



FRAME

FORECASTING AND ASSESSING EUROPE'S
STRATEGIC RAW MATERIALS NEEDS

WP7 Historic Mine Sites revisited

Case Study

The Røros Mines, Norway

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(photo: Terje Bjerkgård, NGU)



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FRAME

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STRATEGIC RAW MATERIALS NEEDS

Table of Contents

1	Introduction	4
1.1	Storwartz ore field.....	4
1.1.1	Geological Setting.....	5
1.1.2	Mining History and raw material potential	6
1.1.3	New investigations	6
1.2	Nordgruve ore field.....	7
1.2.1	Geological Setting.....	7
1.2.2	Mine History and raw material potential.....	8
1.2.3	New investigations	8



1 Introduction

The Røros Ore District, situated in the south-eastern Trondheim Region, was a major copper producer in Norway in the period 1644-1977 and about 7.5 mill. t of ore was produced from mainly 12 deposits during the 333 years of production.

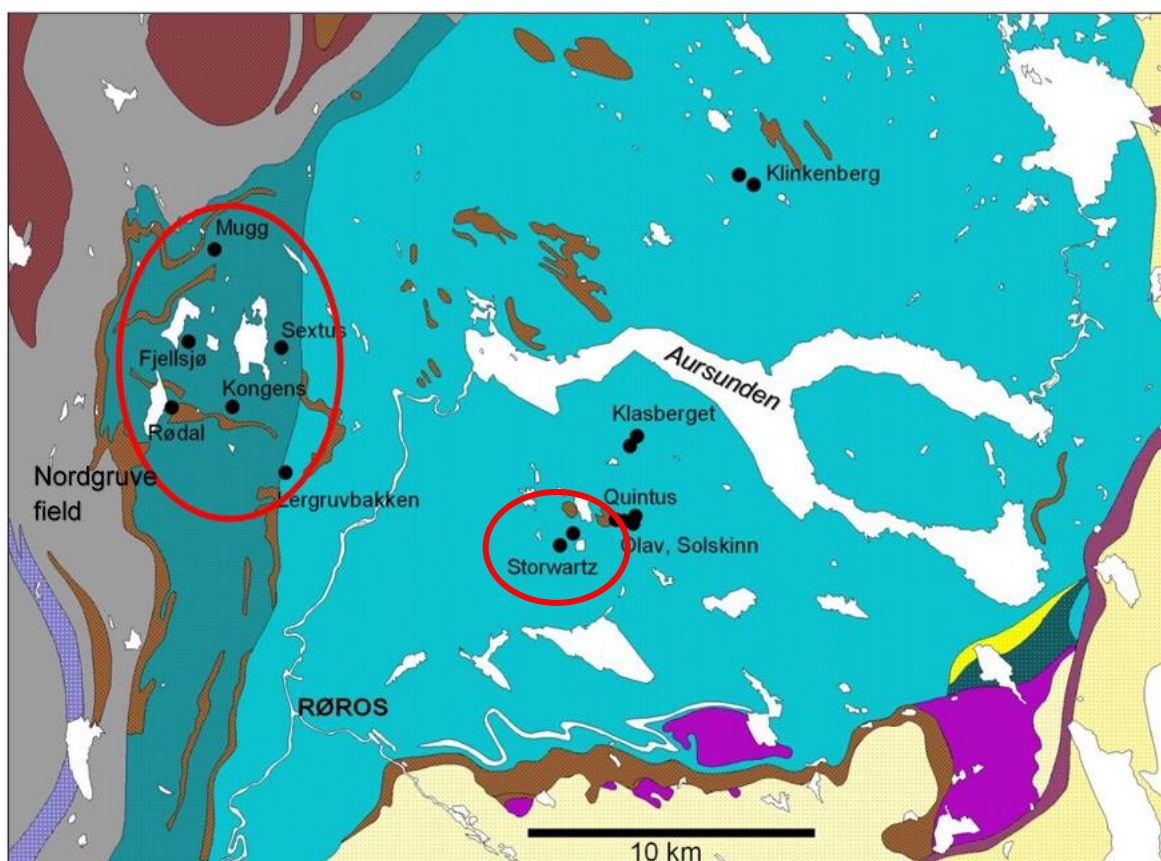


Figure 1: Location of the Nordgruve field and the Storwartz deposit

1.1 Storwartz ore field

The Storwartz ore field consists of six deposits one after the other over a distance of about 3100 meters, and a total width of 100-300 meters. The ore bodies form shallow, flat-laying, typically 1-2 meters thick plates, but with locally thicker parts due to folding. Investigations have shown that the deposits all were part of one large ore body, disrupted during deformation and faulting. Mining was carried out in the years 1645 to 1972 in eight different mines.



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STRATEGIC RAW MATERIALS NEEDS

1.1.1 Geological Setting

The Røros Ore District is situated in the south-eastern Trondheim Region, in the Upper Allochthon of the Norwegian Caledonides. This region comprises tectonic and lithological units derived from several different environments, thrust upon the Precambrian basement of Baltica during the Scandian event of the Caledonian Orogeny. The ores are situated in the Aursund Group, comprising mainly metagraywackes with lesser amounts of tuffites, metabasalts and gabbroic sills/dykes, representing a marginal basin environment, probably close to Baltica.

The Storwartz ore field are situated in a thick sequence of greywacke/turbidites, with gabbroic sills and dykes attesting to magmatic activity in the sedimentary basin. The deposits are interpreted to be VMS deposits of the siliciclastic-mafic class (former known as Besshi-type deposits).

The deposits consist of Cu-Zn-(Pb) ores in quartz-chlorite-calcite-plagioclase dominated matrix. The ore field shows a pronounce zonation from Cu-dominated deposits in the east to Zn-Pb dominated deposits in the west. Major ore minerals are chalcopyrite, sphalerite, galena and pyrrhotite, pyrite is subordinate, and native bismuth, dyscrasite, cubanite, hessite and arsenopyrite are accessory phases.



Figure 2: Mine dumps at the Kvintus mine, the Storwartz ore field in the Røros district, Norway (photo: Terje Bjerkgård, NGU)



1.1.2 Mining History and raw material potential

It is estimated that about 4 mill. tons of ore was produced from the Storwartz deposits in the years 1645 to 1972, mainly copper, but also some pyrite and sphalerite. Most of the sphalerite was wasted at the dumps during the first 250 years.

The remaining raw material potential of the Storwartz deposits is unknown. The deposits probably only have a limited potential of additional ore. The remaining Zn wasted is probably to weathered and degraded to be produced. Generally, the main commodities in the deposits are Cu, Zn, Pb and Ag, possible CRM include Co, In, Sb and Bi.

1.1.3 New investigations

New investigations of the Storwartz ore field as well as limited sampling were carried out in 2019 and 2020. The work and analytical data confirm the strongly increasing Zn+Pb and decreasing Cu content going from east to west. Furthermore, some new observations of massive Cu-rich veins strongly suggest that the easternmost deposit (known as Gamle Solskinn) at least partly represent a major stringer/feeder zone to the ore body.

With respect to trace elements, **cobalt** is enriched in the eastern Cu-rich deposits (170-350 ppm), compared to the Zn-rich deposits in the west (105-130 ppm). **Bismuth** is enriched in the Zn-rich deposits (110-210 ppm) compared to the Cu-rich deposits (20-60 ppm), whereas the contents of **antimony** and **indium** are very low and show no obvious zonation trends (Sb 2.5-18 ppm and In 2.5-5.1 ppm). Contents of other trace elements are also low (Ge < 1 ppm, Ga 1.8-12.5 ppm, Te 3.5-9.2 ppm, Se 39-107 ppm, Mo 3.5-86 ppm).

Table 1: Average metal contents in the deposits of the Storwartz ore field. Cu, Zn, Pb and Fe in %, Au, Pt and Pd in ppb, all others in ppm.

Deposit	Zn/Cu	Cu	Pb	Zn	Ag	Au	Ni	Co	Mn	Fe	As	Mo	Cd	Sb	Bi	Ba	Pt	Pd	Se	Te	Ga	Ge	Sn	In
Gamle Storwartz	7.36	1.26	0.90	9.24	23.7	184	36	128	880	22.2	124	34.5	209.8	8.3	108	44	2	2	81.5	4.7	12.5	0.5	9.1	4.3
Nye Storwartz	5.45	1.77	1.15	9.64	17.9	192	27	120	1462	16.1	55	86.3	196.0	6.0	209	15	1	1	61.9	5.1	8.9	0.6	12.9	5.1
Hestkjetten	2.59	2.46	0.60	6.36	22.9	593	23	105	425	13.2	28	17.0	148.4	18.5	62	17	1	8	39.1	3.5	3.1	0.4	6.6	2.7
Kvintus	1.95	2.21	0.20	4.32	6.5	105	36	234	415	37.3	9	5.9	99.5	5.9	62	13	2	2	106.6	7.6	2.2	0.5	3.4	3.7
Olavsgruva	0.25	5.38	0.01	1.32	12.8	122	27	351	284	46.8	22	3.5	44.5	2.5	48	12	1	2	76.5	7.1	1.8	0.5	2.4	2.5
Nye Solskinn	0.48	4.35	0.03	2.10	8.9	413	25	303	432	30.2	19	3.5	60.8	15.4	58	18	1	1	76.7	9.2	5.4	0.9	8.1	3.9
Gamle Solskinn	2.61	1.42	0.01	3.69	2.3	135	21	169	809	20.7	13	16.0	103.7	2.5	21	41	1	2	52.6	3.8	7.1	0.6	2.3	3.3



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1.2 Nordgruve ore field

The Nordgruve ore field comprises five deposits (the Kongens-Rødalen, Lergruvbakken, Fjellsjø, Mugg and Christians Sextus deposits) of which four have been mined (in six different mines). Mining in the ore field commenced in 1657 (the Arvedal and Kongens mines exploiting the upper parts of the Kongens deposit) and lasted until 1977 (the Lergruvbakken mine).



Figure 3: Old buildings and dumps at the Christianus Sextus mine, the Nordgruve ore field in the Røros district, Norway (photo: Terje Bjerkgård, NGU)

1.2.1 Geological Setting

The Røros Ore District is situated in the south-eastern Trondheim Region, in the Upper Allochthon of the Norwegian Caledonides. This region comprises tectonic and lithological units derived from several different environments, thrust upon the Precambrian basement of Baltica during the Scandian event of the Caledonian Orogeny. The ores are situated in the Aursund Group, comprising mainly metagraywackes with lesser amounts of tuffites, metabasalts and gabbroic sills/dykes, representing a marginal basin environment, probably close to Baltica.

The Nordgruve ore field (as the Stortvart ore field) are situated in a thick sequence of greywacke/turbidites, with gabbroic sills and dykes attesting to magmatic activity in the



sedimentary basin. The deposits are interpreted to be VMS deposits of the siliciclastic-mafic class (former known as Besshi-type deposits).

The deposits consist of Cu-Zn-(Pb) ores in quartz-chlorite-plagioclase-dominated matrix. All the deposits, except Mugg is Zn-dominated. Major ore minerals are chalcopyrite, sphalerite, galena and pyrite, pyrrhotite is subordinate. Bismuth-bearing phases are accessory.

1.2.2 Mine History and raw material potential

It is estimated that 3 mill. tons of ore was produced from the deposits in the Nordgruve field in the years 1657 to 1977, copper and pyrite and sphalerite, the latter a major product in Lergrubakken.

The remaining potential at the Nordgruve field is generally unknown but has probably only a limited potential of additional ore. Zn wasted is probably to weathered and degraded to be produced. In general, the main commodities are Cu, Zn, Pb and Ag, possible CRM includes Co, In, Sb and Bi.

1.2.3 New investigations

New investigations, including geology mapping and sampling were carried out in 2019 and 2020. Most of the deposits in this ore field is zinc-dominated (Zn/Cu ratio from 1.3 to 15.1), the only exception being the Mugg deposit, which is copper-dominated (Zn/Cu-ratio 0.5).

Looking at the trace elements, **cobalt** varies between 103 and 231 ppm without any correlation to the major elements, **bismuth** is very low in the Cu-rich deposit (5 ppm), whereas the most zinc-rich contain up to 80-85 ppm Bi. The content of **indium** is generally low (2.3-12 ppm), with the lowest value in the Cu-dominated deposit. The content of **antimony** is very low (<0.3-5.6 ppm), as are also molybdenum (8-22 ppm), tellurium (10-18 ppm), gallium (10-18 ppm) and germanium (0.2-8.8 ppm).

Table 2: Average metal contents in the deposits of the Nordgruve ore field. Cu, Zn, Pb and Fe in %, Au, Pt and Pd in ppb, all others in ppm.

Deposit	Zn/Cu	Cu	Pb	Zn	Ag	Au	Ni	Co	Mn	Fe	As	Mo	Cd	Sb	Bi	Ba	Pt	Pd	Se	Te	Ga	Ge	Sn	In
Lergrubakken	15.07	1.29	0.50	19.39	23.9	110	33	103	1341	21.8	25	9.9	325.7	0.4	85	62	-5	-1	51.2	10.1	16.7	0.2	17.8	4.7
Fjellsjø	5.13	1.88	0.14	9.65	11.3	188	32	231	384	25.4	56	13.9	205.1	0.6	44	25	3	1	110.6	11.6	18.1	0.6	12.2	8.1
Kongens gruve	3.32	2.04	0.36	6.78	21.9	212	39	173	388	28.7	74	22.1	175.1	2.6	77	25	2	2	103.6	14.0	9.5	8.7	9.5	9.9
Christianus Sextus	2.46	2.05	0.17	5.04	10.4	159	35	145	423	21.0	66	11.5	125.8	5.6	29	10	1	1	140.0	18.5	16.0	8.8	5.3	12.0
Rødalen	1.34	3.22	0.20	4.33	14.9	233	42	212	418	25.8	29	14.2	101.7	-0.3	62	23	2	2	88.6	12.1	13.9	0.7	14.4	8.1
Muggruva	0.47	3.04	0.00	1.42	10.7	284	44	121	792	31.0	2	8.3	46.2	1.8	5	117	2	1	76.5	11.6	15.9	0.7	6.2	2.3