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A study of the neotocite group

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AN examination has been carried out of ten specimens assigned to the group. These include metatype specimens of neotocite (Gestrikland, Sweden) and penwithite (Wheal Owles, Penwith, Cornwall) and topo-type specimens of stratopeïte (Pajsberg, Sweden), klipsteinite (Herborn, Dillenberg, Germany), and opsimose (specimen labelled klipsteinite, but from Klapperud, Dalecarlia, Sweden). The investigation arose out of the recent find of neotocite at the Geevor mine, Cornwall, close to the site of the type locality for penwithite.

In the investigation klipsteinite has been confirmed as a mixture (Fisher, 1880), the dominant mineral in the mixture giving an X-ray pattern close to birnessite. Chemical analyses, refractive indices, and specific gravity determinations are given for the remainder in the miniprint section, p. M27 (Table I). They show that the group can be represented fairly closely by the formula $(Mn, Fe)SiO_3.H_2O$, but with significant carbonate present in each sample. CO_2 has not generally been reported before in these minerals and the water content is lower than previous analyses, as a result of the precautions taken in drying the material before analysis (over magnesium perchlorate at room temperature).

The specimens examined are all dark brown or black in appearance (often darkening on exposure to light) with a vitreous lustre and conchoidal fracture. The group should be regarded as poorly crystalline since all the specimens gave similar X-ray powder patterns with three very broad and diffuse lines around 3·5, 2·6, and 1·6 Å respectively (see Whelan and Goldich, 1961). After heating to 1000 °C all form braunite, with the exception of stratopeïte, which gave an X-ray powder pattern closer to pyroxmangite. Hausmannite or spinel were also found associated with braunite in several specimens.

The full text includes the results of differential thermal analysis and infra-red spectra from the samples.

Of the names used in the group, opsimose (Beudant, 1832) was the first recorded, but in this and the subsequent work of Bahr (1850), it was associated with material much richer in manganese. Wittingite and neotocite (Nordenskiöld, 1849) were named separately on account of the higher iron content of neotocite. Stratopeïte (Igelström, 1851) is a magnesium-bearing variety, while penwithite (Collins, 1878, 1879) was thought to have a different manganese valency state from wittingite.

In view of its current widespread usage and the fact that neotocite was originally named for an iron-bearing manganese silicate it is proposed that neotocite be defined as the group of poorly crystalline manganese silicates with formulae close to $(Mn, Fe)SiO_3.H_2O$ and $Mn > Fe$. With $Fe > Mn$ the series grades into hisingerite. Limited substitution of MgO, Al_2O_3, and CO_2 should be acceptable. Finally it has been proposed that the other names be discarded. The Commission on New Minerals and Mineral Names, IMA, has approved these proposals, but came to no firm conclusion as to whether the group name should be spelt 'neotocite' or as in the original description 'neotokite'. Accordingly either are permissible.

The full paper appears in the Miniprint section, pp. M26-30.

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Pargasite from the Eastern Ghats, Andhra Pradesh, India

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HORNBLENDES are not common in the charnockites of Kondpalli, but occur as an important constituent in the pyroxene granulites and pyroxenites of Seshadripuram hill. Analyses and optical data for two pargasites are given. (Miniprint section, p. M31.)

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Allanite from the Kondapalli charnockites, Krishna District, Andhra Pradesh, India

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THE coarse-grained charnockites of Donabanda hill, Kondapalli, contain metamict allanite. An analysis is given, also optical data for the heated allanite, and the conditions of formation of the rocks are shortly discussed. (Miniprint section, p. M31.)

M26 A. M. Clark *et al.*: The neotocite group

A study of the neotocite group

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Neotocite is the name given to a series of manganese silicates close in composition to $MnSiO_3.H_2O$, often with considerable amounts of manganese replaced by iron or by lesser amounts of calcium, magnesium, or aluminium. Structurally they are X-ray amorphous, or at best, poorly crystalline (Whelan and Goldich, 1961). The members of the group are fairly common in manganese deposits of the volcanogenic-sedimentary type (Roy, 1976) and are thought to have been formed from gelatinous siliceous suspensions deposited in cavities at low temperatures.

The investigation arose out of the recent find of such a mineral at the Geevor mine, Cornwall. This occurrence is a little over one mile NNE of Wheal Owles, the type locality for the related mineral penwithite (Collins, 1878, 1879). The mineral was first discovered at Geevor in 1967 during development of the Simms lode on the 10th level horizon. Unfortunately no specimens of this first find survive, but it was thought at the time to be a form of opal, being glassy in texture and fracture and of deep red colour which faded to dark brown several days after removal from the mine. The 'host rock' occurring within the lode structure was a dark brown iron-rich jasper with an uneven to conchoidal fracture.

Early in 1974 a similar mineral was found in a 'prospect' stope in the N-E section of the mine. This prospect was first encountered underground at 3340 ft. in 9.E.5 crosscut some 700 ft. below the surface, its outcrop having been known many years ago in the Pendeen mines as the Calartha lode. The preliminary development of this structure on the 9th level horizon had revealed an extremely complex orebody of greatly varying dip and strike, showing at least eight major mineralization phases, three of which bore cassiterite in economic quantities. It was not until stope development took place that the glassy mineral was rediscovered and specimens collected for study. The mineral showed the same properties as the 1967 find, but the host rock was more complex, being an iron-rich jasper with areas rich in manganese minerals and dendritic native copper. A section of the lode is illustrated in Fig. 1. A second set of samples was collected in May 1974 from a pillar left after stoping. This was by far the finest exposure of this mineral, the host rock containing only a trace of manganese minerals but considerable native copper and cassiterite.

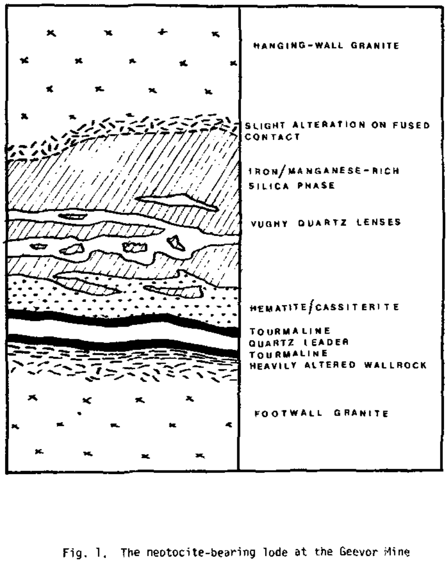

Fig. 1. The neotocite-bearing lode at the Geevor Mine

Nomenclature and history

A number of names have been applied to different specific occurrences of the mineral group, among which neotocite and wittingite (N. Nordenskiöld, 1849) have chronological priority. Nordenskiöld is believed to have classified wittingite and neotocite separately on account of their different iron contents. Early analyses of the two minerals (Svanberg and Igelström, 1849; Moberg, 1856; A. E. Nordenskiöld, 1863) put wittingite (from Wittingi, Storkyro, Finland) near $MnSiO_3.H_2O$ with Fe_2O_3 between 3 and 6%. Neotocite (from Gasböle, Ingo, Finland and Gestrikland, Sweden) was shown to be much richer in iron with Fe≈Mn, and the mineral falls in an intermediate position between wittingite and the poorly crystalline hydrated iron silicate, hisingerite.

Igelström (1851) described and published the first analysis of stratopeite (from Pajsberg, Filipstad, Sweden). He believed it to be a new mineral on account of the large concentration of MgO (8%) relative to that contained in neotocite and wittingite, its iron content being intermediate between the two. Cleve and Nordenskiöld (1866) reanalysed the three varieties and assigned formulae as follows:-

Wittingite	$(2MnO,Mn_2O_3)_2.5SiO_2.9H_2O$	
Neotocite	$(2\underline{R}O,Fe_2O_3)_3.5SiO_2.7H_2O$	where $\underline{R} = Fe^{2+},Mn^{2+}$
Stratopeite	$(2\underline{R}O,Fe_2O_3)_3.5SiO_2.7H_2O$	where $\underline{R} = Mn^{2+},Mg,Pb$

Collins (1878, 1879) introduced into the group a fourth name, penwithite, for a reddish brown manganese silicate from Wheal Owles, Penwith, Cornwall, associated with quartz and rhodochrosite. He justified the allocation of a new name by comparing his chemical analysis with that of the nearest member of the group, wittingite (A. E. Nordenskiöld, 1867), and concluding that manganese is present in wittingite as a sesquioxide, but as a protoxide in penwithite. This claim appears rather dubious as Nordenskiöld's analysis does not make the manganese valency state in wittingite at all clear. Collins' penwithite gave an analysis close to $MnO.SiO_2.2H_2O$.

Some years prior to the description of these minerals, Klaproth (1807) had published an analysis of an amorphous manganese silicate from Klapperud, Dalecarlia, Sweden, which occurred associated with rhodonite. Its composition was given as MnO 60%, SiO_2 25%, H_2O 13% and Beudant (1832) restated these figures, naming the mineral opsimose. Subsequently Bahr (1850) published five analyses of hydrated manganese silicates from the same locality. One of these is close to Klaproth's original analysis and is classified in Dana (1868) as opsimose, whereas the remaining four are much closer to the neotocite group, and have been entered in that section. The name klipsteinite was first used by von Kobell (1866) for a mineral from Herborn, Germany, with a similar composition to opsimose. The mineral was re-examined by Fisher (1880) who concluded that it was an intergrowth, and the validity of the species has remained in doubt ever since although the name klipsteinite is generally given in preference to opsimose.

Specimens examined

The investigation was undertaken to compare the mineral found at Geevor with the penwithite co-type specimens supplied to the British Museum (Natural History) by J. H. Collins. As the collection also includes topotype specimens of all the varieties mentioned previously, apart from wittingite, the opportunity was taken to include these in the study, together with a number of more recent finds of the minerals. The following specimens were examined, the names given being those under which each specimen was supplied. The same specimen numbers have been used in the chemical and thermal analysis tables and figures which follow.

1. Neotocite. Gambatesa mine, Chiavari, Liguria, Italy, BM 1968,302, consisting of brown resinous veins in quartz and manganoan calcite.
2. Penwithite. Wheal Owles, Penwith, Cornwall. Five specimens from Collins are in the Collection, three having been presented by him in 1878 and two acquired much more recently with the Russell Collection. Like the Geevor mineral this material has also become much darker than originally described, now being a vitreous black colour, thin fragments appearing brown under a microscope. The specimen examined in this study (BM 52182) contains penwithite deposited on the walls of a large cavity and showing a botryoidal surface covered with a number of minute radiating spherules of a yellow-orange mineral recently identified as triploidite.
3. Neotocite. Geevor mine, Cornwall. A number of the specimens collected in 1974 are in the Collection and two of these (BM 1974, 277 a & b) have been used in the investigation.

4. Penwithite. Noda-Tamagawa Mine, Iwate Pref., Japan, BM 1971, 342. A dark brownish black vitreous, massive specimen. The occurrence has been described by Ito (1961).
5. Klipsteinite. Two specimens have been examined. BM 50668 from Klapperud, Dalecarlia, Sweden, purchased in 1876 and BM 40229 from Herborn, Dillenberg, West Germany, purchased in 1866. The latter specimen showed none of the vitreous lustre associated with other members of the group.
6. Penwithite. Aichi Pref., Japan, BM 1962,110. A dark brown vitreous massive specimen.
7. Neotocite. Nant manganese mine (no. 2 level), Llanfaerhys, Rhiw, Caernarvonshire. One specimen has been examined from the four collected by Sir Arthur Russell in 1911. Like the Wheal Owles penwithite, the specimens are massive, black resinous, giving dark olive-green to brown translucent fragments.
8. Stratopeite. Pajsberg, Filipstad, Sweden. The specimen examined is BM 89836, from the Allan-Greg Collection purchased in 1860. The Allan-Greg catalogue does not reveal the source of the material, which consists of a compact deposit on reddish black rhodonite.
9. Neotocite. Erik Ers mine, Gestrikland, Sweden, BM 43219, purchased from Prof. A. D. Nordenskiöld in 1869. The specimen consists of massive black material with conchoidal fracture.

Chemical analysis

Chemical analyses of the nine neotocite group specimens, together with their specific gravities and refractive indices, are given in Table I, the results being presented in order of increasing iron content. All the specimens mentioned in the previous section were included, apart from the second klipsteinite, BM 40229. The determinations were carried out using material dried at room temperature over anhydrous magnesium perchlorate.

Silica was determined after a sodium hydroxide fusion, using the reduced silicomolybdate complex; total iron on a solution in HF and H_2SO_4 using the 2,2'-dipyridyl complex (Riley and Williams, 1959) and manganese as permanganate; the remaining elements were measured by atomic absorption spectroscopy on a separate lithium metaborate fusion dissolved in dilute nitric acid.

The total oxidation state was determined after the addition of a slight excess of solid ferrous sulphate before dissolution in an inert atmosphere (Easton, 1972), using the 2,2'-dipyridyl complex. Since only a total oxidation value was available, total iron has been calculated to Fe_2O_3 since it is more likely to be stable in the presence of Mn^{3+} than ferrous iron. Since this group of minerals converts readily to braunite ($3Mn_2O_3.MnSiO_3$) on heating, reduction of Mn^{4+} at comparatively low temperatures is thought unlikely to occur and total manganese has been allocated to Mn^{2+} and Mn^{3+}, applying the total oxidation values to arrive at concentrations of Fe_2O_3, MnO, and Mn_2O_3. The water and carbon dioxide determinations were made using a Perkin Elmer microanalyser (model 240) on approximately 20 mg samples.

The Geevor and Wheal Owles specimens are broadly similar in composition, both being virtually iron-free, but of the two, the Wheal Owles material shows the higher Mn^{3+}/Mn^{2+} ratio and is also richer in CO_2. Collins' (1879) analysis of penwithite gave similar figures, although he did not report CO_2, and the water determined in the present work is much lower as a result of the precautions taken in drying the material. Neotocite from Gestrikland (BM 43219) shows by far the greatest concentration of iron, the molecular proportion being greater than that of the total manganese and the oxidation value for this specimen requires FeO to be present in addition to Fe_2O_3. Stratopeite (BM 89836) contains significantly more Fe_2O_3 than any of the other remaining specimens. The lowest SiO_2/MnO ratio occurs in the specimen of klipsteinite (BM 50668) which also gives the highest concentration of CO_2.

Recalculation of the analyses to molecular proportions shows that, despite the amorphous nature of the minerals, the formula $MnSiO_3.H_2O$ can be applied as a reasonable approximation to the composition of the group. The chemical analyses are in good agreement with other published work apart from the generally lower H_2O values and the presence of CO_2, not widely reported in these minerals before. Specific gravities and refractive indices (Table I) were determined for each specimen on the same sample of material and show a consistent relationship, the highest S.G. being found in the specimen with the highest R.I.

Since the specimens showed a marked tendency to take up moisture from the atmosphere a series of hydration experiments was carried out using a Perkin Elmer AD2 autobalance. A nickel micro-crucible containing a known weight of each mineral, together with a tare, was placed in a series of closed containers having different relative humidities at room temperature (approximately 25°C). After three or four days the samples reached constant weights. The relative humidities of the atmospheres within the container were controlled by the presence of a small beaker containing one of the following compounds in contact with its saturated aqueous solution: 0% r.h., magnesium perchlorate (solid alone); 15% r.h., lithium chloride; 35% r.h., chromic oxide; 47% r.h., potassium thiocyanate; 66% r.h., sodium nitrite; 80% r.h., ammonium chloride; 100% r.h., water. It was found necessary to make rapid weighings, since slight changes in relative humidity were sufficient to cause a change in the weights of some of the samples.

The reversible nature of the absorption and desorption of water was demonstrated on two of the samples, the Geevor and Nant mine specimens, which were cycled from 100% r.h. to 0% and back to 100%; water lost at 0% being regained

Table I. Chemical analyses of neotocite group minerals

	1	2	3	4	5	6	7	8	9
SiO_2	39.8	38.4	40.1	41.4	30.0	43.8	36.6	39.8	35.7
Al_2O_3	1.5	0.4	1.3	< 0.2	< 0.2	0.5	2.9	< 0.1	0.2
Mn_2O_3	5.1	14.1	7.7	11.0	33.2	3.4	-	1.6	-
MnO	33.7	27.5	33.7	25.7	10.4	28.6	37.2	24.5	19.1
Fe_2O_3	< 0.1	0.2	0.3	0.4	0.5	1.6	3.3	8.8	18.7
FeO	-	-	-	-	-	-	-	-	9.6
CaO	0.2	0.1	1.3	1.1	0.3	0.5	2.3	0.4	1.3
MgO	1.3	0.5	1.5	4.0	1.6	4.7	1.3	9.6	3.9
Na_2O	< 0.1	0.1	0.1	< 0.1	< 0.1	< 0.1	0.3	0.1	0.1
K_2O	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	0.3	0.1	< 0.1
CO_2	7.4	6.3	2.2	4.0	13.4	5.7	6.2	3.9	2.8
H_2O^+	10.4	11.8	11.6	11.7	8.2	10.9	9.7	10.8	9.0
Total	99.4	99.4	99.9	99.3	97.6	99.7	100.1	99.6	100.4
Molecular ratios based on Si+R+C+H = 3 (R = $Al+Mn^{3+}+Mn^{2+}+Fe^{3+}+Fe^{2+}+Ca+Mg+Na+K$)									
Si	0.99	0.94	0.99	1.01	0.80	1.06	0.91	0.96	0.93
R	0.90	0.88	0.99	0.91	0.99	0.87	1.07	1.05	1.19
C	0.25	0.21	0.07	0.13	0.49	0.19	0.21	0.13	0.10
H	0.86	0.97	0.95	0.95	0.73	0.88	0.81	0.87	0.78
S.G.	2.08	2.39	2.41	2.28	2.67	2.25	2.07	2.67	2.73
R.I.	1.500	1.548	1.512	1.512	1.548	1.52	1.475	1.568	1.654

1. BM 1968,302. Neotocite. Gambatesa mine, Liguria, Italy.
2. BM 52182. Penwithite. Wheal Owles, Penwith, Cornwall.
3. BM 1974,277a. Neotocite. Geevor mine, Cornwall.
4. BM 1971,342. Penwithite. Noda-Tamagawa mine, Japan.
5. BM 50668. Klipsteinite. Klapperud, Dalecarlia, Sweden.
6. BM 1962,110. Penwithite. Aichi Pref., Japan.
7. Russell spec. Neotocite. Nant manganese mine, Rhiw, Caernarvonshire (now Gwynedd).
8. BM 89836. Stratopeite. Pajsberg, Filipstad, Sweden.
9. BM 43219. Neotocite. Erik Ers mine, Gestrikland, Sweden.

at 100%. The increase in weight shown by each specimen when increasing the relative humidity from 0 - 100% is given in Table II. When the total increase in weight between 0% and 100% r.h. is plotted against the specific gravity (Fig. 2), the samples of lower specific gravity are shown to be the greater absorbers of water.

Table II. Weight per cent increase of neotocite specimens during hydration from 0-100% r.h. (20°C)

r.h.	1	2	3	4	5	6	7	8	9
0-15%	< 0.1	1.5	2.5	3.1	< 0.1	0.8	1.4	1.1	< 0.1
15-35	4.6	4.2	6.8	6.6	2.0	5.7	4.5	2.0	0.7
35-47	7.3	5.0	7.4	8.9	2.2	7.0	5.8	1.9	0.9
47-66	10.2	5.6	7.9	10.0	2.9	9.2	10.0	1.8	1.2
66-80	11.5	5.3	7.8	11.0	4.1	10.6	10.9	1.9	1.1
80-100	11.5	5.6	8.1	11.0	4.0	10.6	13.6	1.9	1.2

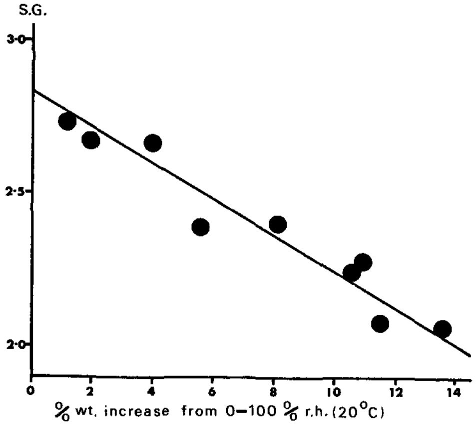

Fig. 2. Percentage increase in weight, during absorption of water, plotted against specific gravity, for the nine neotocite samples.

Thermal analysis

Each of the specimens was examined by simultaneous differential thermal analysis and thermogravimetry with 0.1-0.2 g of crushed material being heated in air at an average rate of 6.3°C per minute up to temperatures of 1000-1150°C. The DTA profiles (Fig. 3) each show an endothermic peak at 150°C resulting from the loss of water and exothermic peaks between 280°C and 330°C. The latter peaks, apparently the result of oxidation of Mn^{2+} to Mn^{3+}, were not reported in the work of Ito (1961) or Whelan and Goldich (1961), although their investigations were carried out under broadly similar conditions. Specimens from the Geevor mine (3) and the Nant mine (7) show low broad peaks in this region. The reason for the absence of a prominent exothermic peak from these two specimens is not clear, since both have values of MnO/Mn_2O_3 typical of the whole group. Possibly the oxidation process in these samples proceeds at a slower rate, maintaining near equilibrium conditons.

The nature of this exothermic peak was examined in more detail on the Noda-Tamagawa mine specimen which showed the peak quite strongly. Separate samples of the mineral were heated to temperatures of 180°C and 350°C, either side of the peak. Chemical determinations on these samples showed that the specimen heated to the higher temperature had increased its oxygen content by 7.9%. This is in very good agreement with the calculated figure of 8.0% obtained from the full chemical analysis when Mn^{2+} is converted to Mn^{3+} and the assumption made that at 180°C no water remains in the sample. This experiment also reinforces the assumption that manganese is present in these minerals primarily in the oxidation states Mn^{2+} and Mn^{3+}.

The DTA profiles in Fig. 3 have also been arranged in order of increasing iron content and it can be seen that for the two iron-rich specimens (8 and 9) the position of the exothermic peak shifts noticeably to higher temperatures. The thermogravimetric curves (not reproduced here) correlate with the DTA data, showing the greatest loss in weight between 100 and 200°C, during dehydration. The total weight loss over the whole heating range varied between 14 and 23% (Table III).

Each DTA run was repeated several times, although only one from each specimen is shown in Fig. 3. In addition to the two peaks described several others are visible in individual samples, but are ascribed to sample impurities since only one of these was reproduced in separate runs. The one referred to is the endothermic peak at 750°C on the klipsteinite specimen (5). Since this mineral is low in SiO_2 and rich in CO_2, comparatively large quantities of rhodochrosite are thought to form at low temperatures during the run, the peak representing its decomposition.

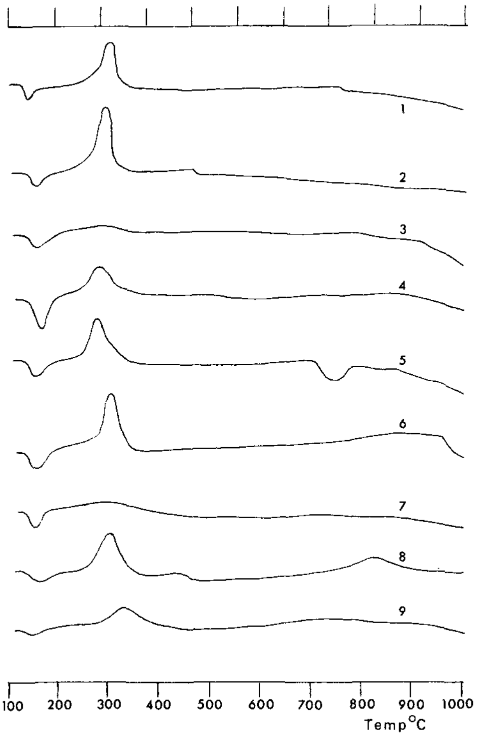

Fig. 3. DTA profiles for the nine neotocite specimens.

Infra-red spectra

The infra-red spectra (Fig. 4) were recorded using a Grubb Parsons Spectromaster infra-red spectrophotometer over the wavelength ranges 2 to 5 µm and 5 to 25 µm. The samples were allowed to equilibrate in air before being pressed into discs with KCl. KCl was found to give a blank free from absorptions in the range studied, whereas KBr gave small variable peaks at around 3.0, 6.3, and 7.0 µm even after prolonged drying.

The spectra are all similar, the major differences being due to the varying carbonate content of the samples. The carbonate peaks at 7.0, 11.45, and 14.1 µm are clearly visible in spectrum 5 and correspond to the ν^3, ν^2, and ν^4 modes of the $(CO_3)^{2-}$ ion in calcite. The carbonate peaks in spectrum 7 however, correspond more closely to those given by the $(CO_3)^{2-}$ ion in rhodochrosite. All the spectra show the 6.9 to 7.0 µm carbonate absorption. Among the remaining peaks present are those due to Si-O stretch at around 9.80 µm, and Si-O bending at around 16 and 22 µm. The peaks at 2.75 and 2.95 µm are due to OH stretching, those at around 6.2 µm to OH bending. Definite assignment of these hydroxyl peaks would require further investigation and a better understanding of the structure of these minerals; there is also the possibility of the hydrogen bonding being affected by the interaction of the samples with KCl.

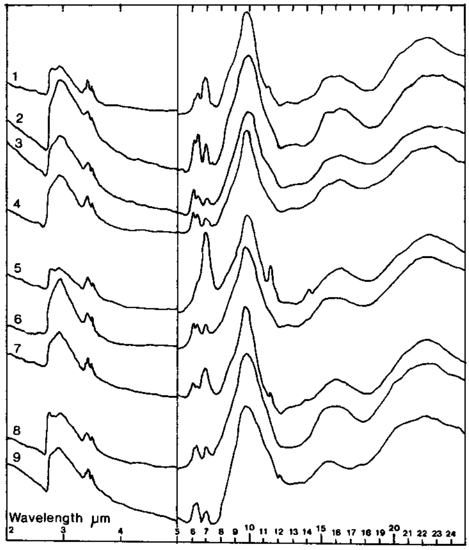

Fig. 4. Infra-red spectra of the nine neotocite specimens.

X-ray studies

X-ray powder films, using a 6 cm. diameter camera, were made from samples of the unheated mineral from each of the British localities and on the residues from each of the thermal analysis experiments. Details of the films obtained are given in Table III, showing that each of the unheated specimens gives a similar pattern with three very broad and diffuse lines around 3.5, 2.6, and 1.6 Å respectively. These lines agree with those reported for neotocite from the Montreal mine, Wisconsin (Whelan and Goldich, 1961). The films from two separate samples of the Geevor material showed admixed hematite. Thus natural neotocite is not completely amorphous, but should be regarded as poorly crystalline. No discrete carbonate minerals were detected in any of the unheated samples so their CO_2 contents cannot be ascribed to impurities.

For the heat-treated material the dominant product in the temperature range 1000-1100°C is shown to be braunite. The main exception was the stratopeite specimen (BM 89836) which gave a diffuse photograph at 1090°C and a pattern resembling pyroxmangite at 1135°C. This specimen appears to behave in a fashion similar to that outlined by Ito (1961) who reported that his Noda-Tamagawa material formed braunite, which was stable up to 1000°C whereupon the appearance of rhodonite was first noticed, this being the dominant phase at 1100-1200°C. In the case of stratopeite, significant iron is present, leading to the formation of pyroxmangite instead of rhodonite. The neotocite from Gestrikland (BM 43219) contains by far the greatest concentration of iron, and the phase forming at 1000°C+ is found to be a spinel (jacobsite or magnetite) as was found by Ito (1961) in an iron-rich specimen from Noda-Tamagawa.

Table III. Results of thermal treatment of neotocite samples

Spec. no.	Max. temp. °C	X-ray identification	Wt. loss %
1	unheated	diffuse (neotocite)	
	1070	braunite (+ quartz)	23.05
2	unheated	diffuse (neotocite)	
	1050	braunite	
3	unheated	diffuse (neotocite + hematite)	
	1005	braunite	16.44
4	unheated	diffuse (neotocite)	
	185	pyroxmangite + rhodochrosite	
	350	rhodochrosite	
	1000	braunite	21.58
5	unheated	diffuse (neotocite)	
	1000	braunite + hausmannite	
	1070	braunite + hausmannite	18.95
*5a	unheated	birnessite +	
	1050	braunite + hausmannite	
6	unheated	diffuse (neotocite)	
	1075	braunite	21.28
7	unheated	diffuse (neotocite)	
	1010	braunite	20.33
	1055	braunite	
8	unheated	diffuse (neotocite)	
	1090	diffuse	15.88
	1135	nr. pyroxmangite	15.81
9	unheated	diffuse (neotocite)	
	980	spinel (jacobsite or magnetite) + braunite	

*Specimen 5a, BM 40229, klipsteinite, Herborn, Dillenberg, West Germany

It is worth noting that both the klipsteinite specimens (BM 50668 and BM 40229) contain a small amount of hausmannite in addition to braunite in the temperature range 1000-1100°C. This phase possibly results from the decomposition of rhodochrosite previously mentioned. An X-ray powder photograph of the unheated Herborn klipsteinite (BM 40229) gave a pattern differing from the remainder of the neotocite group by showing a number of sharply defined lines due to the presence of several minerals, the dominant phase being birnessite. Fisher's (1880) conclusion that this skipsteinite is an intergrowth is therefore confirmed, and the material was not for this reason included in the major part of the investigation reported here.

Discussion

Of the names used in this mineral group, opsimose (Dalecarlia, Sweden) was the first to be documented. The analysis in the present study confirms this occurrence as low in SiO_2, but with high CO_2 not reported in the old analyses. Its thermal properties are in good agreement with the other specimens examined. Stratopeite has been confirmed as a member of the group, but rich in MgO. In addition to the original Cornish find, penwithite is the name more recently applied to several Japanese occurrences of the mineral (Kato, 1924; Ito, 1961), but the two specimens from that country examined here are typical of the group as a whole. Penwithite was the last name to be introduced (in 1879) and there would seem, therefore, to be no justification for extending this name to the whole group.

The name neotocite, however, has been the most widely used for these silicates, additional occurrences having been described in detail by Pardee et al (1921), Ham and Oakes (1944), Lee (1955), and Whelen and Goldich (1961). It is unfortunate therefore that the topotype material studied here furnished a manganese-iron silicate with Fe slightly greater than Mn (i.e. ferrian neotocite). Nevertheless, in view of current usage, it is proposed that neotocite be defined as the group of poorly crystalline manganese silicates with formulae close to $(Mn,Fe)SiO_3.H_2O$ with Mn>Fe. Limited substitution of MgO, Al_2O_3, and CO_2 should be acceptable and the other names in the group should be discarded. The Commission on New Minerals and Mineral Names, IMA, has approved these proposals, but came to no firm conclusion as to whether the group name should be spelled " neotocite" or as in the original description "neotokite". Accordingly either are permissable.

The neotocite series probably grades into hisingerite but as all reported occurrences of the latter mineral have iron substantially greater than manganese, the Gestrikland material is, for the present, included with neotocite. Whelan and Goldich (1961) have noted a similarity in the X-ray powder patterns of the two minerals, despite the broad and diffuse nature of the lines. They draw attention to similarities between the hisingerite patterns and those of nontronite and iron-rich saponite. Lindqvist and Jansson (1962) pursued this question by examining a number of manganese-rich hisingerites (including neotocites from Gestrikland and Klapperud), suggesting instead a micaceous nature for the group. The neotocite specimens and mineral fragments examined in the present study do not support this conclusion. Soklakov and Dorfman (1964) on the other hand put hisingerite in a series grading into chinglusuite, an amorphous (metamict?) silicate of manganese, titanium, and sodium. There is clearly scope for examining neotocite in conjunction with end-member hisingerite and chinglusuite.

The role of iron in these minerals is possibly of some significance. Roy (1976) has pointed out that in the types of deposit in which neotocite is found, manganese and iron are precipitated from acidified sea-water when the solution is oxidized and rendered alkaline through mixture with fresh sea-water. Iron is precipitated under conditons of lower Eh and pH than manganese and, in slowly changing environments, is generally precipitated first, leaving the manganese in solution to form later separate deposits. On the other hand, rapid oxidation and increasing alkalinity results in the co-precipitation of iron and manganese. The iron content of these gel-like silicates is therefore a possible indicator of this aspect of a deposit's formation conditons.

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