incorrect determination of the chemical composition of the Brazilian mineral by the supposition that the crystallographic measurements were made on the true mineral, while the specific gravity determination and chemical analysis were made on another, a tantaloniobate of yttrium associated with it. This idea was supported by the fact that the baddeleyite from Ceylon was found in association with a so-called yttritanalite, having very approximately the same specific gravity as that first attributed to brazilite. It is this mineral which is the subject of the present communication. Since its specific gravity (about 5) was some way below the lower limit for yttritanalite a complete quantitative analysis seemed desirable in order to determine its true nature. The specimen analysed was one of seven rounded pieces from the gem mines at Rakwana, Ceylon, which were presented to the British Museum collection by Mr. Joseph Baddeley. Of these specimens the three largest had approximately the same specific gravity, about 5; but in one of the other pieces the specific gravity was as high as 5.49, and in another as low as 4.54. Of the remaining pieces, one turned out to be a tourmaline and the other a spinel. The specimen from which material was taken for analysis was, like the others, a rounded pebble showing no signs of crystal faces. The specific gravity of the whole specimen weighing 10 grms., by hydrostatic weighing, was 4.950; that of the carefully selected material for analysis in small fragments, by the pycnometer, 5.023. Hardness 5-6. Very brittle. The lustre is vitreous to sub-metallic on the surface of fracture, which is conchoidal and brilliant. There is no clearly marked cleavage. The colour is very dark brown to black, and in fine powder pale brown. Thin splinters are translucent and bright yellowish brown in colour. The mineral is isotropic. It is

infusible. Fragments heated in the closed tube decrepitate very slightly, and give off water which has a slightly acid reaction, so that the mineral in all probability contains traces of fluorine, though I have not attempted to determine the amount. The phenomenon of glowing was not observed. It was completely soluble with some little difficulty in the microcosmic bead, which in the inner flame was reddish yellow when hot, colourless or very faintly green when cold. The mineral was decomposed to some extent when heated with hydrochloric acid.

The results of the two analyses are given in Columns I. and II., while in III. is added, for the sake of comparison, an analysis by Rammelsberg of a brown Fergusonite from Ytterby.

	I.	II.	III.
Nb ₂ O ₅ } Ta ₂ O ₅ }	49.82	44.65	40.16
		4.98	8.78
UO ₃ } UO ₂ }	4.98	5.11	1.98
Y ₂ O ₃ } Er ₂ O ₃ }	39.84	24.67 } atomic weight 18.24 } 112	38.26
CaO		2.02	3.40
Fe ₂ O ₃	0.50	0.51	3.09(FeO)
H ₂ O		4.58	4.47
F ?			WO ₃ } SnO ₂ } 0.91
		99.76	101.00
G =	5.028		G = 5.056

Weight of material used in analysis I., 1.1064 grm., in analysis II. 0.7254 grm.

In No. I. the method of Lawrence Smith (Original Researches in Min. and Chem. p. 350, *Chem. News*, XLVIII., 13, 29, and *Am. Chem. Journ.* V., 44 and 73) was followed, *i.e.* the very finely powdered mineral was decomposed by strong hydrofluoric acid. The action of the acid in the cold was not very energetic, and complete decomposition had to be effected by warming at about 70°, evaporating nearly to dryness, and renewing the acid once or twice. In the case of samarskite Lawrence Smith mentions that the decomposition takes place as readily as that of calcite by dilute acids. The filtrate containing the metallic acids also contained about half of the uranium, so that this element was present in the mineral both as UO₃ and as UO₂. The insoluble fluorides were decomposed by H₂SO₄, and all the earths precipitated by ammonium oxalate. The attempt

to separate members of the cerium group by means of K_2SO_4 and also by Na_2SO_4 was repeated several times, but no appreciable precipitate was obtained. The iron and uranium were separated in the usual way by means of ammonium carbonate and ammonium sulphide. Before precipitating the uranium it was found to be absolutely necessary to evaporate and expel the ammonium salts.

In the second more complete analysis the old method of fusion with $KHSO_4$ was resorted to. The separation of the niobic and tantallic acids was effected by Marignac's method (*Ann. Chim. Phys.* VIII. (1886), 60); but as far as my experience of the method goes I can only consider the result as approximately correct. In the filtrate from the metallic acids the earths were precipitated twice by $AmOH$, and the calcium in the filtrate was thrown down by $Am_2C_2O_4$.

The ammonia precipitate of the earths was redissolved, and the yttria, etc., precipitated by oxalic acid. The atomic weight was determined in the usual way by conversion of the oxides into sulphates, and the relative proportion of the yttria and erbia was deduced from the formula of Bahr and Bunsen. The presence of erbia was indicated by the decided pink colour of the salts.

Owing to the lack of crystalline form and the isotropic nature of the mineral the crystallographic and optical properties could not be determined, but the result of the analysis can leave no doubt that it should be referred to Fergusonite. In specific gravity and chemical composition it stands very close to one of the brown Fergusonites from Ytterby, the analysis of which is given in column III. In all external characters also, lustre, colour, etc., it closely resembles the Fergusonites from Ytterby in the British Museum collection with which I have compared it.

In their paper on yttria and thoria minerals from Llano Co., Texas (*Am. J. Sci.*, 88, 482), Hidden and Mackintosh give analyses and descriptions of two varieties of Fergusonite. One with specific gravity 5.67 and containing about 2 per cent. of water they distinguish as mono-hydrated; the other with specific gravity 4.36-4.48 and containing as much as 8 per cent. of water, as tri-hydrated Fergusonite. The first variety decrepitated when heated and exhibited the phenomenon of glowing, changing at the same time to a pale olive green colour. The other variety did not decrepitate nor show signs of glowing. The authors consider that the name Fergusonite should be reserved for the anhydrous mineral, and that the various definite hydrated varieties should be distinguished as mono- di- and tri-hydrated. To the di-hydrated variety they refer the brown and yellow minerals from Ytterby, which were

originally regarded as ytrotantalite until Rammelsberg (*Ber. Akad., Berlin*, 1871, 406) showed that they must be referred to Fergusonite.

From its specific gravity, chemical composition and percentage of water, the specimen which I have analysed naturally falls into this same class, and must be considered as a di-hydrated Fergusonite.

But it is very probable that amongst the specimens received from Mr. Baddeley we have examples of both the other varieties described by Hidden and Mackintosh. Thus the specimen with higher specific gravity (5.49) answers closely to the description of their mono-hydrated Fergusonite with specific gravity 5.67. Heated in the tube it decrepitates, though not very strongly, and the phenomenon of glowing is very pronounced even in small splinters; just at the point of redness a small fragment suddenly appears to take fire, and a bright red glow spreads rapidly through it. It was lighter in colour and more distinctly brown than the specimen analysed, and the fracture was not so brilliant and more resinous; in thin splinters it was rather more opaque, but of the same light yellowish brown colour. Qualitative examination showed that it contained niobic acid (blue colour with Sn and HCl) and yttria earths. The specimen with lower specific gravity (4.54) was very similar in appearance, but more transparent in thin splinters than either of the other two. It so far behaved like the tri-hydrated variety of Hidden and Mackintosh, that it did not decrepitate on heating nor show signs of glowing.

The phenomenon of glowing, which some of these minerals possess in common with so many specimens of gadolinite, was, I believe, first pointed out by Lawrence Smith in 1877 (*Am. J. Sci.* 13, 367) in a Fergusonite from Rockport, in which it was exhibited, he states, in a more striking manner than in any specimen of gadolinite with which he had experimented. In the case of gadolinite the connection between the phenomenon and the isotropic character of the majority of specimens of this mineral has been pointed out by Petersson. He has shown (*Geol. Fören. Stockholm, Förhandl.* Bd. XII., p. 275) that in most localities the original gadolinite has been more or less converted by a paramorphic change into an amorphous and isotropic mineral. Both the anisotropic and isotropic varieties have the same chemical composition, but the latter has resulted from the former by a molecular re-arrangement. By the action of heat both varieties rose in specific gravity, and no longer gelatinised with HCl, but the interesting point is that the isotropic and amorphous variety becomes doubly refracting, the conversion into the anisotropic form being accompanied by a development of light and heat as exhibited in the phenomenon of glowing.

I find that these specimens of Fergusonite exhibit precisely similar phenomena. All the specimens after heating to redness become doubly refracting. In the specimen with the highest specific gravity which exhibits the phenomenon of glowing, and is less translucent with a duller fracture, the amorphous change from an original anisotropic mineral has no doubt proceeded furthest. In the specimen analysed, although no glowing could be observed, yet the conversion of the isotropic material to anisotropic was well marked: splinters which, before heating, were quite isotropic became rather more opaque, but strongly doubly refracting; and in one flake a tolerably distinct uniaxial figure in convergent light was observed. In the specimen with lowest specific gravity the conversion into a doubly refracting form was equally distinct. According to Petersson there are only two localities in which anisotropic gadolinite is found, viz. Hitterö, Norway, and Stora Skedevi, Dalarna, Sweden.

Whether anisotropic Fergusonite exists anywhere I am unable to say, for all the specimens belonging to the British Museum collection which I have examined proved to be isotropic. I find that the mineral from Greenland, the locality in which it was originally discovered by Giesecke, decrepitates when heated, exhibits the phenomenon of glowing perhaps more strikingly than any of the others, and becomes doubly refracting. The brown Fergusonite from Ytterby decrepitates and becomes doubly refracting, but does not glow.

The actual phenomenon of glowing appears to be connected with the degree of hydration; since, as far as the evidence goes at present, it is confined to the anhydrous and mono-hydrated Fergusonite, for the specimens in which I have observed it have specific gravities respectively of 5.5 and 5.8, while the specific gravity of the Fergusonite in which it is noted by Hidden and Mackintosh is 5.67, and that of the specimen described by Lawrence Smith is 5.68.
