# The emerald deposit at Byrud, Eidsvoll, South Norway

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## Introduction

In Scandinavia, just one occurrence of emerald has been mined, located at the Byrud farm on the shore of Lake Mjøsa near Minnesund in Eidsvoll, about 70 km north of Oslo. The deposit was worked by an English company around 1900, and even today collectors are able to find good specimens.

## History

The initial discovery of the emerald occurrence is not documented, but it probably took place some time in the 1860s. In the collection of the Swedish Natural History Museum in Stockholm, five catalogue numbers are registered in 1868, comprising two samples of fetid quartz and seven pieces with translucent crystals of green beryl (emerald). At a later stage, the name Gustaf Nauckhoff (1847-1919) is written on the labels.

In the collection of the Geological Museum in Oslo, there are four old boxes with green, non-translucent beryl crystals from Byrud, in which the labels say that they were gifts to the museum from Elling Gjethus in 1869. The Natural History Museum in London has one beryl specimen from 1870 and four from 1871, all purchased from the mineral dealer Dr. A. Krantz in Germany.

Preliminary prospecting and blasting were performed around 1880 (Bull 1952). (Maud) Evelyn Aston (1877-1978) inspected the emerald occurrence on a ski tour on Lake Mjøsa in November 1898. She had recently followed courses in geology and mineralogy in England. From her description the prospect had at that time an opening of two meters in height and one meter in width, and inside was a semi-circular gallery, about 3.5 meters in diameter with a quite good height to the roof (Cameron 1963). She hammered out a specimen with an emerald crystal. At her next visit she brought a miner who blasted a little, and they found gem emerald crystals in small clay-filled pockets, which she soon after showed to the well-known goldsmith David Andersen in Oslo, who bought the crystals.

Evelyn's father, the English mining prospector Edward Yates Aston (1848-1900), who at the time worked at the nearby Eidsvoll gold mines, bought the emerald prospect, called Narum, and a small property where the prospect was located from Ole P. Byrud on 5 April 1899 for 5,000 Norwegian kroner. Public concession for the property transaction was given on 1 May 1900.

A London based company was established: "The Norwegian Exploration Company, Limited." Registered on 9 May 1899, with a nominal capital of 120,000 shares at one pound each, the company bought properties and rights for £80,000, of which at least £60,000 should be paid in shares. The emerald occurrence was the main property, but other prospects were also included in the purchase. After excluding the other prospects as worthless, the company was in June 1900 named The Norwegian & General Exploration Company, Limited, and the capital reduced to £95,000. At the first ordinary general assembly on 22 September 1899, Edward Y. Aston owned 20,200 shares, his wife Emma Jane Aston 5,000 shares and seven other members of the Aston family 1,000 shares each.

Most other shareholders were English, although a few German shareholders from Frankfurt am Main are recorded.

Edward Y. Aston died on 21 September 1900 at Evje in Setesdal. At a general assembly in June 1904, the deceased Edward Y. Aston was still registered with 1,000 shares, while Emma Jane had 100 shares and three other members of the Aston family 50, 500 and 1,000 shares, respectively. At an extraordinary general assembly on 28 December 1907, the Company's assets were sold to The Cornish Development Company, Limited, and the Company liquidated. The mine was abandoned in 1909.

In the first years, up to 30 miners were at work, lead by the English mining engineer Arthur Dickinson (born 1869). In the beginning they seem to have found quite a number of gemmy emeralds. An exhibit of gems and specimens was made at the Paris World Exposition in 1900. "Many cut stones, most of them pale in colour, but generally free from flaws, were shown." (Kunz 1902). In 1902, emeralds for 50,000 Norwegian kroner were obtained in one single find, according to the newspaper Romerike Blad. Quite soon, however, the amount of gemmy emeralds decreased, and at the end of the 10-years mining period, only nine miners were employed. The mine seems not to have been profitably worked, not even during the first years. However, the shareholders were informed that the emeralds might generally become darker green, and therefore more valuable, the deeper the mine became.

The Geological Museum in Oslo has a few emerald specimens received as a gift from Mrs Emma Jane Aston on 8 February and 5 July 1903. Professor W.C. Brøgger also received a single crystal for his private collection in 1903 (later purchased by the Geological Museum). Mrs Aston donated three emerald matrix specimens to Bergen Museum in 1909. Emeralds were also donated to Bergen Museum from her estate, after she died 18 June 1915.

A cut emerald is said to have been used in a jewel belonging to the royal family of Great Britain, possibly made in connection with the crowning of King Edward VII in 1902. A great deal of the production was apparently sold to buyers in Turkey and India. Documentation of the emerald sales have, however, not been found.

A crusher, a washery, a blacksmith's forge, an administration building and a small atelier with glass walls, where the emeralds were measured, are said to have been built at the mine, but building remains are scarcely preserved today.

Websky (1876) described the morphology of beryl crystals from Eidsvoll and tells that emerald-green beryl from the occurrence was commercially available. His investigated specimens were provided from "der Niederlage von Pech in Berlin" (from the stock of the mineral dealer C.F. Pech, Berlin). The occurrence is also briefly mentioned by Kjerulf (1879), Vogt (1884), Hintze (1897), Kunz (1902) and Beyschlag, Krusch and Vogt (1909), and is described in some more detail by Goldschmidt (1911). More recent, short descriptions are those of Selset (1963), Wilke (1976) and Werner (1995). Kvamsdal (1995) published a list of minerals from Byrud. Historical accounts on the discovery of the emeralds and the mining history are those of Bull (1952), Cameron (1963), Lindaas (1982) and Saltnes (1998).

It is remarkable that no modern, scientific investigations of the geology and geochemistry of the Byrud occurrence have been undertaken. However, the mineralogy at Byrud has been extensively studied at the Geological Museum in Oslo by G. Raade in cooperation with the late mineral collector Jan Haug. A total of 45 different minerals from the Byrud occurrence can be found in the appended list.

## Geology

The emerald-bearing rocks are located in the north-eastern part of the Oslo region, a rift structure of Permian age. At Byrud, flat lying maenaite (syenitic) sills, usually from 0.5 to several meters thick, are transecting Cambrian alum shales (black shales) over a distance of about 200 m. The sills are often quartz-rich along the borders (Ihlen 1978), the quartz often occurring as smoky quartz. The sills are gently dipping 15-20° to the west or may be nearly horizontal. They occur in at least three levels and have been intruded by pegmatites, which also may occur in the alum shales. Close to the pegmatites, the alum shales are often bleached. The pegmatites usually are from a few centimetres up to 30 cm in thickness, but may locally reach up to one meter. They appear as lenses or dykes which are often not continuous and have variable thickness. They often contain small cavities. The pegmatites have an alkali syenitic composition, consisting mainly of K-feldspar (microcline), and were intruded in Permian time during a period of alkaline magmatic activity in the area (Ihlen 1978). A large alkaline granite intrusion occurs not far to the west of Byrud, and the formation of the pegmatites are probably associated with this intrusive. Mining operations have taken place along the maenaite sills at different levels. Beryl occurs chiefly in the pegmatites, occasionally also in the maenaites and the black shales adjacent to the pegmatites. The best quality emeralds were found in the northern part of the area, and they were apparently found in small clay-filled pockets.

In addition to the main mineral microcline, quartz and muscovite are also frequently present, and albite, pyrite, pyrrhotite, fluorite, topaz and beryl are quite common in the pegmatites. Several minerals have been observed in small quantities (see the mineral list).

## Minerals

*Beryl (emerald)*

Green beryl is common in parts of the pegmatites, embedded most often in feldspar but also in quartz, in pyrrhotite, and in fluorite. Beryl is also reported from the syenite dykes and the alum shales close to the pegmatite dykes. The emerald colour is variable, commonly quite light green, but quite often darker grass green. Some of the beryl occurring in feldspar, and especially quartz, show well-developed crystal shape. Crystals within quartz have often a faint bluish tint compared with the ones in feldspar. Crystals up to 6 cm long and 2 cm wide have recently been found. They are usually non-transparent or translucent, although gemmy parts of crystals may occur. Some crystals have a lighter core, and in some cores topaz is present. Greyish yellow beryl is not uncommon.

Transparent crystals, mostly as tiny needles up to 2 cm long and 2 mm wide with light green colours, occur in small cavities. A few crystals are, however, nearly colourless and some are darker green. Gemmy crystals up to 0.7 cm in width and 1 cm in length have been found by collectors in recent years. Many gemmy crystals seem to be completely free of flaws. Some small stones have been cut and quite a number of cabochons have been made in recent years. No information about the number and sizes of crystals and cut stones produced during the years of mining has been found.

Analyses show that the grass green colour of the emeralds quite clearly is caused by minor amounts of vanadium and chromium, which were leached out from the alum shales by hydrothermal alteration and assimilation (Goldschmidt 1954). It is important to note that the Byrud emeralds are characterized by high levels of vanadium and lesser amounts of chromium.

The earliest trace-element studies of emerald from Byrud were reported as follows (in wt.%):

0.01 $Sc_2O_3$ (Goldschmidt and Peters 1931b) and 0.001 $Ga_2O_3$ (Goldschmidt and Peters 1931a); 0.1 $Cr_2O_3$ and 0.9 $V_2O_3$ (Goldschmidt 1954). More recent data are tabulated below in wt.%:

| | Durán (1982) * | Schwarz (1991) |
|---|---|---|
| $Cr_2O_3$ | 0.12-0.35 | 0.10-0.32 |
| $V_2O_3$ | 0.74-1.61 | 0.88-1.53 |
| FeO | 0.10-1.13 | 0.10-0.18 |
| MgO | 0.11-0.12 | 0.07-0.11 |
| $Na_2O$ | 0.01-0.02 | 0.06-0.10 |

* Recalculated from wt.% elements by the present authors.

Refractive indices and density were published by Durán (1982): ω 1.567 to ε 1.572, 1.561 to 1.567, *D*(meas.) 2.678 to 2.682 g/cm$^3$. Stable-isotope data of oxygen in the beryl and heavy hydrogen (D) of $H_2O$ in the structure channels are, respectively: $\delta^{18}O_{SMOW}$ 9.4 and 9.6 ‰, $\delta D_{SMOW}$ (channel) -40.8 and -37.8 ‰, and the $H_2O$ content in the structure channels is 1.10 wt.% (Groat et al. 2002).

The morphology of emerald crystals from Byrud was studied by Websky (1876) and Goldschmidt (1911), the former reporting a number of uncommon crystal forms. Goldschmidt observed the following forms: {10-10}, {11-20}, {0001}, {20-21}, {11-21} and {31-41}. None of them provides a crystal drawing, and their morphological axial ratio of *a*:*c* ~ 1:0.5 is not in accordance with the structural axial ratio of *a*:*c* ~ 1:1.

*Topaz*
Small white to colourless crystals of topaz are sometimes found in the cavities. Transparent crystals rarely exceed 0.5 cm. From cut slices of the pegmatite, non-transparent, light greyish yellow crystals up to 5 cm are visible, often perched on quartz and cemented in quartz and microcline. Two crystal drawings of topaz from Byrud are presented by Goldschmidt (1911) (Fig. 1).

*Fluorite*
Fluorite is common, mostly found as small anhedral, dark lilac specks, but some appears as pale green aggregates and more or less developed octahedrons up to 0.5 cm in small cavities.

*Apatite*
Bluish apatite crystals are sometimes found in small cavities. The crystals are usually of micro size. Fine crystals up to 0.65 cm long and 0.85 cm in diameter have been reported.

*Vesuvianite*
Bundles of elongated, light brown crystals up to 1 cm in length and 1-2 mm in width have rarely been found in cavities, occurring within aggregates of the same mineral. Electron-microprobe analyses gave the composition
$Ca_{18.0}(Al_{9.0}Mg_{1.5}Fe_{1.1}Ti_{1.0}Mn_{0.1})_{\Sigma 12.7}Si_{17.4}O_{68}(O,OH)_{8.4}F_{2.0}$ (Eldjarn et al. 2005).

*Laumontite*
Small, white crystals and fan-shaped crystal aggregates of laumontite are quite common in small cavities. Most fan-shaped crystal aggregates earlier thought to be bavenite are actually laumontite (Ellingsen 2003).

*Gersdorffite, rutile ("ilmenorutile"-"strüverite") and titanite*
Micro crystals of rutile are common, micro crystals of gersdorffite are very rare and micro brownish spherical aggregates of titanite are rare. Crystals of other micro minerals are very rare.

*Microcline*, *quartz* and *muscovite* are very common and *albite* relatively common. The three former are also often found as crystals in the small cavities, but rarely of good quality.
*Pyrite, pyrrhotite* and greyish yellow *beryl* are quite common.

Of the secondary minerals, *goethite* and *jarosite* are very common, while *gypsum* is common and *opal* and *sulphur* quite rare.

## Collecting possibilities

Many geologists and collectors have visited the deposit, especially from the 1970s. A large number of emerald crystals have been found, also many small and gemmy crystals. For many years, collectors have had to pay a small fee for a day's mineral hunt (now about 10 €). A few years ago, the couple Anne Grethe Røise and Ole Jørgen Bjørnstad, who now own the farm Byrud and the emerald deposit, started a more active commercial use of the mine. They are advertising the mine and have printed small pamphlets. Usually in the spring, they turn around some of the gravel at the mine dumps. Fine specimens have been found in the springtime of the last 10-15 years, but the chances of making good finds are gradually decreasing, and quality specimens are now very difficult to discover. Coffee, cakes, minerals and local handicraft are for sale at the farm during the summer season.

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## Literature

BALIĆ-ŽUNIĆ, T. & RAADE, G. (2003): The crystal structure of kyzylkumite, $BeV_2TiO_6$. *Abstracts, 21st European Crystallograhic Meeting (Durban, South Africa)*, 145.
BEYSCHLAG, F., KRUSCH, P. & VOGT, J.H.L. (1909/1914): Die Lagerstätten der nutzbaren Mineralien und Gesteine, I. Band. Stuttgart, Ferdinand Enke. 446/511.
BULL, E. (1952): Eidsvoll bygds historie. Volume 1, Part 2, 537.
CAMERON, E.A. (1963): Skattejaktminner fra Minnesund. *Kvinner og Klær*, Nr. **40**, 33 and 54.
DURÁN, R.M. [MÖLLER, R.] (1982): Estudio colorimétrico de las variedades verdes de berilo – esmeralda. Thesis, Universitat de Barcelona, 434 pp.
ELDJARN, K., KVAMSDAL, L.O., SELBEKK, R. & MULLER-SIGMÜND, H. (2005): Norske vesuvianer og vesuvianforekomster. *Norsk Bergverksmuseum, Skrift* **30**, 30-40.
ELLINGSEN, H. V. (2003): Bavenitt fra Byrud. *Stein* **30(2)**, 23.
GOLDSCHMIDT, V.M. (1911): Die Kontaktmetamorphose im Kristianiagebiet. *Videnskapsselskapets Skrifter, I. Mat.-naturv. klasse*, Nr. **1**, 56 and 357-358.
GOLDSCHMIDT, V.M. (1954): Geochemistry (ed. A. Muir). Oxford at the Clarendon Press, 730 pp.
GOLDSCHMIDT, V.M. & PETERS, C. (1931a): Zur Geochemie des Galliums. *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen. Mathematisch-Physikalische Klasse*, 165-183.
GOLDSCHMIDT, V.M. & PETERS, C. (1931b): Zur Geochemie des Scandiums. *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen. Mathematisch-*

*Physikalische Klasse*, 257-279.
GROAT, L.A. et al. (plus 14 authors) (2002): Mineralogical and geochemical study of the Regal Ridge emerald showing, southeastern Yukon. *Canadian Mineralogist*, **40**, 1313-1338.
HINTZE, C. (1897): Handbuch der Mineralogie, B. II, 1286.
IHLEN, P.M. (1978): Ore deposits in the north-eastern part of the Oslo region and in the adjacent Precambrian areas. In E.-R. Neumann & I.B. Ramberg (eds.), Petrology and geochemistry of continental rifts. Proc. NATO Advanced Study Institute. Oslo 1977. Reidel, Dordrecht. 277-286.
KJERULF, TH. (1879): Udsigt over det sydlige Norges geologi. Christiania. 185.
KUNZ, G.F. (1902): Precious stones. Geological Survey. Mineral resources of the U.S. 1901, 729-771.
KVAMSDAL, L.O. (1995): Smaragd – Byrud. Stein, **22 (4)**, 193.
LINDAAS, K.D. (1982): Gruvedrift etter smaragd på Byrud, Minnesund. *Romerike historielag. Årbok 1982*, 90-93.
RAADE, G. & BALIĆ-ŽUNIĆ, T. (accepted for publication in Canadian Mineralogist 2005): The crystal structure of $(Be,\square)(V,Ti)_3O_6$, a mineral related to kyzylkumite.
SALTNES, D. (1998): Fant smaragdene på skitur for hundre år siden. *Eidsvold Blad*, 7. Februar 1998.
SCHWARZ, D. (1991): Die chemischen Eigenschaften der Smaragde II. Australien und Norwegen. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **40**, 39-66.
SELSET, R. (1963): Emerald locality on Mjøsa lake, Norway. Rocks and Minerals, **38**, 608-609.
VOGT, J.H.L. (1884): Undersøgelser ved den sydlige del af Mjøsen i 81 og 82. *Nyt Magazin for Naturvidenskaberne*, **28**, 215-248.
WEBSKY, M. (1876): Ueber Beryll von Eidsvold in Norwegen. *Tschermaks Mineralogische Mitteilungen*, **6**, 117-118.
WERNER, R. (1995): De smaragd-mijnen van Byrud. *GEA*, **28**, 54-56.
WILKE, H.J. (1976): Mineral-Fundstellen, Band 4, Skandinavien. Chr. Weise Verlag, München. 117-118.

**Mineral list** (* X-ray powder-diffraction identification; ** SEM/EDS identification)

| | |
|---|---|
| Albite | Common |
| Andalusite | Occurs in the alum shale |
| Apatite * | Rare |
| Bavenite * | Rare |
| Beryl * | Common |
| Brannerite ** | One microscopic grain identified |
| Calcite | Very rare |
| Diopside * | Very rare |
| Epidote * | Very rare |
| Fluorite * | Common |
| Galena | Very rare |
| Gersdorffite * | Very rare |
| Goethite | Relatively common |
| Graphite | Occurs in the alum shale |
| Grossular * | Rare |
| Gypsum * | Common secondary product |
| Illite * | Very rare |
| Jarosite | Common secondary product |
| Laumontite * | Relatively common |
| Lepidolite $2M_2$ * | Very rare |
| Marcasite * | Very rare |
| Microcline | Main mineral |
| Molybdenite | Rare |
| Monazite * | Very rare |
| Montmorillonite * | Very rare |
| Muscovite 1M * and 2M * | Common |
| Opal (var. hyalite) | Rare |
| Orthoclase * | Rare |
| Phlogopite * | Very rare |
| Pyrite | Relatively common |
| Pyrrhotite * | Common |
| Quartz * | Very common |
| Rutile ("ilmenorutile"-"strüverite") * | Common |
| Siderite | Very rare |
| Sphalerite | Very rare |
| Sulphur * | Rare, secondary after sulphides |
| Thorianite * | Very rare |
| Thorite * | Very rare |
| Titanite * | Rare |
| Topaz * | Common |
| Tourmaline * | Rare |
| Tremolite * | Rare |
| Vesuvianite * | Rare |
| Wollastonite * | Occurs in the alum shale |
| Unnamed $(Be,\square)(V,Ti)_3O_6$ * [1)] | Very rare |

[1)] Balić-Žunić and Raade (2003); Raade and Balić-Žunić (accepted 2005)

Edward Yates & Emma Jane Aston in 1900. Photo Finnes.

(Maud) Evelyn Aston Cameron, probably photographed 27 October 1900 in Canada.