Mineralogical characters of Turite (= turgite) and some other iron-ores from Nova Scotia.

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THE material examined forms part of the late Dr. Henry S. Poole's[2] collection, which shortly before his death he decided to present to the British Museum. Dr. Poole was at one time Government Inspector of Mines in Nova Scotia, and his collection is rich in Nova Scotian ores and minerals from many well-defined localities. Amongst the iron-ores, the following mineral-species and localities[3] are represented:

Magnetite, massive: *Whycocomagh, Inverness Co.*
— massive, with amethyst: *Bay of Fundy.*
— crystals (110) (111): *Five Islands, Cumberland Co.*
Haematite, red, massive: *Blanchard, East River, Pictou Co.*
— red, earthy and micaceous: *East River, Pictou Co.*
— stalactitic, partly altered to turite: *Bridgeville, Pictou Co.*
— red, massive: *Torbrook, New Cannan, Annapolis Co.*
— red, massive: *Owl's Head, Halifax Co.*
— red, soft and scaly, with fluorite: *Cheticamp, Inverness Co.*
— black, massive: *Londonderry, Colchester Co.*
— fibrous, mamillated crusts; compact and earthy; and pseudomorphous after goethite (p. 345): *Old Barns, Colchester Co.*
— foliated specular-iron-ore, with quartz: *Gaysborough, Gaysborough Co.*
Turite, hard, black, lustrous, on limonite (p. 342); also soft earthy, brick-red layers on limonite and haematite: *Bridgeville, Pictou Co.*
— earthy, pseudomorphous after ankerite: *Londonderry, Colchester Co.*
Goethite[4], crystals altered to haematite, i.e. pseudomorphs of haematite after goethite (p. 345): *Old Barns, Colchester Co.*
— minute crystal scales on calcite crystals in limestone cavity: *McLean's Bank, Pictou Co.*

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[1] Communicated by permission of the Trustees of the British Museum.

[2] See this volume, p. 143.

[3] Compare R. A. A. Johnston, A list of Canadian mineral occurrences. Geol. Survey Canada, 1915, Mem. 74.

[4] The British Museum collection also has a specimen of minutely crystallized, velvety goethite (var. przibramite or sammetblende), on limonite with barytes, from Bridgeville, Pictou Co.

LIMONITE, fibrous and compact, with smooth, black, botryoidal or mamillated surface, sometimes with iridescent tarnish; also earthy, with turite pseudomorphous after ankerite: *Londonderry, Colchester Co.*

— fibrous and compact, with bright, black, botryoidal or stalactitic surface, with barytes and turite: *Bridgeville, Pictou Co.*

— fibrous and compact: *Glengarry, Pictou Co.*

— compact and siliceous: *East River, Pictou Co.*

— cellular and friable: *Smith's farm, Parrsboro, Cumberland Co.*

CHALYBITE, massive, cleavable, var. sideroplesite: *Londonderry, Colchester Co.*

— small crystals closely set in a matrix of chlorite: *Bridgeville, Pictou Co.*

— massive, crystalline, coarse-grained: *Sutherland brook, Pictou Co.*

— band of clay-iron-stone: *Stellarton, Pictou Co.*

— nodule of clay-iron-stone: *Mabou, Inverness Co.*

MESITITE, pale-brown cleavage masses with ankerite: *Londonderry, Colchester Co.*

ANKERITE, pale-brown and white cleavage masses: *Londonderry, Colchester Co.*

— small twisted crystals with calcite on sandstone: *McKay's ford, East River, Pictou Co.*

My attention to these iron-ores was attracted in the first place by the pseudomorphs of haematite after goethite. These specimens were labelled goethite, but I found them to give a dark-red streak resembling that of turite; and I started work on them with the hope that the material might prove to be crystallized turite. In this I was disappointed; but as the results obtained add a few new data respecting the mineralogical characters of these ores, they are now offered for publication.

Before proceeding to a more detailed description of the particular specimens, it will be well to give in this place a few general remarks on the group of ferric hydroxide minerals. Several of these, which have been described under special names, are listed below with some of the corresponding data, haematite being added to complete the series:

		H_2O %	Sp. Gr.
Haematite	Fe_2O_3	0	5.2
Turite	$2Fe_2O_3.H_2O$	5.3	4.3
Goethite	$Fe_2O_3.H_2O$	10.1	4.2
Hydrogoethite	$3Fe_2O_3.4H_2O$	13.1	3.7
Limonite	$2Fe_2O_3.3H_2O$	14.5	3.9
Xanthosiderite	$Fe_2O_3.2H_2O$	18.4	—
Limnite	$Fe_2O_3.3H_2O$	25.3	2.8[1]
Esmeraldaite	$Fe_2O_3.4H_2O$	31.1	2.6

Of these, the only hydroxide that occurs as definite crystals is the

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[1] Determination in a heavy liquid on material from Moss mine, Ranen-Fjord, northern Norway, described by J. M. Campbell, Mining Magazine, 1917, vol. xvii, p. 220.

orthorhombic goethite; but some of the others have a fibrous structure, and limonite and hydrogoethite have been described as orthorhombic from their optical characters.[1] Instead of regarding them as distinct mineral-species there is a general tendency at the present time to consider them as colloids containing water in variable amount. The name ehrenwerthite[2] has been applied to the colloidal hydrate with the composition $Fe_2O_3.H_2O$ corresponding with the crystalloid goethite, and stilpnosiderite[3] for the colloidal form corresponding to limonite. In some of the more recent text-books (e.g. those of Hintze, Lacroix, Tschermak) all these minerals, with the exception of goethite, are treated together under limonite. There does not, however, appear to be sufficient reason for this; and certainly it is not logical to include turite here, since this falls between haematite and goethite, which are the only distinctly crystallized members of the whole series. It would be preferable to include turite (then calling it by its synonym hydrohaematite) under haematite, since most earthy, red haematite contains 1–2 per cent. of water,[4] representing perhaps a stage in the alteration of haematite to turite or perhaps a mixture of the two. Reasons will, however, be given farther on for regarding turite as a distinct mineral-species.

The parallel series of aluminium hydroxides includes fewer members, and here two—diaspore and gibbsite—are distinctly crystallized:

Corundum	Al_2O_3	(corresponding with Haematite).
Diaspore	$Al_2O_3.H_2O$	(„ „ Goethite).
Bauxite	$Al_2O_3.2H_2O$	(„ „ Xanthosiderite).
Gibbsite	$Al_2O_3.3H_2O$	(„ „ Limnite).
Shanyavskite	$Al_2O_3.4H_2O$	(„ „ Esmeraldaite).

Some explanation is needed in this place for the name *turite* in preference to the established spelling turgite. The latter is based on an incorrect German transliteration from the Russian, and was afterwards changed by its author, R. Hermann,[5] to Turjit. The mineral was origi-

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[1] A. Lacroix (Minéralogie de la France, 1901, vol. iii, p. 360) also makes out a distinction between the optical characters of goethite and its scaly variety lepidocrocite; for the latter he suggests the composition $5Fe_2O_3.6H_2O$ or $4Fe_2O_3\,5H_2O$.

[2] F. Cornu, Zeits. Prakt. Geol., 1909, vol. xvii, p. 82.

[3] A. Lacroix, loc. cit., p. 366; F. Cornu, 1909, loc. cit.

[4] H. W. Fischer, Zeits. Anorg. Chemie, 1910, vol. lxvi, p. 48.

[5] R. Hermann, Bull. Soc. Nat. Moscou, 1845; vol. xviii, No. 1, p. 252, 'Ich habe den Namen Turgit nach dem Flusse Turga, in dessen Nähe sich die berühmten turginskischen Kupfergruben bei Bogoslowsk, wo sich dieses Mineral vorfand, befinden'. R. Hermann, Heteromeres Mineral-System, Moskau und Leipzig, 2nd edit., 1860, p. 81.

nally found in the Turinsky mines at Turinsk, near Bogoslovsk in Govt. Perm, Urals; and was named, like the village and the mines, from the adjoining Turya (Turia, Turja, Турья) river. J. V. Samoilov[1] gives the name in Russian as Турьитъ (i.e. turite), and writing in German as Turjit; these two forms are, however, not exactly equivalent.

TURITE AND LIMONITE FROM BRIDGEVILLE, N. S.

The specimen (B.M. 1917, 120) which was examined in detail consists of a mass of hard, dark-brown to black, mamillated limonite, on the surface (normal to the fibres) of which is a layer of turite about 1 cm. in thickness. The two minerals are quite distinct in character and show a perfectly sharp line of demarcation, along which they can be broken apart. The turite forms the exterior mamillated surface, and beneath it is a mamillated surface of limonite. The turite is black with a brilliant, pitchy to sub-metallic lustre. In a strong light, in certain positions, it shows a deep reddish tinge of colour. There is a columnar structure perpendicular to the surface and a fine concentric banding parallel to the surface.

A plane surface was cut and polished normal to the junction of the two minerals. The turite takes a much higher polish than the limonite; and on the polished surface the wavy concentric banding is brought into prominence with little indication of the fibrous structure. The limonite, on the other hand, shows the fibrous structure more prominently than the concentric. Included in the limonite area are a few narrow veins and spots that have taken the higher polish: these presumably consist of turite. A thin micro-section, cut normally to the junction and including both minerals, shows that the narrow concentric bands of turite are separately built up of short fibres or rods arranged normally to the surface. In a strong light it transmits a deep crimson colour for vibrations parallel to the length of the fibres, whilst for vibrations perpendicular to this direction it is almost opaque; the material is thus strongly pleochroic. Between crossed nicols it extinguishes uniformly parallel to the length of the fibres. The limonite in thin section shows a pronounced plumose arrangement of its fibres, and in places it forms spherulitic structures. This mineral is much more transparent, and is of a rich brownish-yellow colour. Pleochroism is scarcely perceptible, but the greatest absorption is here also for vibrations per-

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[1] J. V. Samoïlov, Bull. Soc. Nat. Moscou, 1900, n.s. vol. xiv (for 1899), p. 142; J. V. Samoilov, Die Turjiterze Russlands. Zeits. prakt. Geol., 1903, vol. xi, p. 301.

pendicular to the length of the fibres. The extinction is uniform and straight. Both minerals, when fragments are crushed in oil on a microscope-slide, break up into short stumpy fibres, which show the optical characters described for the thin section.

The streak of the turite is dark cherry-red, and of the limonite yellowish-brown. The turite is harder (H = 6½) than the limonite (H = 6), but it is more brittle, breaking concentrically as well as radially: the limonite is tougher and breaks only radially. Specific gravity of the turite $D_4^{22} = 4{\cdot}35$, of the limonite $D_4^{23} = 3{\cdot}87$.

When heated in a bulb-tube the two minerals give off water, but otherwise their behaviour is quite different. At a low red-heat turite suddenly decrepitates with surprising violence, hot fragments being shot out of the tube, and the piece of material is broken up into a heap of minute fibres with a purplish-black colour. Water is given off both before and after the decrepitation. Limonite, on the other hand, gives off its water quietly and without breaking up: it changes to black in colour. The percentage loss of water at various temperatures was determined under identical conditions for the two minerals. The finely powdered material, about 1·5 gram of each, was heated in two crucibles placed side by side in an air-oven, and finally over a Bunsen-burner. Heating at each temperature was continued for one hour, and was repeated until a constant weight was attained. During the heating, the turite shows no marked change in colour, though after ignition it is rather

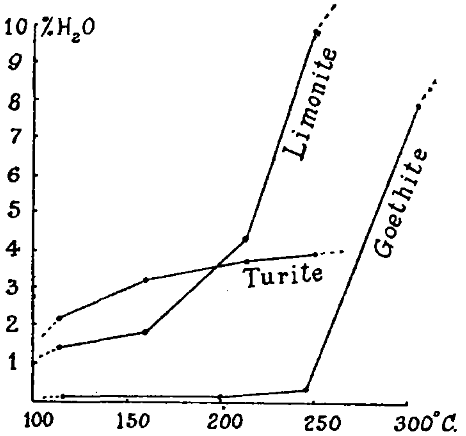

FIG. 1.—Dehydration curves of Turite, Limonite, and Goethite.

darker red, or purplish-black whilst still hot. The limonite changes to dark brown at 250°, and after ignition shows the same colour as the turite. The results are tabulated below; and are plotted, together with the results for goethite (p. 347), on the curve (fig. 1).[1] There is a marked difference in the character of these three curves, sufficient to indicate that the minerals are distinct and not colloidal.

	114°.	160°.	212°.	250° C.	Red heat.	Theory.
Turite	2·2	3·2	3·7	3·9	5·7	5·3 % H_2O
Limonite	1·4	1·8	4·3	9·8	13·5	14·5 % H_2O

The deviation from the theoretical amount of the total percentage of water expelled at a red-heat is to be attributed, in the case of the limonite, to the presence of admixed turite. As mentioned above, turite is visible on the polished surface of the limonite, but in selecting material for the determinations this was avoided as far as possible by picking out small fragments under a lens.

The other specimens of turite, mentioned on p. 339, are earthy in character with a brick-red to dark-red colour. Beyond determining the red streak and the presence of water, these were not further examined. When heated in a bulb-tube they do not decrepitate. They perhaps represent the colloidal form of turite.

The fibrous turite described above is without doubt a definitely crystallized mineral with the composition $2Fe_2O_3.H_2O$, and it must rank as a distinct mineral-species. This conclusion is amply confirmed by the observations of earlier authors on material from various localities. A very similar occurrence is that described by J. G. Brush[2] from the iron mines at Salisbury, Connecticut, where the fibrous, lustrous turite forms a layer, an inch in thickness, on limonite, with a sharp separation between the two minerals. This material has sp. gr. 4·14, H. $5\frac{1}{2}$, H_2O 5·02 – 5·20 per cent., a dark red streak, and it decrepitates in a remarkable manner. E. Manasse[3] has described similar material from Rosseto at the iron mines of Rio Marina, Elba, here also as a fibrous crust on limonite, with sp. gr. 4·34, H. 5, H_2O 4·95 – 5·58 per cent. The original hydrohaematite of Breithaupt,[4] from Siebenhitz near Hof in Bavaria, is also precisely similar, with sp. gr. 4·30 – 4·33, H. $6\frac{1}{2} - 7\frac{1}{2}$, H_2O 4·61 per cent. Other material probably identical in character has been

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[1] Similar dehydration curves may be plotted from the results given by H. W. Fischer, in Hintze's Handbuch d. Min., 1910, vol. ii, p. 2075; and Zeits. Anorg. Chemie, 1910, vol. lxvi, p. 45.

[2] J. G. Brush, Amer. Journ. Sci., 1867, ser. 2, vol. xliv, p. 219.

[3] E. Manasse, Atti Soc. Toscana Sci. Nat., 1911, Mem. vol. xxvii, p. 76.

[4] A. Breithaupt, Handbuch der Mineralogie, 1847, vol. iii, p. 846.

less completely described by P. I. Yorke[1] from Wunsiedel in Bavaria; C. F. Rammelsberg[2] from Horhausen in Rhineland; H. How[3] from Tennycape, Hants Co., Nova Scotia; P. Zemyatchensky[4] from the Melenki district, Govt. Vladimir, Russia. The original turite (turgite) of R. Hermann (loc. cit.) from the Turinsky mines, Urals, differs, however, in some respects from those above mentioned. It is compact but not fibrous, and has a much lower specific gravity (3·56 – 3·74); it decrepitates violently when heated; hardness 5, H_2O 5·31 per cent. J. V. Samoilov (loc. cit.) mentions turite from several Russian localities, some of which possibly belong to the more definite fibrous variety.

Summary of Characters of Turite.—Ferric hydroxide $2Fe_2O_3.H_2O$, containing 5·3 per cent. of water, and occurring as hard, lustrous, mamillated or botryoidal masses with a radially-fibrous and concentric-shelly structure. It is black with often a reddish tinge of colour, and a brilliant sub-metallic lustre; the streak is dark cherry-red. Very thin fibres transmit a rich crimson colour; they are strongly pleochroic, and are birefringent with straight extinction. Sp. gr. 4·35, hardness 6½. Decrepitates violently when heated. It usually occurs as a layer on fibrous limonite. Synonyms: turgite, turjit, hydrohaematite.

A second, possibly colloidal, form is earthy and of a bright red colour, and does not decrepitate when heated. This includes, in part, red-ochre or red-iron-ore.

HAEMATITE PSEUDOMORPHOUS AFTER GOETHITE.

A specimen (B.M. 1917, 113), labelled 'Goethite, Old Barns', consists of an aggregate of globular groups of radiating acicular crystals. These rest on a thin mamillated layer of finely fibrous haematite, which in turn is deposited on a matrix of compact and earthy haematite intermixed with some calcite. There are also one or two minute crystals of barytes, which are of later formation than the fibrous haematite. The globules present a rough crystallized surface on which the individual crystals are more or less distinctly separated, but in the interior the fibres are closely packed together. The colour is dark reddish-black, with a bright, sub-metallic lustre especially on the broken fibrous surfaces. The streak is dark purplish-red and the hardness about 4.

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[1] P. I. Yorke, Phil. Mag., 1845, ser. 3, vol. xxvii, p. 268.

[2] C. F. Rammelsberg, Handbuch der Mineralchemie, 1860, p. 989.

[3] H. How, Phil. Mag., 1869, ser. 4, vol. xxxvii, p. 268.

[4] P. Zemyatchensky, Trav. Soc. Nat. St. Pétersbourg, 1889, vol. xx, Sect. Geol. Min., p. 201.

The specific gravity, determined by the pyknometer method with small selected fragments consisting of aggregates of needles is $D_4^{17} = 4{\cdot}30$.

The individual crystals are small, measuring at their free ends ¼ to ½ mm. across; but the fibres, measured from the centre of the globules, reach 1 cm. in length. On the main surface of the globules the crystals are terminated by the basal plane (fig. 2), but in corners and spaces other terminal faces are developed. These give a wedge-shaped (fig. 3) or pointed habit (fig. 4) depending on the width of the dome face *e* (011). In their appearance and orthorhombic habit the crystals are suggestive of goethite, and the measurements obtained from three crystals on the goniometer were sufficiently good to identify the following goethite forms: *b* (010), *d* (210), *m* (110), *e* (011), *r* (311).

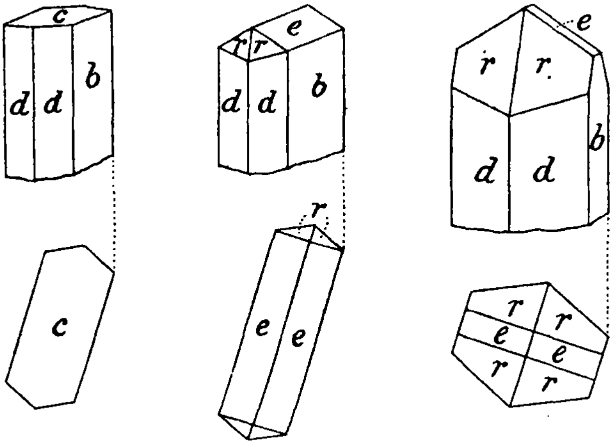

Fig. 2. Fig. 3. Fig. 4.
Goethite crystals from Nova Scotia.

The form *c* (001) seems to be present only on the less perfectly developed crystals. The prism-zone is deeply striated parallel to its edge, and *d* (210) is the predominating prism. The crystals readily break across perpendicular to their length, suggesting a basal cleavage, but perhaps due to a concentric banding of the material as in the turite specimen described above.

There is nothing whatever in the appearance of the crystals to suggest that they are pseudomorphs, since they are quite sharp and the faces bright and smooth; but the dark-red streak (instead of yellowish-brown) is sufficient to prove that the material is not goethite. When crushed in oil and examined under the microscope in a strong light, the smallest particles transmit a blood-red colour. Elongated fragments, which appear to be cleavage flakes, show a greater absorption for vibrations perpendicular to their length, and between crossed nicols give uniform and straight extinction. So far as could be determined, the optical characters do not differ from those of the turite described above (p. 342); and in any case they are quite distinct from those of goethite, Cornish crystals of which were examined by the same method for comparison.

Heated in a bulb-tube the material gives off a small amount of water, but there is no decrepitation, change in colour, or breaking up of the fragments. Dehydration experiments were carried out in parallel with crystallized goethite from Cornwall,[1] about 1·5 gram each of the finely-powdered minerals being heated side by side. They remained for three days over sulphuric acid; and for one hour at each temperature.

	H_2SO_4.	117°.	200°.	246°.	304°.	Red-heat.
Nova Scotian pseudomorphs	0·1	0·3	0·3	0·3	0·3	0·65 % H_2O.
Cornish goethite	0·1	0·1	0·1	0·3	7·9	10·1 % H_2O.

The results obtained with this material were confirmed with a second specimen (B.M. 1917, 114) found without any label in Dr. Poole's collection. This is a smaller specimen with little matrix and the globular groups show to better advantage. In addition to calcite and haematite, it shows, in one cavity, a few small crystals of quartz. The specimen is so exactly similar in all its characters to the one just described that it undoubtedly came from the same locality. Two crystals were measured on the goniometer, and the same forms identified as before. Specific gravity determined on about 1·5 gram of material

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[1] *Goethite from Cornwall.*—The specimen (B.M. 35384) used in the comparative experiments came from the Restormel iron mines at Lanlivery, and consists of radiating groups of crystals associated with psilomelane and quartz. They are black with a brilliant sub-metallic lustre and give an ochre-yellow streak. Specific gravity, $D_4^{20} = 4·18$. Crushed in oil under the microscope the material shows clear brownish-yellow cleavage flakes, which are slightly pleochroic, the colour being yellow for vibrations parallel to the *c*-axis, and brown for vibrations perpendicular thereto. The extinction is straight; optic axial plane parallel to *c* (001), acute negative bisectrix perpendicular to the cleavage *b* (010); optic axial angle in air 2E = 60° about, the brushes being brightly coloured owing to the high dispersion. Heated in a bulb-tube, the material gives off much water, but does not decrepitate or break up. Crystals that had been heated to redness did not appear to be affected in any way, the faces still being as bright and smooth as before; but they now give a dark purplish-red streak. The powdered mineral had changed from ochre-yellow to dark brownish-red at 304° C.

crushed to separate fibres, $D_4^{20} = 4{\cdot}26$. The loss of water from the finely-powdered material amounted to only 0·1 per cent. for temperatures up to 240° C., and 0·5 per cent. at a red-heat.

The material is thus practically anhydrous ferric oxide corresponding with haematite; but in its specific gravity, colour of streak, and perhaps also optical characters, it agrees with turite; whilst the external form of the crystals is that of goethite. The only conclusion to be drawn from these observations is that the material represents pseudomorphs of haematite after goethite. The crystals themselves are, however, so unlike pseudomorphs that I still had some doubt as to the correctness of this, until I noticed that the bright crystals of Cornish goethite preserved their sharpness and freshness after being heated to redness (p. 347, footnote). These are, in fact, exactly similar pseudomorphs of haematite after goethite, but produced by artificial means. The Nova Scotian specimens show no signs of having been heated artificially; and, besides, the presence of calcite would preclude this, since the water of goethite is lost only at a red-heat. It is certainly a remarkable fact that the crystals can lose 10 per cent. of their weight without being visibly affected. In this connexion it may be noted that the specific gravity of the pseudomorphs (4·3) is only slightly greater than that of goethite (4·2), but considerably less than that of haematite (5·2); its identity with that of turite (4·3) is probably only an accidental coincidence. Pseudomorphs of haematite after goethite have already been described by Haidinger[1] from Cornwall, and he mentions that the fine brilliant crystals were measured by G. Rose. These were, however, possibly artificial, since Greg and Lettsom[2] mention that some specimens of Cornish goethite were strongly heated by dealers with the idea of passing them off as rutile.

Since the above was written, several other specimens of turite, exactly similar to the one described on p. 342, have been found in the Poole collection. These I had incorrectly put aside as duplicates of limonite, which superficially they closely resemble in appearance.

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[1] W. Haidinger, Abhandl. Böhm. Gesell. Wiss. 1847, ser. 5, vol. iv, p. 480.

[2] R. P. Greg and W. G. Lettsom, Mineralogy of Great Britain and Ireland, 1858, p. 254.