Sillimanite in a granite pegmatite at Evje, Aust-Agder

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Introduction

The hundreds of pegmatites within the Iveland-Gautestad metagabbroic complex, previously called the Iveland-Evje amphibolite (Barth 1947), are worldwide known as host of a large number of accessory minerals (Andersen 1931b, Barth 1931, Bjørlykke 1935, Bjørlykke 1939, Hansen 2001, Iveland Bygdesogenemd 2007). In 2013 relatively large samples of an unidentified mineral was found by A. Haugland and later sent to Geological Museum in Oslo for identification. It was identified as sillimanite, and obviously pseudomorphs after a precursory mineral. Bluish and black particles within the sillimanite masses were identified (by AOL) using PXRD as corundum + diaspore and magnetite, respectively. Bundles and needles of sillimanite in granite pegmatites have previously been described from pegmatites of anatectic origin in the Bamble Sector where the pegmatites may reflect the mineralogy of their Al-rich host rocks (Andersen 1931a, Bugge 1943, Starmer 1976). Sillimanite pseudomorphs, however, have never before been observed in a Norwegian granite pegmatite and this fact prompted the following investigation in order to shed light on this unusual occurrence. Based on the morphology of the pseudomorphs and their mineral assemblage andalusite seems to be a likely candidate as the primary mineral.

Fig. 1. The pegmatite quarry at Smænelia, Åneland, Evje, October 2014. Photo: AOL.

The pegmatite and its minerals

The pegmatite quarry (Fig. 1), mentioned as Åneland II by Andersen (1931b), is situated at Smænelia (N58.58710, E7.85627), 800 m NNW of Åneland and about 3 km E of the Evje village. Feldspar quarrying at the site started up in the late 1920's, but was closed down about 1930-31. The present landowner resumed quarrying about the year 2000. Apart from a couple of years in halt, the operation has continued till present time delivering feldspars for ceramic production abroad. The quarry is an open pit stretching E-W, about 40 m long and 15 m wide. The pegmatite is a dike with an E-W strike and a 45° fall towards N. Within the quarry the width of the dike varies from a couple of metres in the eastern part (possibly pinching out further east) to several metres in the mid part. The dike seems to end abruptly in the westernmost part of the quarry. The pegmatite is situated within the gabbroic rocks.

The pegmatite shows signs of having been subject to tectonic stress and alteration; the main minerals are heavily cracked and chloritization is frequently present. The pegmatite has a fine-grained border zone, which inwards changes into graphic granite with varying degree of grain size, both of the combinations quartz and K-feldspar as well as quartz and plagioclase. These zones may be up to a metre in thickness. Scattered in the fine grained zones are chloritized biotite flakes up to several cm across. The main minerals of the central part of the pegmatite are quartz and a pale reddish, mottled K-feldspar, which occurs in masses and crystals up to a couple of metres in size. The central part of the pegmatite consist of a mass of quartz several metres across. White plagioclase is a subordinate mineral in the coarse part of the pegmatite. Accessory minerals include a dark reddish brown garnet of the almandine-spessartine series and occur as dodecahedra up to 5 cm across. The crystals frequently contain very fine platy muscovite both inside as well as on the surface. Primary muscovite as coarsely crystalline masses, partly chloritized, occurs only rarely in the pegmatite. Epidote with transition to clinozoisite is found as locally concentrated masses. Allanite-(Ce) as acicular crystals a few cm long and a sparse, yellow crust of a secondary uranium mineral have been found as rarities. Vugs containing centimeter-sized quartz crystals, albite crystals, stilbite and chlorite are known from the locality.

The sillimanite pseudomorphs

The sillimanite pseudomorphs have been found at a few places in the coarse, intermediate part of the pegmatite. Several crystals always occur concentrated together, usually in more or less divergent fans (Fig. 2). The grayish pseudomorphs are up to 20 cm in length and 5 cm wide and occur as tapering, anhedral to subhedral crystals, which internally are coarsely acicular. A square to slightly rhombic cross section is often discernible. The pseudomorphs are rimmed by muscovite.

Microscopically multiple generations of sillimanite are identified, as illustrated in Figs. 3 and 4. The optically continuous, coarser grained sillimanite generation seems to have undergone recrystallization, commonly exhibiting multiple nuclei with darker fibrous centers of a yet unidentified mineral phase (Fig. 5), and in part recrystallized to form fibrolitic patches (Fig. 6). The contact between the sillimanite and surrounding pegmatitic feldspar (Kfs) crystals are all rimmed by muscovite and/or chlorite (Fig. 7). Euhedral royal blue corundum (var. sapphire) and anhedral diaspore crystals are found in subordinate quantities frequently embedded in a muscovite-rich matrix (Fig. 8).

Fig. 2. Grayish sillimanite pseudomorphs. Field width appr. 25 cm. Photo: AOL.

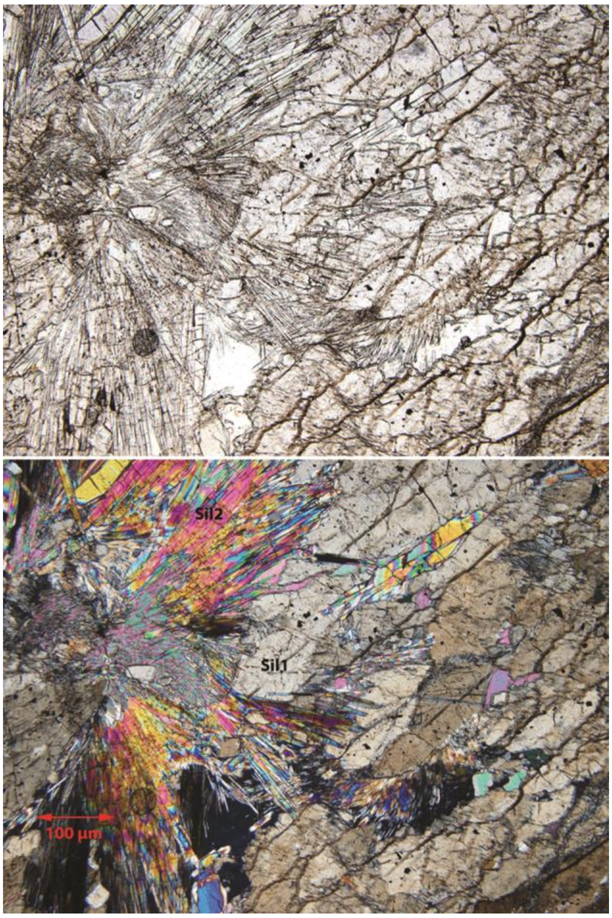

Fig. 3. Representative texture consisting of early coarse grained sillimanite (Sil1) and late, recrystallized fibrous sillimanite (Sil2). Transmitted light and crossed polarized light images. Photo: JBK.

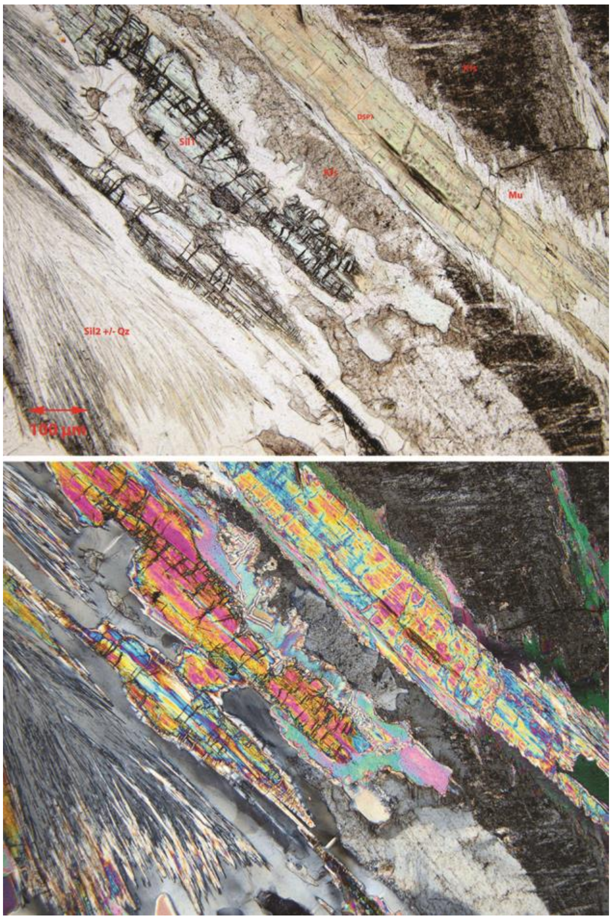

Fig. 4. Resorbed coarse grained sillimanite (Sil1), potassium feldspar (Kfs) and diaspore (Dps) partially replaced by muscovite (Mu), quartz and fibrous quartz/Sillimanite intergrowths. Transmitted light and crossed polarized light images. Photo: JBK.

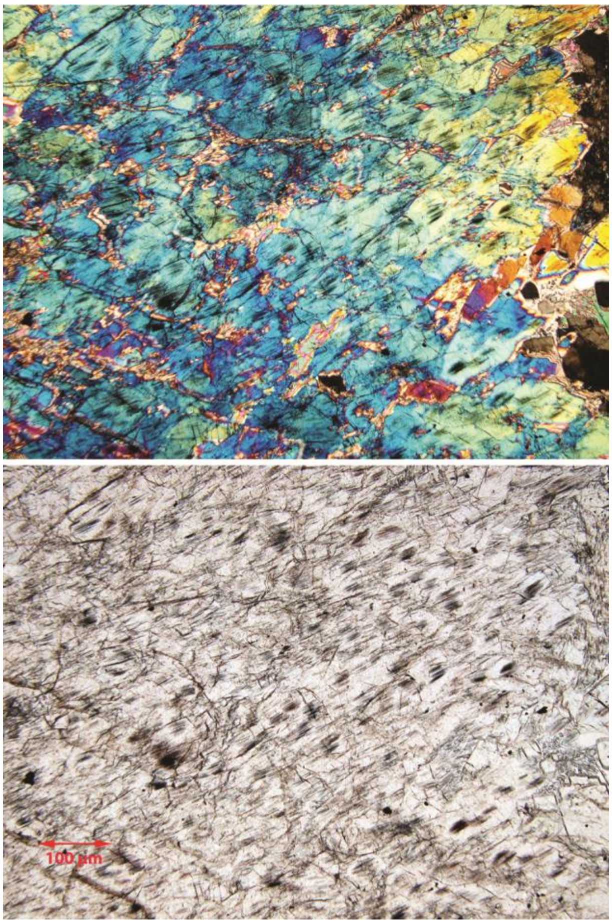

Fig. 5. Overview of optically continuous large patches of coarse grained sillimanite, where the cores of single grains exhibit signs of fibrous sillimanite recrystallization, more or less also in optical continuity. Transmitted light and crossed polarized light images. Photo: JBK.

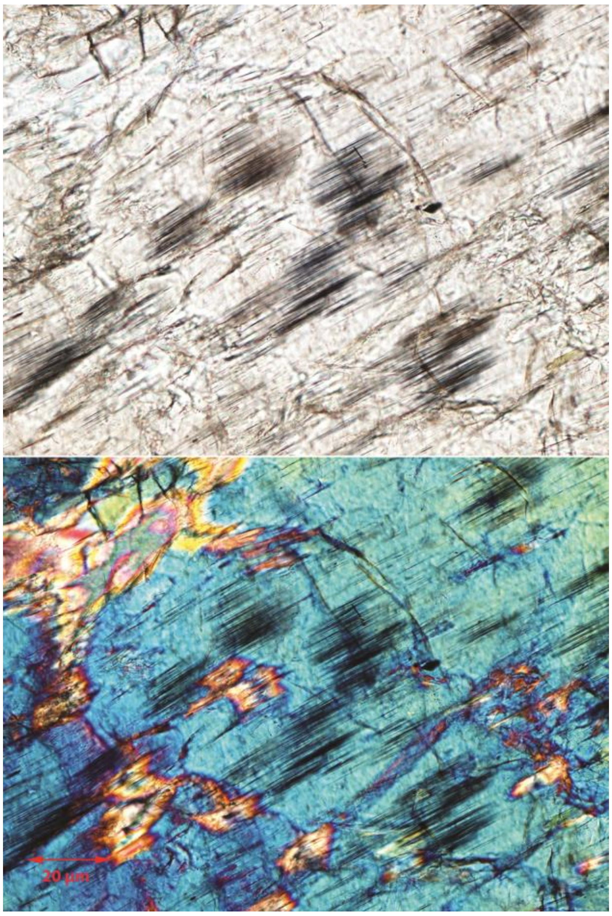

Fig. 6. Close-up of Fig. 4. Transmitted light and crossed polarized light images. Photo: JBK.

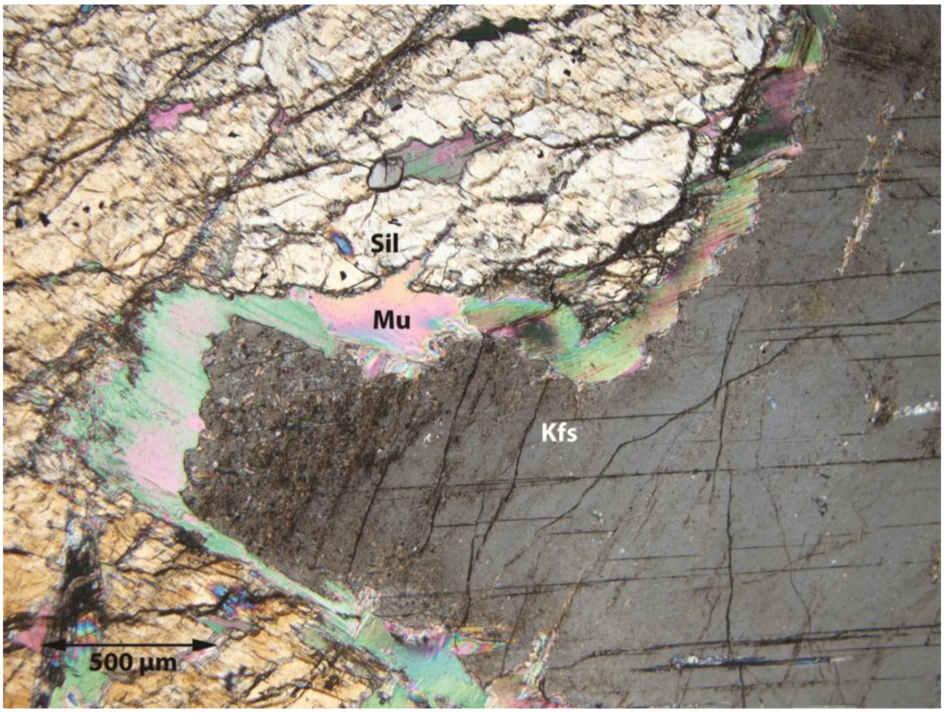

Fig. 7. Contact between coarse grained pegmatitic potassium feldspar (Kfs) and coarse grained optically continuous sillimanite, the border of which consists of a thin muscovite (Mu) rim. Crossed polarized light image. Photo: JBK.

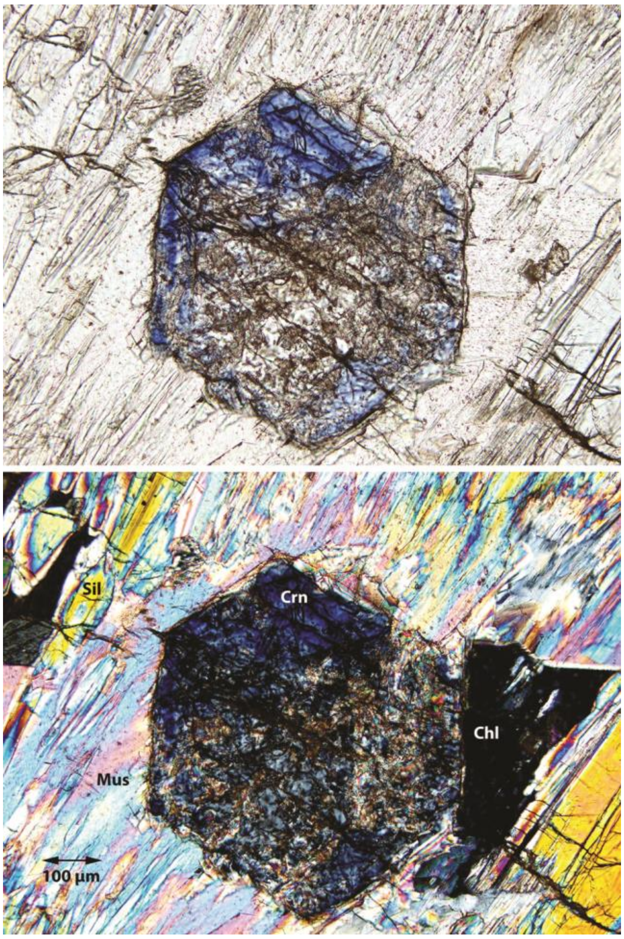

Fig. 8. Euhedraly shaped corundum (Crn) grains (var. sapphire) in a setting of muscovite (Mu), sillimanite (Sil) and chlorite (Chl). Rims are slightly enriched in Fe and Ti. Transmitted light and crossed polarized light images. Photo: JBK.

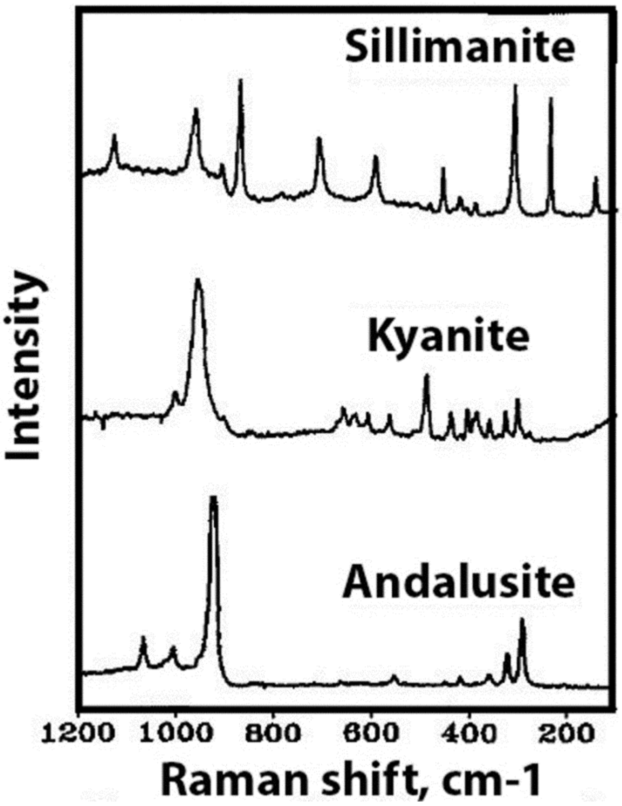

Fig. 9. Representative non-destructive micro Raman-scattering spectra of the three Al_2SiO_5 polymorphs revealing unique fingerprints of each species. Courtesy of Mernagh, T.P & Liu, L.G (1991).

Though no optical verification of a possible andalusite precursor has been identified, the presence of minor andalusite is not excluded; the application of non-destructive FTIR-Raman micro-spectroscopy mapping (Kihle & Johansen 1993, and references therein), would readily discern any andalusite from silllimanite (Mernagh & Liu 1991) based on significantly different Raman scattering spectra of these two aluminum silicate polymorphs (Fig. 9).

Acknowledgement

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References

Andersen, O. (1931a): Discussions of certain phases of the genesis of pegmatites. *Norsk Geologisk Tidsskrift* **12**, 1-56.

Andersen, O. (1931b): Feltspat II. Forekomster i fylkene Buskerud og Telemark, i flere herreder i Aust-Agder og i Hidra i Vest-Agder. *Norges Geologiske Undersøkelse* **128b**, 1-109.

Barth, T.F.W. (1931): Feltspat III. Forekomster i Iveland og Vegusdal i Aust-Agder og i flere herreder i Vest-Agder. *Norges Geologiske Undersøkelse* **128b**, 111-154.

Barth, T.F.W. (1947): The nickeliferous Iveland-Evje amphibolite and its relation. *Norges Geologiske Undersøkelse* **168a**, 71 pp.

Bjørlykke, H. (1935): The mineral paragenesis and classification of the granite pegmatites of Iveland, Setesdal, southern Norway. *Norsk Geologisk Tidsskrift* **14**, 211-311.

Bjørlykke, H. (1939): Feltspat V. De sjeldne mineraler på de norske granittiske pegmatittganger. *Norges Geologiske Undersøkelse* **154**, 78 pp.

Bugge, J.A.W. (1943): Geological and petrographical investigations in the Kongsberg-Bamle formation. *Norges Geologiske Undersøkelse* **160**, 150 pp.

Helvig Hansen, G. (2001): *Mineralene i Evje-Iveland*. Private publication. 84 pp.

Kihle, J. & Johansen, H. (1994): Low temperature isothermal trapping of hydrocarbon fluid inclusions in synthetic crystals of KH_2PO_4. *Geochimica et Cosmochimica Acta* **58**, 1193-1202.

Iveland bygdesogenemd (2007): Minerala i Iveland. *In* Iveland bygdesogenemd: *Iveland V. Gruvedrift*. 332-370.

Mernagh, T.P & Liu, L.G. (1991): Raman Spectra from the Al_2SiO_5 polymorphs at high pressures and room temperature. *Physics and Chemistry of Minerals* **18**, 126-130.

Starmer, I.C. (1976): The early major structure and petrology of rocks in the Bamble Series, Søndeled-Sandnesfjord, Aust-Agder. *Norges Geologiske Undersøkelse* **327**, 77-97.