Contributions to the mineralogy of the syenite pegmatites in the Larvik Plutonic Complex

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The book covering the mineralogy on the syenite pegmatites of the Larvik Plutonic Complex was published three years ago (Larsen 2010). Since then, several species new to the district or new to science have been found and verified. This paper briefly describes these new species. The number of documented species found in the syenite pegmatites in the Larvik Plutonic Complex is now close to 210.

Pyrrhotite

Because of an inadvertence, the description of the mineral pyrrhotite was unfortunately omitted in the book "The Langesundsfjord" (Larsen 2010). Here is the text as it should have been published.

Pyrrhotite
$Fe_{1-x}S$ (x = 0 - 0.2)
Crystallography: Pyrrhotite occurs as several polytypes. The two most common polytypes are:
1) Monoclinic (prismatic), *C*2/*c*, *a* = 11.90, *b* = 6.87, *c* = 22.88 Å, β = 90.3°
2) Hexagonal (dipyramidal), $P6_3/mmc$, *a* = 3.44, *c* = 5.75 Å
XRD patterns of pyrrhotite from Håkestad and Melau show pure monoclinic polytype, while pyrrhotite from Thorstein is a mixture of monoclinic and hexagonal polytypes.
Colour: Bronze-yellow
Streak: Dark greyish black
Lustre: Metallic on fresh surfaces, but tarnishes quickly.
Tenacity: Brittle
Cleavage: Good parting on {0001}
Fracture: Uneven to subconchoidal
Hardness: 4
Density: 4.7 g/cm^3
Remark: Weakly magnetic

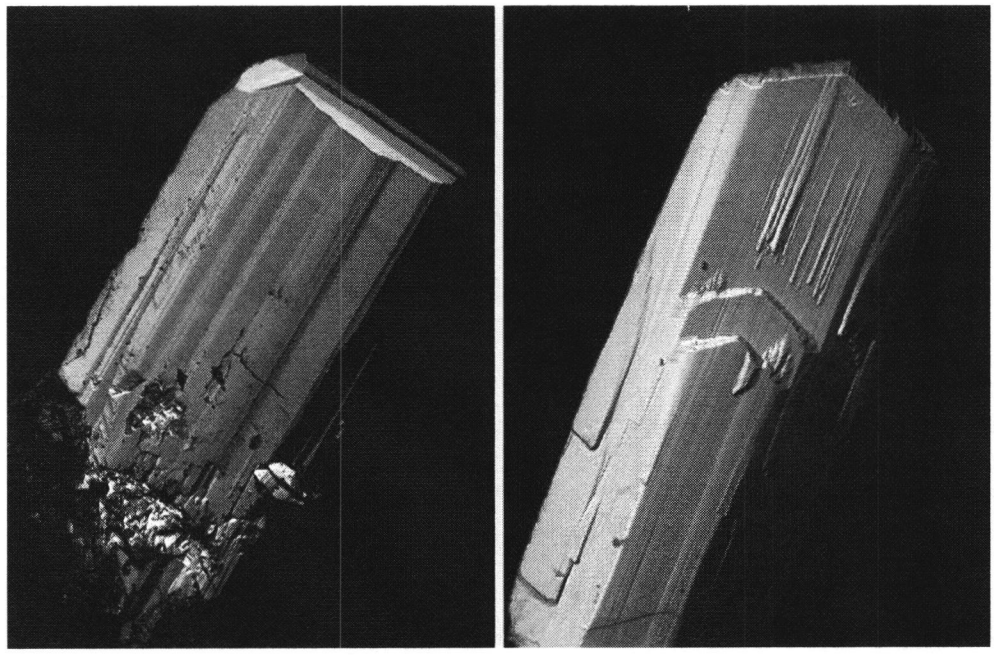
Pyrrhotite was probably first observed in the syenite pegmatites in the Larvik Plutonic Complex around 1975. The mineral crystallized during the hydrothermal stage of the pegmatite formation, and occurs associated with zeolites and other sulfides.
Pyrrhotite is a relatively rare mineral in the syenite pegmatites in the Larvik Plutonic Complex. In certain pegmatites in the Thorstein and the Melau quarries in Brunlanes, however, massive pyrrhotite occurs quite abundant together with pyrite and minor amounts of chalcopyrite and molybdenite. Sulfides fill several cm wide fissures, cracks and spaces between the earlier crystallized minerals. Pyrrhotite has been found in as masses up to 1- 2 cm in the Håkestad quarry in Tjølling. Small amounts of pyrrhotite have been observed in an E-18 roadcut at Rønningen in Eidanger. Pyrrhotite has been found in the Saga I quarry, Mørje and the Tuften quarry, Tvedalen area in very scarce amount as tabular hexagonal crystals up to 1 mm across. Subhedral crystals of pyrrhotite up to 2 mm across have been found in a hydrothermally altered pegmatite in the Østskogen quarry in Tvedalen. The mineral was associated with minor amounts of chalcopyrite, and embedded in chlorite and finely scaly muscovite. Small pyrrhotite crystals have been observed in the Saga Pearl quarry in Tvedalen. Pyrrhotite has also been found at Bratthagen in Lågendalen.

Bastnäsite-(La)

Bastnäsite-(La), (La,Ce)(CO_3)F, was briefly described by Kolitsch et al. (2013). The mineral form tiny rounded platelets, either arranged in sprays embedded in matrix or as crusts covering surfaces of tiny voids in F-bearing schörl at the Almenningen quarry, Tvedalen.

Brookite

Brookite (TiO_2) was identified by A.O. Larsen in 2011 in samples collected by P. Andresen from the Midtfjellet larvikite quarry, Malerød, Larvik. The mineral occurs as black, semi-metallic well-developed, ruler-shaped crystals up to 0.5 mm in length. The following forms are identified: {100}, {110} and {111}. The crystals are arranged in aggregates up to 5 mm across, usually circumferencing pyrite crystals, and associated with gonnardite in vugs lined with analcime. An elemental analysis using SEM/EDS showed that brookite, apart from Ti and O as major elements, contains minor amounts of Fe, Si and Nb.



Brookite from the Midtfjellet quarry, Malerød, Larvik. The crystals are about 0.5 mm in length. SEM micrograph by A.O. Larsen.

Cassiterite

Cassiterite, SnO_2, as tiny, anhedral inclusions (max 5 µm across) in schörl and xenotime-(Y) from the Almenningen quarry, Tvedalen was briefly described by Kolitsch et al. (2013).

Chromatite

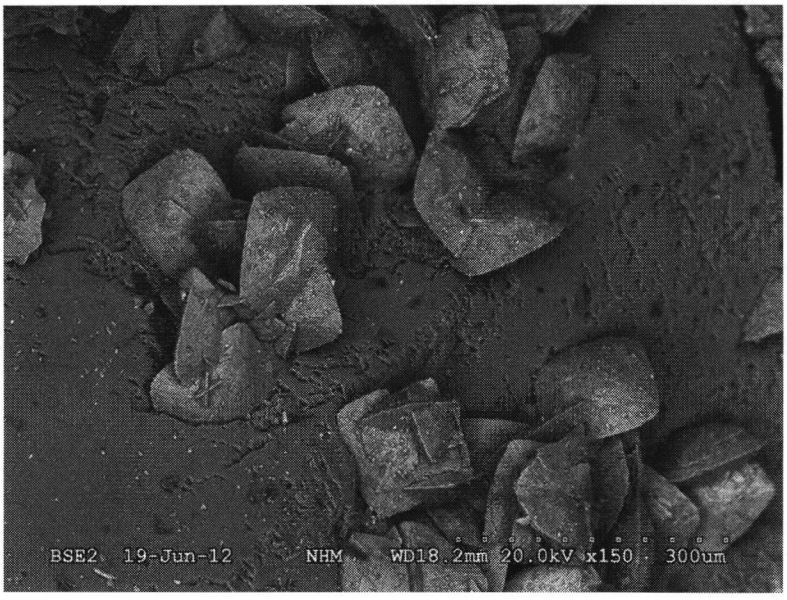
Chromatite, $CaCrO_4$, was mentioned by Piilonen et al. (2012) from the dump at Buer, Bjørkedalen. The mineral occurs as tiny brownish-rusty, blocky crystals in a small vug and was identified by XRD (P. Piilonen, pers. comm. 2013).

Ferri-fluoro-leakeite

The rare, lithium-bearing amphibole ferri-fluoro-leakeite, $NaNa_2(Mg_2Fe_2^{3+}Li)Si_8O_{22}F_2$, is recently identified by R. Oberti (University of Pavia, Italy) in a sample from Bratthagen, Lågendalen that was collected by R. Kristiansen in 1978. Ferri-fluoro-leakeite occurs as mustard-yellow lath-shaped crystals up to 10 mm in length (R. Kristansen, pers. comm. 2013). Ferri–fluoro-leakeite was type described from Kazakhstan as fluoroleakeite (Camara et al. 2010), and the name was later changed according to the recent definition of the nomenclature of amphibole supergroup (Hawthorne et al. 2012) to ferri-fluoro-leakeite. The Bratthagen species is the second find of the mineral.

Gugiaite

Hydroxyl-bearing gugiaite with the average empirical formula $(Ca_{1.3\square 0.7})(Si_{0.9}Be_{0.1})(Be_{1.2}Si_{0.8})[O_5(OH)_2]$, ideally $Ca_2BeSi_2O_7$, was recently described by Grice & Kristiansen (2013). The mineral was found by R. Kristiansen both at Blåfjell, Langangen and Saga I quarry, Mørje, Porsgrunn. The mineral occurs as small, ~100 µm, rod-like, pale yellowish crystals or as white or grey, anhedral grains and rarely as euhedral crystals, with a flattened pillow-shaped tetragonal dipyramid form (see SEM micrograph below). It is tetragonal with a = 7.415(1), c = 4.961(2) Å, V = 272.9(1) Å^3 and Z = 2. The cell parameters are slightly smaller than gugiaite from other localities and the refractive indices ω = 1.622(2), γ = 1.632(2) are lower. The chemical composition of the Norwegian gugiaite differs from gugiaite from the type locality in China.



Crystals of gugiaite from Saga I quarry, Mørje, Porsgrunn.
SEM micrograph by R. Kristiansen.

IMA 2012-039

The new mineral species with the chemical composition $Ca_{1-2}FeSi_5Be_2O_{13}(OH)_2]\cdot 2H_2O$ has been found in syenite pegmatites at Blåfjell, Langangen, Norway and in the AS Granite quarry, Tvedalen (Grice et al. 2013).

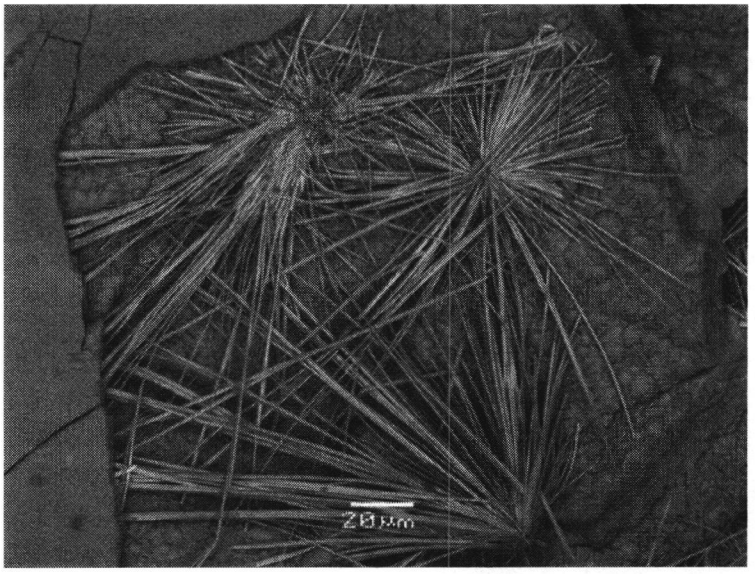
IMA 2012-084

The first, natural hexaniobate mineral, $Mn_4Nb_6O_{19}\cdot 14H_2O$, is recently approved by IMA as a new species and briefly discussed by Friis (2012). The mineral was found by P. Andresen in the AS Granit quarry, Tvedalen in November 2010.

Karibibite

In April 2013 P. Andresen found two aggregates of löllingite, each about 7x7 cm in size, in a pegmatite on level 1 in the AS Granit quarry, Tvedalen. The löllingite was intimately intergrown with galena. The samples contain masses of fluorite. The löllingite and galena has been subject to supergene alteration resulting in the formation of several arsenates, of which three (underlined) are new to the Larvik Plutonic Complex: karibibite, philipsbornite, yukonite and pharmacosiderite. The minerals are identified by AOL using XRD and SEM/EDS.

Karibibite, $Fe_2As_4(O,OH)_9$, occurs as yellow to yellowish brown, finely fibrous, divergent aggregates, up to 1 mm across, in tiny vugs lined with yukonite in feldspar and fluorite.



Fibrous aggregates of karibibite on yukonite from the AS Granit quarry, Tvedalen. SEM micrograph by A.O. Larsen.

Lead

Native lead (Pb) was identified by AOL in 2010 in samples collected by P. Andresen from a syenite pegmatite showing a rich diversity of minerals on level 2 in the AS Granit quarry, Tvedalen. An elemental analysis using SEM/EDS showed Pb as the only detectable element. Lead occurs as grey, soft and malleable patches and flakes, up to a few mm across, closely associated with galena, litharge and hydrocerussite. Lead, litharge and hydrocerussite were formed as the result of hydrothermal alteration of galena. The pegmatite and its minerals are described by Andresen (2013).

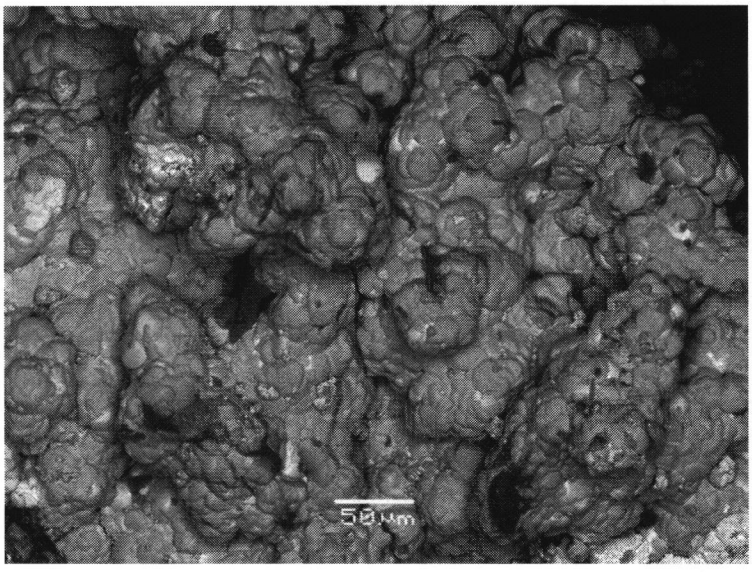
Luinaite-(OH)

Luinaite-(OH), $(Na,\square)(Fe^{2+},Mg)_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$, is a monoclinic-pseudorhombohedral member of the tourmaline group, and can be considered as the monoclinic analogue of

schorl. The symmetry reduction is caused by cation ordering. The mineral can be correctly identified only using high-resolution XRD (SXRD) studies. The mineral was submitted to IMA in 2009 (IMA 2009-046) and subsequently accepted as a new species. The type description is still in preparation (Mills et al., to be submitted). Luinaite-(OH) has been identified by U. Kolitsch (Naturhistorisches Museum Wien) in October 2011 as brown-black radiating crystals and crystal aggregates up to 10 mm in length in analcime/natrolite matrix from the Midtfjellet larvikite quarry, Malerød, Larvik (collected by P. Andresen in 2006/2007). The mineral has also been identified by U. Kolitsch from AS Granit quarry, Tvedalen as small, black prisms. Luinaite-(OH) and other tourmalines from the Larvik Plutonic Complex are described by Kolitsch et al. (2013).

Philipsbornite

Philipsbornite, $PbAl_3(AsO_4)_2(OH,H_2O)_6$, occurs as very pale greenish, botryoidally crusts in tiny vugs, and fills cracks and fissures in löllingite. The mineral is associated with pharmacosiderite, yukonite and karibibite. The minerals were found by P. Andresen in April 2013 on level 1 in the AS Granit quarry, Tvedalen, and subsequently identified by A.O. Larsen.



Botryoidally masses of philipsbornite from the AS Granit quarry, Tvedalen.
SEM micrograph by A.O. Larsen.

Pyrochlore supergroup species

Piilonen et al. (2013) presents a thorough investigation of pyrochlore minerals from the pegmatites in the Larvik Plutonic Complex. Most of the unaltered pyrochlores can be named **fluorcalciopyrochlore**, which, according to Atencio (2010) and Christy & Atencio (2013), is a "possible new species", but formally not yet approved by CNMNC-IMA. Some of the unaltered samples may be classified as **calciopyrochlore** ($F < 0.5$ apfu). Piilonen et al. (2013) points out the fact that pyrochlores from the LPC often suffer from different types of alteration, resulting in domains of varying chemical composition ranging in composition from **calciopyrochlore** to **kenopyrochlore** or **hydropyrochlore**.

Rinkite

Johnstrupite has for many years been considered as a variety of mosandrite. Bellezza et al. (2009b) has proved, however, that *johnstrupite* is identical to rinkite, and that there are structural, crystallographic and chemical differences between mosandrite and rinkite (Bellezza et al. 2009a). In brief, mosandrite compared to rinkite is characterized by a low content of Ca, Na, F, and a relatively high content of H_2O. The chemical formulae for mosandrite is $Ti(\square,Ca,Na)_3(Ca,REE)_4(Si_2O_7)_2(OH,F)_4 \cdot 2H_2O$, rinkite is $Ti(Na,Ca)_3(Ca,REE)_4(Si_2O_7)_2(OF_3)$. The two species can be properly identified only by chemical analysis.

Ten samples of alleged mosandrites from the Langesundsfjord district were analysed by Larsen & Erambert (2010). Four of these samples were identified as rinkite: Saga I larvikite quarry at Mørje, Arøyskjærene (NW towards Dypingen), Fredriksen's prospect on Arøyskjærene, and a locality in the forest in the centre of Arøya.

Micheelsenite

A fibrous mineral from Bratthagen was found by the author and tried identified using XRD at the Geological Museum in Oslo both in 1978 and 1981, but without success. In autumn 2010, however, a new try using both XRD and SEM/EDS gave a positive result for micheelsenite, $(Ca,Y)_3Al[PO_3OH,CO_3](CO_3)(OH)_6 \cdot 12(H_2O)$, which was type described from Mont Saint-Hilaire, Canada and Nanna pegmatite, South Greenland by McDonald et al. (2001). Micheelsenite from Bratthagen occurs as colourless, fibrous crystals up to 0.7 mm long and as fan-shaped aggregates up to 1.5 mm across. The mineral occurs in vugs in microcline associated with zircon, hilairite, aegirine and gonnardite. The Bratthagen find was described by Berge (2011).

Surkhobite

The rare mineral surkhobite, $(Ba,K)_2CaNa(Mn,Fe^{2+},Fe^{3+})_8Ti_4(Si_2O_7)_4O_4(F,OH,O)_6$, has recently been identified by M. Cooper (University of Manitoba) and briefly described by Kristiansen (2013). The sample of surkhobite was collected by R. Kristiansen at Bratthagen, Lågendalen in 1978. Surkhobite occurs as nearly colourless, extremely thin, lathshaped crystals, up to 150 µm in length and 10 µm in width. The crystals are situated on the surface of kupletskite. This is the second find of surkhobite worldwide.

Sveinbergite

Sveinbergeite, $Ca(Fe^{2+}_6\ Fe^{3+})Ti_2(Si_4O_{12})_2O_2(OH)_5(H_2O)_4$, was described as a new astrophyllite-group mineral by Khomyakov et al. (2011) from a syenite pegmatite at Buer on the Vesterøya peninsula, Sandefjord. The mineral occurs in cavities as lamellar crystals up to 10 mm in length, forming rosette-like divergent groups and spherical aggregates. Crystals of sveinbergeite are deep green with a pale green streak and a vitreous and pearly lustre. The mineral has perfect cleavage on {001} and a Mohs hardness of 3. Its calculated density is 3.152 g/cm^3. The mineral is named after the mineral collector Svein Arne Berge. The mineral and the locality have been described by Larsen (2012) and Berge et al. (2011).

Taramite, ferro-pargasite

The amphiboles taramite and ferro-pargasite was mentioned by Piilonen (2012) from Bratthagen, Lågendalen. These amphiboles are indistinguishable from other black amphiboles in the LPC, and can be identified only through chemical analyses.

UK-17 (aspedamite–like mineral)

In the syenite pegmatite at Virikkollen at Sandefjord described by Larsen & Kolitsch (2013) small (up to 0.1 mm) well-developed, reddish, dodecahedral crystals was found in vugs associated with albite, quartz, epididymite, ilmenite, bastnäsite-(Ce), aegirine, mica, pyrochlore, arfvedsonite and a clay mineral. Preliminary analysis showed that the mineral is essentially a Th-heteropolyniobate, identical to or very closely related to the relatively recently described mineral aspedamite (Cooper et al. 2012).

UK-19

A white mineral occurring as fibrous bundles and sprays in tiny vugs was collected by P. Andresen from a syenite pegmatite showing a rich diversity of minerals on level 2 in the AS Granit quarry, Tvedalen (Andresen 2013). A preliminary elemental analysis by A.O. Larsen using SEM/EDS indicates that the mineral is a Pb arsenate with minor amounts of Ca and Si.

Yukonite

Yukonite, $Ca_2Fe_3(AsO_4)_3(OH)_4 \cdot 4H_2O$, is rather common in the altered löllingite aggregates found by P. Andresen in April 2013 on level 1 in the AS Granit quarry in Tvedalen. The mineral forms brownish to reddish brown masses filling cracks and fissures. Some of the yukonite shows a micaceous appearance on a microscopically level, while other part of the mineral is massive and resinous. Associated minerals include philipsbornite, pharmacosiderite and karibibite.

Zektzerite

A colourless mineral occurring in a large cavity in a syenite pegmatite at Virikkollen, Sandefjord together with zircon, opal-A_N, bertrandite and aegirine was discovered in 2010 by the K.E. Larsen. The mineral was subsequently identified by Uwe Kolitsch as zektzerite, $NaLiZrSi_6O_{15}$. Zektzerite occurs as vitreous, colourless, strongly hydrothermally etched, blocky crystals up 9x7 mm in size. Due to the etching, crystal faces with a somewhat curved appearance have been recognised in only a few crystals. The locality and its accessory minerals were described in detail by Larsen & Kolitsch (2011).

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References

ANDRESEN, P. (2013): Gedigent bly og andre spennende mineraler fra en unik pegmatitt i Tvedalen. *Norsk Bergverksmuseum Skrift* **50**, 83-87.

ATENCIO, D., ANDRADE, M.B., CHRISTY, A.G., GIERÉ, R. & KARTASHOV, P.M. (2010): The pyrochlore supergroup of minerals: Nomenclature. *The Canadian Mineralogist* **48**, 673-698.

BELLEZZA, M., MERLINO, S. & PERCHIAZZI, N. (2009a): Mosandrite: structural and crystal chemical relationships with rinkite. *Canadian Mineralogist* **47**, 897-908.

BELLEZZA, M., MERLINO, S., PERCHIAZZI, N. & RAADE, G. (2009b): "Johnstrupite": a chemical and structural study. *Atti della Società Toscana di Scienze Naturali, Serie A* **114**, 1-3.

BERGE, S.A. (2011): Micheelsenitt – et nytt mineral for Norge. *Stein* **38 (2)**, 12-13.

BERGE, S.A., LARSEN, K.E. & ANDERSEN, F. (2011): Buer, Vesterøya, Sandefjord - en typelokalitetet for et nytt mineral. *Norsk Bergverksmuseum Skrift* **46**, 49-56.

CÁMARA, F., HAWTHORNE, F.C., BALL, N., BEKENOVA, G., STEPANOV, A.V. & KOTEL'NIKOV, P.E. (2010): Fluoroleakeite, $NaNa_2(Mg_2Fe_2^{3+}Li)(Si_8O_{22})F_2$, a new mineral of the amphibole group from the Verkhnee Espe deposit, Akjailyautas Mountains, Eastern Kazakhstan District, Kazakhstan: description and crystal structure. *Mineralogical Magazine*, **74**, 521-528.

CHRISTY, A.G. & ATENCIO, D. (2013): Clarification of status of species in the pyrochlore supergroup. *Mineralogical Magazine* **77**, 13-20.

COOPER, M.A., ABDU, Y.A., BALL, N.A., CERNY, P., HAWTHORNE, F.C. & KRISTIANSEN, R. (2012): Aspedamite, ideally $\square_{12}(Fe^{3+},Fe^{2+})_3Nb_4[Th(Nb,Fe^{3+})_{12}O_{42}]$ $\{(H_2O),(OH)\}_{12}$, a new heteropolyniobate mineral species from the Herrebøkasa quarry, Aspedammen, Østfold, southern Norway: description and crystal structure. *The Canadian Mineralogist* **50**, 793-804.

ESKOVA, E.M., DUSMATOV, V.D., RASTSVETAEVA, R.K., CHUKANOV, N.V. & VORONKOV, A.A. (2003): Surkhobite, $(Ca,Na)(Ba,K)(Fe^{2+},Mn)_4Ti_2(Si_4O_{14})O_2(F,OH,O)_3$, the new mineral (the Alai Ridge, Tadjikistan). *Zapiski RMO (Proceedings of the Russian Mineralogical Society)* **132 (2)**, 60-67.

GRICE, J.D. & KRISTIANSEN, R. (2013): Hydrogen in the gugiaite structure. *GAC-MAC Annual Meeting 2013, Winnipeg, Canada. Technical Program, Abstract.*
http://gac.esd.mun.ca/gac_2013/search_abs/sub_program.asp?sess=98&form=10&abs_no=12

GRICE, J., KRISTIANSEN, R., FRIIS, H., ROWE, R., SELBEKK, R.S., COOPER, M., LARSEN, A.O. & POIRIER, G. (2013) IMA 2012-039. *CNMNC Newsletter No. 15, February 2013*, page 2; *Mineralogical Magazine* **77**, 1-12.

HAWTHORNE, F.C., OBERTI, R., HARLOW, G.E., MARESCH, W.V., MARTIN, R.F., SCHUMACHER, J.C. & WELCH, M.D. (2012): Nomenclature of the amphibole supergroup. *American Mineralogist* **97**, 2031-2048.

KHOMYAKOV, A.P., CÁMARA, F., SOKOLOVA, E., ABDO, Y. & HAWTHORNE, F.V. (2011): Sveinbergeite, $Ca(Fe^{2+}_6Fe^{3+})Ti_2(Si_4O_{12})_2O_2(OH)_5(H_2O)_4$, a new astrophyllite-group mineral from the Larvik Plutonic Complex, Oslo Region, Norway: description and crystal structure. *Mineralogical Magazine* **75**, 2687-2702.

KOLITSCH, U., ANDRESEN, P., ANDERSEN HUSDAL, T., ERTL, A., HAUGEN, A., ELLINGSEN, H.V. & LARSEN, A.O. (2013): Tourmaline-group minerals from Norway, part II: Occurrences of luinaite-(OH) in Tvedalen, Larvik and Porsgrunn, and fluor-liddicoatite, fluor-elbaite and fluor-schorl at Ågskardet, Nordland. *Norsk Bergverksmuseum Skrift* **50**, 23-41.

KRISTANSEN, R. (2013): Surkhobitt fra Bratthagen i Lågendalen. *Norsk Bergverksmuseum Skrift* **50**, 89-92.

LARSEN, A.O. (ed.) (2010): *The Langesundsfjord.* Bode Verlag, Salzhemmendorf, Germany. 240 pp.

LARSEN, A.O. & ERAMBERT, M. (2010): Mosandritt og rinkitt fra nefelinsyenitt-pegmatitter i Langesundsfjordområdet. *Norsk Bergverksmuseum Skrift* **43**, 95-102.

LARSEN, K.E. (2012): Sveinbergeitt – et nytt mineral. *Stein* **39 (3)**, 4-5.

LARSEN, K.E. & KOLITSCH, U. (2011): An unique mineral suite in a syenite pegmatite at Virikkollen, Sandefjord, Larvik Plutonic Complex, Norway. *Norsk Bergverksmuseum Skrift* **49**, 35-44.

LARSEN, A.O., BERGE, S.A., ANDERSEN, F., LARSEN, K.E. & BURVALD, I. (2010): The minerals of the pegmatites in the Larvik plutonic complex. S. 64-222. I Larsen, A.O. (ed.): *The Langesundsfjord.* Bode Verlag, Salzhemmendorf.

McDONALD, A.M.., PETERSEN, O.V., GAULTS, R.A., JOHNSON, O., NIEDERMAYR, G., BRANDSTÄTTER, F. & GIESTER, G. (2001): Micheelsenite, $(Ca,Y)_3Al[PO_3OH,CO_3](CO_3)(OH)_6 \cdot 12(H_2O)$, a new mineral from Mont Saint-Hilaire, Quebec, Canada and the Nanna pegmatite, Narsaarsuup Qaava, South Greenland. *Neues Jahrbuch für Mineralogie, Monatshefte* **2001 (8)**, 337-351.

PIILONEN, P.C., McDONALD, A.M., POIRIER, G., ROWE, R. & LARSEN, A.O. (2012): The mineralogy and crystal chemistry of alkaline pegmatites in the Larvik Plutonic Complex, Oslo rift valley, Norway. Part 1. Magmatic and secondary zircon: implications for petrogenesis from trace element geochemistry. *Mineralogical Magazine* **76**, 649-672.

PIILONEN, P.C., POIRIER, G., ROWE, R. & LARSEN, A.O. (2013): Pyrochlore supergoup minerals from the alkaline pegmatites in the Larvik Plutonic Complex, southern Norway. *Norsk Bergverksmuseum Skrift* **50**, 63-81.

RASTSVETAEVA, R. K., ESKOVA, E. M., DUSMATOV, V. D., CHUKANOV, N. V., & SCHNEIDER, F. (2008): Surkhobite: revalidation and redefinition with the new formula, $(Ba,K)_2CaNa(Mn,Fe^{2+},Fe^{3+})_8Ti_4(Si_2O_7)_4O_4(F,OH,O)_6$. *European Journal of Mineralogy* **20**, 289-295,