New mineral discoveries from the Larvik Plutonic Complex, southern Norway

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Introduction

The Larvik Plutonic Complex (LPC) in Norway comprises a series of plutons mainly of monzonitic composition, formed during Permian rifting in the Oslo area in southern Norway. The monzonites host a large number of syenitic pegmatites known for their mineral diversity and in particular the many Be minerals (Larsen 2010). The most recent list has 226 unique mineral species including 26 Be- minerals (Larsen 2018). We here present seven additional species including trimerite, the 27th Be-mineral from the area, as well as chabazite-Na, chernovite-(Y), desclozite, ferriallanite-(Ce), segnitite and vanadinite.

Data were collected at NHM in Oslo and is stored on their computers and can be sent on request. "Pow_..." refers to X-ray powder patterns collected with the Gandolfi method on the single crystal diffractometer. EDS spectra were collected on unpolished material using SEM, and quantified without external standards. The analysed sample of chabazite-Na is in the collection of TH (sample number S-6.53); the three TH/SAB micromounts are in the collection of SAB.

Trimerite, $CaMn^{2+}_2Be_3(SiO_4)_3$

Trimerite was found in a single micromount specimen (sample TH/SAB 20), collected by SAB in the large pegmatite in the Saga I quarry, Mørje, Porsgrunn, in June 1982. It forms massive aggregates of pale yellowish brown plates covering an area of almost 1 x 1 cm in a porous matrix between crystals of analcime (Figs. 1a,b). Individual plates are up to 1 mm in largest dimension and display no external crystal forms. Associated and younger minerals are bertrandite, natrolite and some unidentified, black and white, powdery phases.

Trimerite was identified by EDS (T-38 9) giving (at.%): Si 11.5, Mn 7.6, Ca 3.36, Sr 1.21, Na 0.71. Its XRD pattern (Pow_285) is in good agreement with PDF 00-017-0477 (trimerite). Single-crystal data were collected from a small fragment using Cu$K\alpha$ radiation and refined to R_1 = 5.6% in the monoclinic space group $P2_1/n$ with a = 8.1033(1) Å, b = 7.6383(1) Å, c = 14.0761(1) Å and β = 90.002(1)°. The refinement of the Ca site occupancy indicates a mixed occupancy between Ca, Sr and Na resulting in a site occupancy of ($Ca_{0.6}Sr_{0.3}Na_{0.1}$). The Saga I pegmatite is the first locality of trimerite outside the Filipstad area, Sweden, and the material from Saga differs from the Swedish material in having a significant amount of Sr and Na replacing Ca, giving slightly larger unit- cell dimensions.


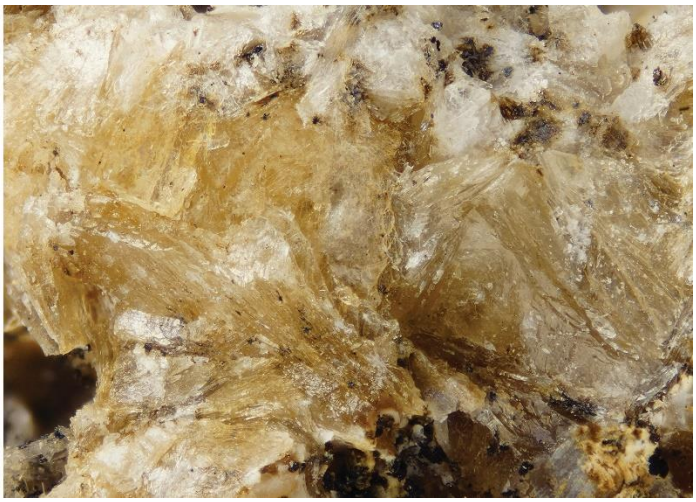

Fig. 1a (left). *The sample "TH/SAB 20" from the Saga 1 pegmatite. FOV 10.2 mm.*
Fig 1b (right). *Aggregates of brownish trimerite in sample "TH/SAB 20". FOV 3.53 mm.*
Both photos: OT Ljøstad.

Chabazite-Na, $(Na_3K)[Al_4Si_8O_{24}] \cdot 11H_2O$

The late Jens Andreas Larsen made a significant find of sphaerobertrandite in the Johs Nilsen quarry on 1 June 2014. Sphaerobertrandite forms white to beige, globular aggregates up to around 0.1 mm in size on rhombohedral calcite and acicular aegirine in cavities in analcime. Chabazite-Na, discovered by OTL, forms colourless pseudorhombohedra up to 0.03 mm in size on the surface of these aggregates (Fig. 2a), directly on the aegirine needles (Fig. 2b) or, in rare cases, on natrolite. Other minerals in this material are analcime, annite, a feldspar, fluorite, hambergite, and stilpnomelane. EDS of chabazite-Na (T-37 1) gives Na >> Ca > K, and an XRD powder pattern (Pow_759), although rather weak due to the small crystal size, is of the chabazite type. This is the first member of the chabazite group found in the LPC. Larsen made a smaller find of sphaerobertrandite in the Johs Nilsen quarry in February 2015, here associated with aegirine, analcime, arsenopyrite, calcite, chiavennite, epididymite, a feldspar, and zircon. Chabazite-Na does not occur in this material.

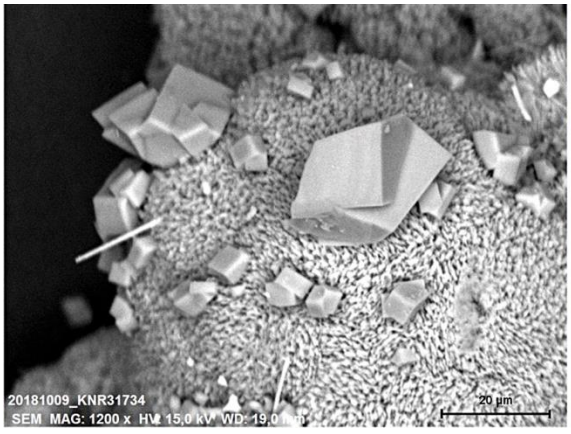

Fig. 2a (left). *SEM-photo of pseudorhombohedral chabazite-Na on globular sphaerobertrandite. Johs Nilsen quarry.*
Fig. 2b (right). *Aggregates of colourless chabazite-Na on acicular aegirine, Johs Nilsen quarry. FOV 0.97 mm. Photo: OT Ljøstad.*

Descloizite, $PbZn(VO_4)(OH)$

Descloizite was discovered by PA in AS Granit quarry, Tvedalen, Larvik, in 2005. The mineral forms aggregates (0.5 mm across) consisting of platy crystals. The colour is orange yellow and the aggregates are found on a feldspar fracture surface. On the same surface, but not in direct contact with the descloizite, is a zone rich in wulfenite. Associated with the descloizite are small fibres of vanadinite. The identification is based on the XRD pattern (Pow_790) and EDS, which gives an almost perfect stoichiometry for descloizite. This is the first find of descloizite in Norway. The sample is in the collection of the Natural History Museum in Oslo (k. nr. 44122).

Ferriallanite-(Ce), $CaCe(Fe^{3+}AlFe^{2+})[Si_2O_7][SiO_4]O(OH)$

A small micromount (TH/SAB34), collected by SAB in 1990 together with a small number of additional samples from pegmatite material at the Buer dump in Bjørkedalen, Porsgrunn, has aggregates of dark brown to black, prismatic crystals of ferriallanite-(Ce) up to 0.3 mm in size occurring in a cavity in microcline (Figs. 3a,b). Associated minerals in the cavity are albite, fluorapatite, two generations of zircon and a yellow helvine group mineral. Observed crystallization sequence is albite → zircon and "helvine" → ferriallanite-(Ce) → zircon → fluorapatite. EDS (T-38 27) of ferriallanite-(Ce) gives a rough composition of $LREE_{0.7}Ca_{1.2}Fe_{1.7}Mn_{0.3}Al_{1.1}Si_{3.0}O_{14}$, with Ce being the dominant LREE. The mineral can be classified as a manganoan ferriallanite-(Ce). The identity was confirmed by single-crystal XRD data using Mo*K*α radiation. The unit-cell parameters are: a = 8.9594(7), b = 5.7729(3), c = 10.2240(8), β = 114.72(1), $P2_1/m$, Z = 2. The refinement of the crystal structure (R_1 = 4.7%) indicates the following cationic repartition: $A1$ = Ca, $A2$ = $Ce_{0.63}Ca_{0.37}$, $M1$ = $Fe_{0.62}Al_{0.38}$, $M2$ = Al, and $M3$ = Fe, thus giving the ideal structural formula $CaCe(FeAlFe)[Si_2O_7][SiO_4]O(OH)$. These data are in agreement with the description of ferriallanite-(Ce) (Kartashov *et al.* 2002).

Fig. 3a (left). *Dark brown crystals of ferriallanite-(Ce) with colourless prisms of fluorapatite, white zircon and a yellow crystal of a helvine group mineral. Sample "TH/SAB 34" from Buer, Bjørkedalen, Porsgrunn. FOV 0.88 mm. Photo: OT Ljøstad.*
Fig. 3b (right). *SEM-photo of ferriallanite-(Ce) from Buer, Bjørkedalen. This is the same aggregate as in Fig. 3a.*

Segnitite, $PbFe^{3+}_3(AsO_4)(AsO_3OH)(OH)_6$, and chernovite-(Y), $Y(AsO_4)$

Both minerals occur intimately intergrown, associated with altered arsenopyrite in the Jahren pegmatite at Jahrehagen cottage grounds, Stavern, Larvik, in material collected by PA. They form crystalline crusts up to 0.5 mm^2 that are white to yellowish in colour and have been identified by their XRD patterns (Pow_811+812). Segnitite is closely related to beudantite, but the EDS analyses gave Pb:As:Fe = 0.87:2.15:2.98 and no S, confirming the identification. This is the second Norwegian find of segnitite, after the Hellemobotn pegmatite (Husdal 2019). There are other secondary minerals occurring on the altered arsenopyrite, but only wulfenite has so far been identified. Arsenopyrite is not an abundant mineral in the pegmatite, and in this part it is always partly to completely altered. Other yttrium bearing minerals in this part of the pegmatite are xenotime-(Y) and a mineral probably related to or belonging to the rhabdophane group. These minerals are of secondary origin and related to hydrothermal alteration of the pegmatite. The primary source of yttrium is not known. Other associated minerals are eudidymite, epididymite, zektzerite, zircon, aenigmatite, brookite and aspedamite or an aspedamite-like mineral (Andresen *et al.* 2018). The analysed micromount sample is in the collection of PA.

Vanadinite, $Pb_5(VO_4)_3Cl$

A small micromount (TH/SAB 26), collected by SAB in the Tuften quarry, Tvedalen. Larvik, in 1985/86, has a cavity with a small area of radiating aggregates of yellow needles up to 0.1 mm in length (Fig. 4). EDS (T-35 136) gives Pb:V:Cl = 4.94:3.00:0.69 which, combined with the hexagonal cross section of the crystals, supports the conclusion that the mineral is vanadinite. This is the first mineral with significant V found in the LPC. Associated minerals are analcime and greyish, tetragonal bipyramids visually identified as wulfenite. Some small fragments of galena are present in the sample, seemingly remnants of a larger crystal and most likely the source of Pb in vanadinite and wulfenite. The pegmatites in the LPC are known for abundant molybdenite, which is believed to be the source of Mo in wulfenite. The source of V in vanadinite is uncertain. Vanadinite has also been found associated with descloizite from AS Granit (see descloizite description above for details). At AS Granit the vanadinite forms faint yellow fibres with a hexagonal cross section andEDS revealed approximately 10 % As substituting for V.

Fig. 4). *Vanadinite with analcime from the Tuften quarry, sample "TH/SAB 26". FOV 0.62 mm. Photo: OT Ljøstad.*

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