Neotocite and hisingerite from nepheline syenite pegmatites in the Larvik plutonic complex, Norway

Alf Olav Larsen and Muriel Erambert

Introduction

Hisingerite was named by J. J. Berzelius and described by Hisinger (1828), while neotocite was named and described by Nordenskiöld (1849). Hisingerite and neotocite are non-crystalline mineral phases, which usually form from the alteration of iron- and manganese-rich silicates and carbonates (Whelan & Goldich 1961). Due to the nature of these ill-defined minerals, several names, now obsolete, have been given to similar phases over the years: *penwithite*, *klipsteinite*, *stratopeite*, *wittingite*, *canbyite*, *chlorophaeite* and *sturtite*. Eggleton et al. (1983) concluded that minerals in the hisingerite-neotocite series have amorphous or gel structure. The two minerals form a solid solution series from $FeSiO_3 \cdot H_2O$ (hisingerite) to $MnSiO_3 \cdot H_2O$ (neotocite) (Clark et al. 1978). The minerals often show limited substitution of Ca, Mg, Al and CO_2.

In the early 1970's the former author collected samples of reddish brown to nearly black minerals associated with eudidymite and hambergite in the Saga I quarry, Mørje, Porsgrunn. Preliminary investigations showed that the minerals were poorly crystalline, hydrated Fe-Mn-silicates, but no conclusive identification was achieved. Because of their nearly amorphous state and relatively dull chemistry the minerals were temporarily put aside. Similar minerals have later been observed sporadically in other pegmatites in the Tvedalen area. During the last year, reddish brown to black masses of a nearly amorphous mineral has been found relatively abundant in the huge pegmatite at the Sagåsen quarry at Mørje. An investigation was initiated in order to clarify the correct identity of this and similar minerals from the Tvedalen area. It soon became evident that the minerals belong to the hisingerite-neotocite series. Hisingerite has been described as a minor constituent of dark larvikite from the Tjølling area (Dietrich 1961), but neither hisingerite nor neotocite have previously been recorded from the syenite pegmatites. The present paper is the first report on the minerals from pegmatites in the Larvik plutonic complex.

General information

Hisingerite and neotocite are the latest minerals in the pegmatite formation. The minerals occur as masses filling voids and fracture between the older minerals, or as crusts covering previously crystallised minerals in vugs. Hisingerite and neotocite are relatively soft, with Mohs' hardness about 2.5 – 3. The density is rather low, varying from 2.1 to 2.7 g/cm^3. They are very brittle, show conchoidal fracture and resineous luster. The minerals are translucent, the darkest coloured samples only in very thin splinters. The powders are pale brown to dark brown depending on the colour of the mineral.

X-ray diffraction data

Hisingerite and neotocite are poorly crystalline. The X-ray powder diffraction patterns consist of broad and diffuse lines with maxima at approximately 2.7 Å and 1.6 Å. A typical diffractogram is shown in Fig. 1. Similar powder diffraction patterns have been reported by Whelan & Goldich (1961), Clark et al. (1978), and White (1987).

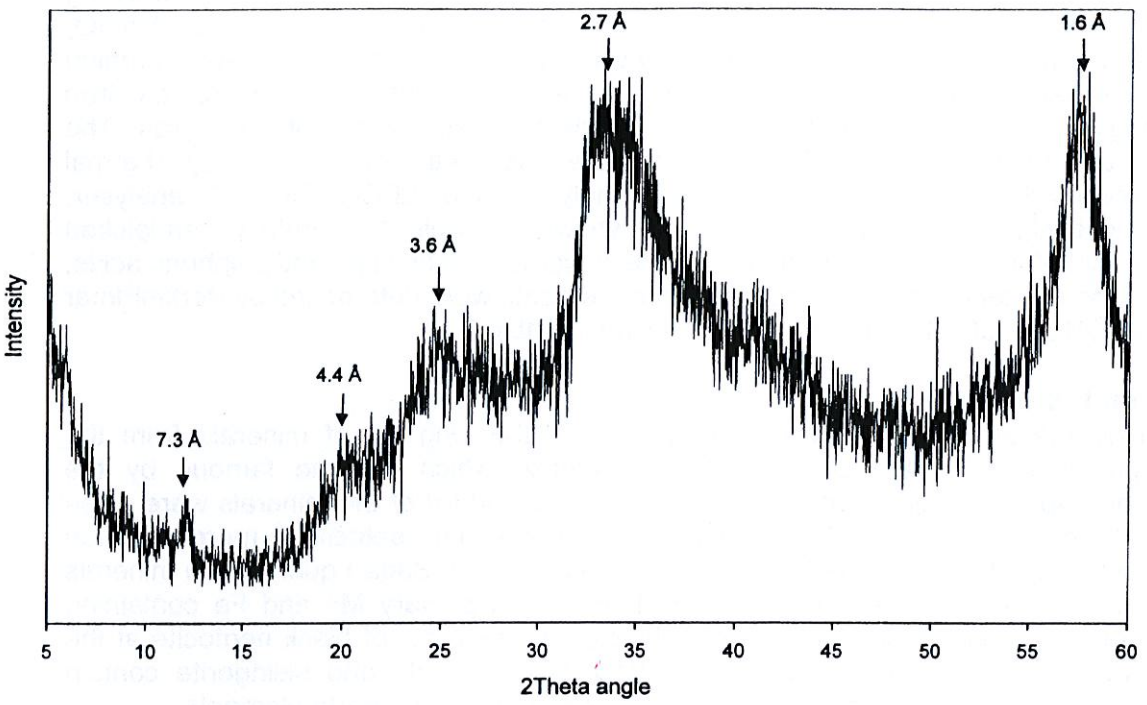

Fig. 1. X-ray powder diffractogram of neotocite (sample SÅ1) from the Sagåsen quarry.

Description of the samples

The Sagåsen quarry, Mørje, Porsgrunn

Sample SÅ1. Black neotocite as masses several cm across filling a void between feldspar individuals.

Sample SÅ2. Black neotocite as pseudomorphs after romb shaped rhodochrosite crystals, up to 2 cm across, embedded in a matrix of coarsely crystalline zircon and feldspar.

Sample SÅ3. Neotocite as globular lining in a vug. The surface of the globules is dull grey, while the interior is concentrically banded showing different shades of greyish brown and brown (SÅ3a and SÅ3b). The base of the globules is dark reddish brown (SÅ3c).

Sample SÅ4. Reddish brown neotocite covering tiny, porous, hexagonal prisms of calcite in a vug.

The Saga I quarry, Mørje, Porsgrunn

Sample SG1. Reddish brown neotocite as masses up to 5 mm across in a complex aggregate of analcime mixed with biotite, aegirine and pyrochlore. The samples also contain cm-sized eudidymite crystals embedded in calcite.

Sample SG2. Black hisingerite fills a void, several centimetres across, between large microcline individuals. Needles of hambergite are embedded in the hisingerite.

The Saga Pearl quarry, Tvedalen

Sample SP1. Reddish brown neotocite as up to half a millimeter thick cover on albite and hambergite needles in a vug between large microcline and aegirine crystals.

Chemical composition

Chemical analyses were conducted on a CAMECA SX-100 electron microprobe using an operating voltage of 15 kV, a beam current of 6 nA, and a beam spot of 20

μm. The instrument was operated in wave-length dispersive mode. The following standards were used: wollastonite (Si*K*α, Ca*K*α), Al_2O_3 (Al*K*α), Fe_2O_3 (Fe*K*α), $MnTiO_3$ (Mn*K*α), MgO (Mg*K*α), albite (Na*K*α) and orthoclase (K*K*α). In order to avoid burning of the samples the counting time was 10 s for all elements. Backscatter electron imaging was used to investigate the compositional zonation of the samples. The amount of CO_2 and H_2O in the sample SÅ1 was determined by thermal decomposition using LECO CS-200 analyser and LECO RC-412 analyser, respectively. The analytical results are shown in Table 1. Carefully handpicked material of the samples SÅ1 and SG2 was decomposed by nitric and sulphuric acids, and the concentrations of minor and trace elements were determined by PerkinElmer Elan DRC-II ICP-MS. The results are shown in Table 2.

Conclusion

Hisingerite and neotocite are new species to the long list of minerals from the pegmatites within the Larvik plutonic complex, which became famous by the monograph of Brøgger (1890). A review and updated list of the minerals were given by Andersen et al. (1996). The present data show that neotocite is more common than hisingerite, which has been identified only from the Saga I quarry. The minerals resulted from hydrothermal alteration of undefined primary Mn and Fe containing minerals. Ferroan rhodochrosite is obviously the precursor of black neotocite at the Sagåsen quarry. Chemical analyses show that neotocite and hisingerite contain significant amounts of Be, Ti, Zn, Sr, Y, Nb, Th, and the rare earth elements.

Acknowledgements

Our sincere thanks to Svein Arne Berge and Tom Engvoldsen for sharing their observations on hisingerite and neotocite from the Sagåsen quarry, and also for donating samples for this study. We thank E. Tveten and A. Åsheim for generously carrying out the water analysis and the ICP-MS analyses, respectively. The microprobe analysis work was financed by Telemark Geologiforening.

References

ANDERSEN, F., BERGE, S. A. & BURVALD, I. (1996): Die Mineralien des Langesundsfjords und des umgebenden Larvikit-Gebietes, Oslo-Region, Norwegen. *Mineralien-Welt* **7 (4)**, 21-100.

BRØGGER, W. C. (1890): Die Mineralien der Syenitpegmatitgänge der südnorwegischen Augit- und Nephelinsyenite. *Zeitschrift für Krystallographie* **16**, 1-235 + 1-663.

CLARK, A. M., EASTON, A. J. & MOUNT, M. (1978): A study of the neotocite group. *Mineralogical Magazine* **42**, 279-280 & M26-30.

DIETRICH, R. V. (1961): Hisingerite in "dark" larvikite. Contributions to the mineralogy of Norway, No. 12. *Norsk Geologisk Tidsskrift* **41**, 95-108.

EGGLETON, R. A., PENNINGTON, J. H., FREEMAN, R. S. & THREADGOLD, I. M. (1983): Structural aspects of the hisingerite-neotocite series. *Clay Minerals* **18**, 21-31.

HISINGER, W. (1828): Analyse des mit den Namen Hisingerit belegten Eisensilikats. *Annalen der Physik und Chemie* **13**, 501-508.

NORDENSKIÖLD, N. (1849): *Über das atomistische-chemische Mineral System und das Examinations System der Mineralien.* Helsingfors. 157 pp.

WHELAN, J. A. & GOLDICH, S. S. (1961): New data for hisingerite and neotocite. *American Minealogist* **46**, 1412-1423.

WHITE, J. S. (1978): Neotocite from the Foote mine, North Carolina. *Mineralogical Record* **18**, 133-134.

Table 1. Chemical composition (in wt.%) of neotocite and hisingerite from pegmatites in the Larvik plutonic complex (SÅ = Sagåsen quarry, SG = Saga I quarry, SP = Saga Pearl quarry) and corresponding number of atoms per formua unit based on 3 oxygen atoms. The reported concentrations are the mean values of *n* analysis points.

	SÅ1 *n* = 7	SÅ2 *n* = 9	SÅ3a *n* = 7	SÅ3b *n* = 3	SÅ3c *n* = 3	SÅ4 *n* = 7	SG1 *n* = 5	SG2 *n* = 5	SP1 *n* = 6
SiO_2	41.54	40.66	43.29	42.81	42.19	42.16	41.99	38.39	39.24
Al_2O_3	1.86	1.89	2.50	2.11	1.43	3.73	3.78	4.03	3.96
Fe_2O_3	7.44	7.34	2.22	3.74	6.18	5.95	1.59	24.30	10.16
MnO	29.99	29.80	31.78	31.61	32.16	23.31	28.10	10.93	24.55
MgO	1.75	1.36	1.69	1.38	1.52	1.27	0.69	0.73	1.24
CaO	1.56	1.59	1.85	1.47	1.22	2.11	2.03	1.33	1.46
K_2O	0.01	0.02	0.05	0.03	0.01	0.06	0.23	0.14	0.11
Na_2O	0.15	0.25	0.27	0.32	0.10	0.33	0.22	0.13	0.22
CO_2	1.02	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.
H_2O	15.8	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.	n. a.
Total	101.12	82.91	83.65	83.47	84.81	78.92	78.63	80.98	80.94
Si	0.978	0.998	1.038	1.033	1.014	1.038	1.051	0.934	0.969
Al	0.052	0.054	0.070	0.060	0.040	0.108	0.112	0.116	0.115
Fe	0.132	0.136	0.040	0.068	0.112	0.110	0.030	0.445	0.189
Mn	0.598	0.620	0.644	0.646	0.655	0.486	0.596	0.225	0.514
Mg	0.061	0.050	0.060	0.050	0.054	0.047	0.026	0.026	0.046
Ca	0.039	0.042	0.047	0.038	0.031	0.056	0.054	0.035	0.039
K	0.000	0.001	0.002	0.001	0.000	0.002	0.007	0.004	0.003
Na	0.007	0.012	0.013	0.015	0.005	0.016	0.011	0.006	0.011
C	0.033								
H_2O	1.241								

n. a. = not analysed

Table 2. Minor and trace elements (in ppm) in neotocite from the Sagåsen quarry (sample SÅ1) and hisingerite from the Saga I quarry (sample SG2).

	SÅ1	SG2
Be	154	1327
Ti	241	29
Zn	793	53
Sr	152	90
Y	1800	1297
Nb	103	940
La	970	365
Ce	1677	283
Pr	162	31
Nd	512	121
Sm	123	43
Eu	11	4
Gd	185	71
Tb	37	16
Dy	266	146
Ho	61	39
Er	200	153
Tm	32	36
Yb	165	324
Lu	16	53
Th	2458	116
U	16	35