NEAB'S WORK AT FROASTAD, VÅRLINUTEN, AUGASTAD, ÅRSNES & LØKEDAL, 2015

CONTENTS

Appended table (table 3) showing analyses of NEAB's samples from four of the five prospects, and a CD with the files necessary to print this report.

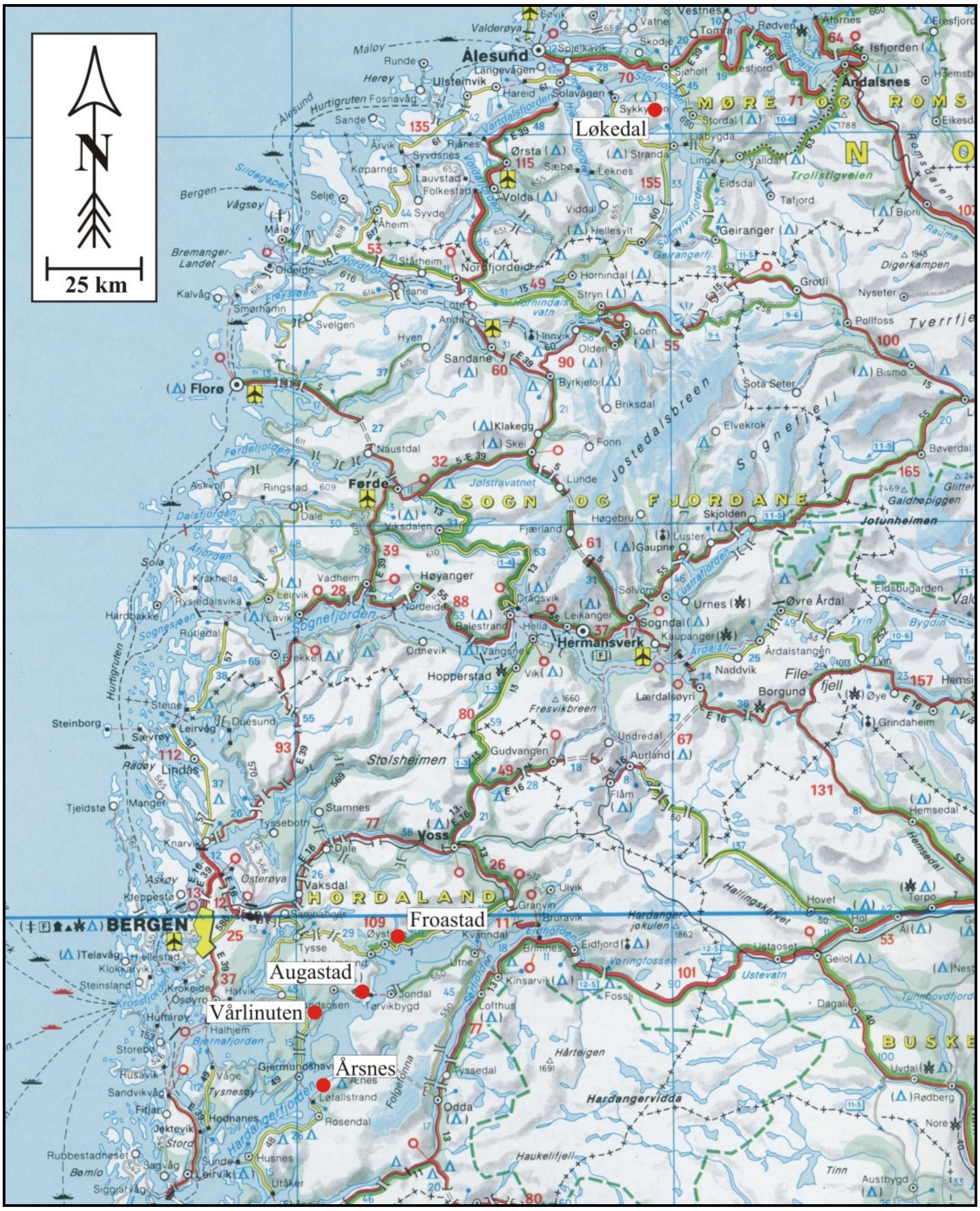


Figure 1: A part of western Norway and the five occurrences dealt with in this report.

INTRODUCTION

NEAB has for some years worked with the Tjosås VHMS-prospect close to the town of Øystese on the northern side of the Hardanger Fiord (figures 1 and 2). Some nearby prospects - Froastad, Vårlinuten and Augastad - which like Tjosås are also hosted in the Mundheim Group (figure 2), were explored in 2015. A recent widening of a road at Årsnes has made two reasonably sized, sulphide containing quartz veins visible. Farther to the north, at Løkedal east of Ålesund (figure 1), NEAB in 2010 took four samples one of which returned 26.5 g/t gold – enough to warrant more work.

FROASTAD

NEAB visited Froastad in 2009 and found six adits to a talc mine but failed to find the pyrite mineralization mentioned in old reports. In 2015 and armed with better maps, the pyrite mineralization was immediately found.

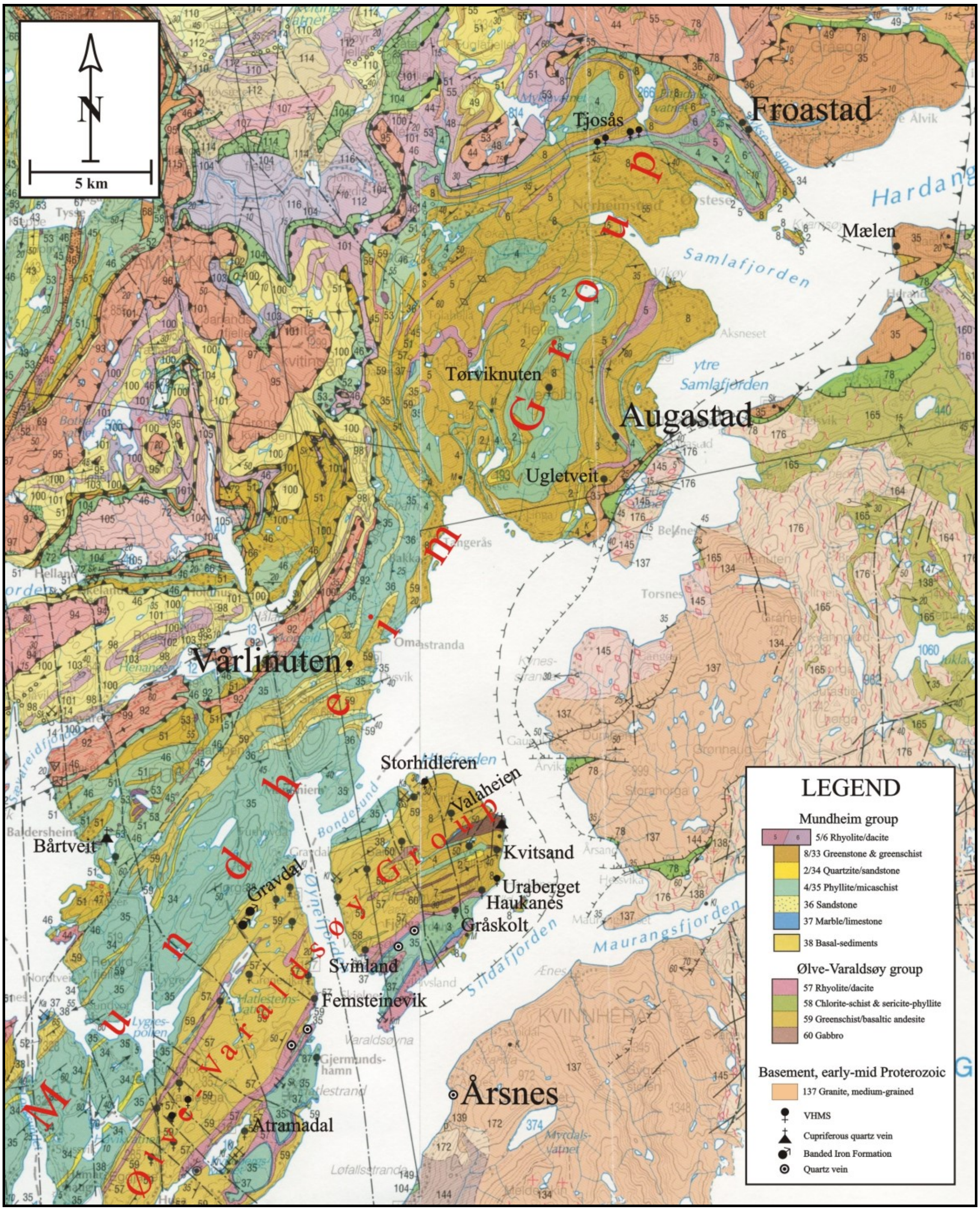
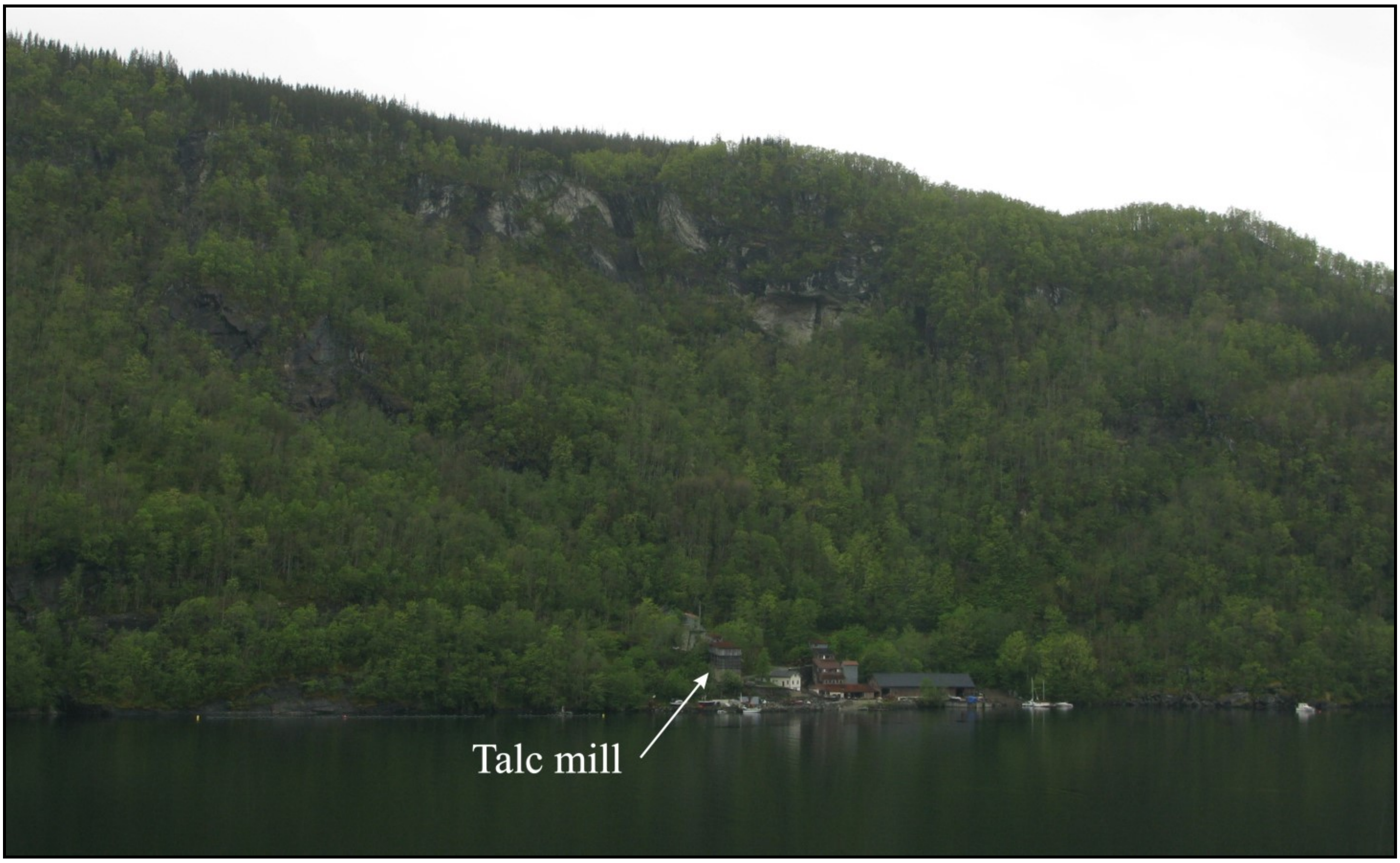


Figure 2: Froastad, Vårlinuten and Augastad are hosted in the Mundheim Group which according to an NGU-geologist is the same as the Ølve-Varaldsøy Group. Årsnes is hosted in basement-granite



Figur 3: Froastad as seen from the other side of the fiord, Fyksesund. The old workings related to the pyrite mineralization are at the foot of the almost vertical part of the mountain side.

History

Below is a compilation of selected information from three reports from around 1905-10 which primarily deals with Froastad as a pyrite mine:

BA1401 (undated but probably the oldest about Froastad): There are two old workings at Froastad: Storgruben and Jakob's Grube. There was an irregular mass of pyrite at the entrance to Storgruben but it wedged out inside the strike drive before being cut and displaced by a fault. Strike is N-S and dip is steeply E. Another pyrite layer strikes NW-SE. In Jakob's Grube are a number of thin pyrite layers and a 50 cm thick, folded pyrite layer. Host rock is "a kind of clay-schist with quartz-layers in between". The mineralization is irregular, inconsistent and impure and the prospect is not promising.

BA1747 (probably written in 1909 by Münster, faded and difficult or impossible to read): The mineralization strikes 305° while dip varies. Host rock is "lerglimmerskifer" (mica-schist), some talc-schist and some quartz-schist or gneiss. The ore is pyrite which occurs as thin layers in quartz or in the other host rocks. Sometimes the ore is "stykkis" (i.e. massive pyrite). Grain size is less than 1 mm. The mine was operated in the summer of 1904 and was closed in 1906. Total production was 3-400 tonnes grading 40% sulphur during these years. The mine was reopened in 1909 by a German company which blasted an adit intersecting a number of cm-thick layers of "stykkis" totaling 10 cm. The German company also continued the lowermost adit in which there is no ore and a strikedrive with 20 cm "stykkis". Another strikedrive has 15-60 cm "stykkis" which faded into thinner layers and low-grade impregnations. There is also a place with a 30-50 cm thick layer of "stykkis". The report concludes that the "Froastad pyrite mine is a prospect which one can safely discourage anybody to invest in".

BA2171 (C.H., 1920): The mineralization is hosted in phyllite and close to the border between the phyllite and the gneiss. In the footwall occurs talc-chlorite-schist, probably altered serpentinite as there is serpentinite nearby. Strike is N-S and dip is both 60° E and 60° W. The mineralization is small and inconsistent. The ore is low-percentage with regards to sulphur content and consists of pyrite with accessory pyrrhotite and chalcopyrite. The sulphides are associated with calcite. Mining started in 1903 and ceased at the end of 1904. The ore mined in 1909 had 42-45% S. Mining ended in 1910. In 1911 the mine was taken over by "Norway Talc Mill" from the nearby town Øystese. Norway Talc Mill mined talc until 1916. During the mining a new sulphide mineralization was found. A local, Swensson, spent 65 workdays exposing the sulphide mineralization but did not produce any ore. 1800 m3 ore and waste was mined during 1903-4. This resulted in 300 tonnes of "stykkis" and 450 tonnes of lower grade. As already said, 300 tonnes grading 42-45% sulphur was produced in 1909.

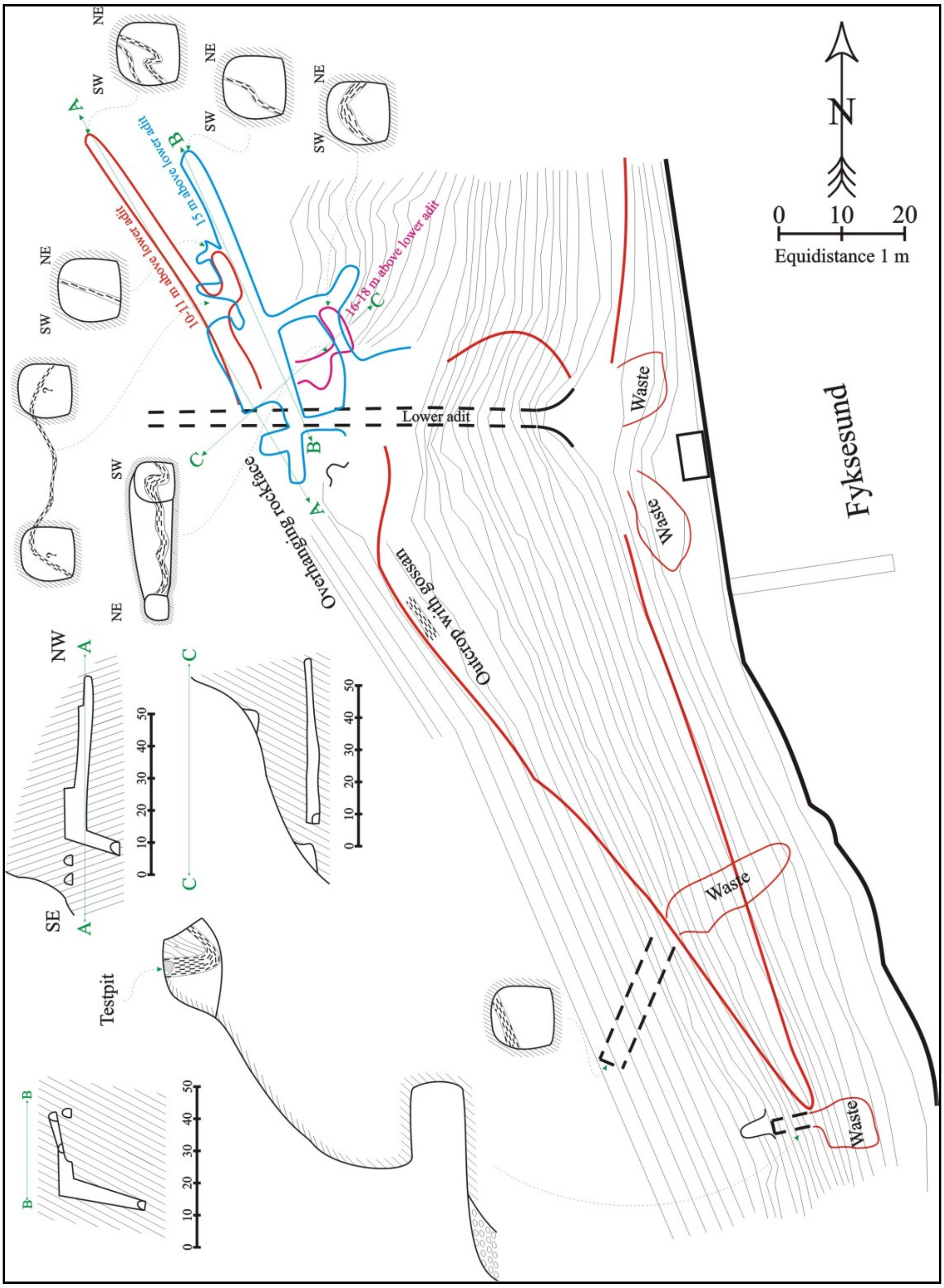


Figure 4: My redraft of Münster's (probably around 1905) Froastad map and figures from report BA382 which primarily consists of sketches. The originals are unclear and more or less faded so the redraft has some inconsistencies, e.g that the equidistance is more like 5 m and not the 1 m written in the old report.

The following comments and two figures are from two reports written by Norwegian geologist Bugge (1941 and 1942) who primarily viewed Froastad, or Høiviken as he calls the site, as a talc mine. He says that: "the host rock is phyllite/greenschist and the talc occurs in three settings: 1) along the margins between serpentinite and greenschist, 2) in faults cross-cutting the greenschist, and 3) as layers in greenschist". Furthermore: "phyllite is the prevalent rock along this part of Fyksesund and hosts lensoid serpentinite bodies which are talc-altered at their margins. Steeply dipping phyllite is more easily eroded than the serpentinite bodies which therefore stand out on the steep hillside. There are often dolomitic and have sulphidic layers together with the talc".

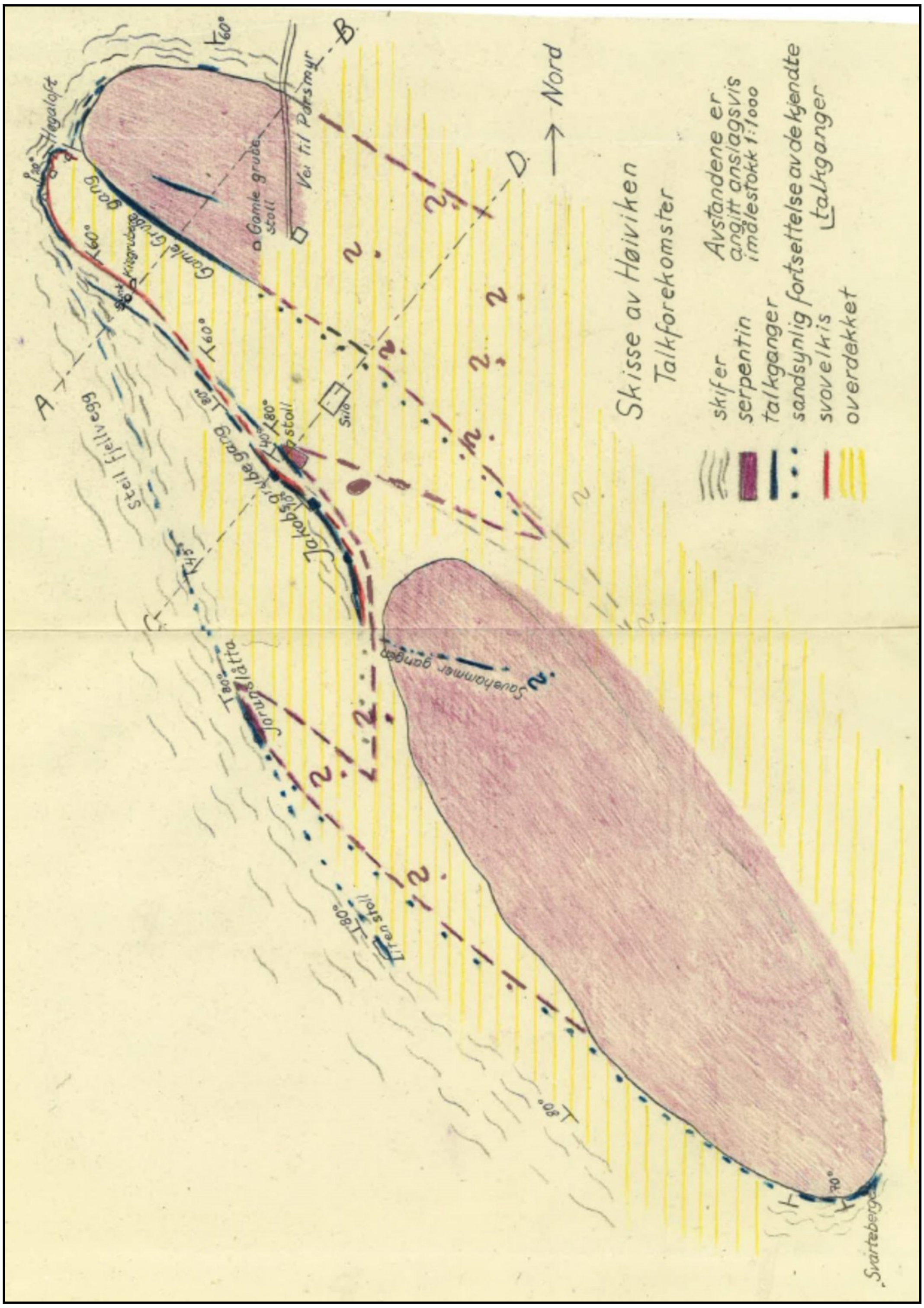


Figure 5: Bugge's sketch of the Froastad/Høiviken pyrite/talc deposit. It seems that the pyrite mineralization stretches for several hundred meters and is related to the talc layers in the phyllite. "Vei til Porsmyr" is a foot path, now partly overgrown.

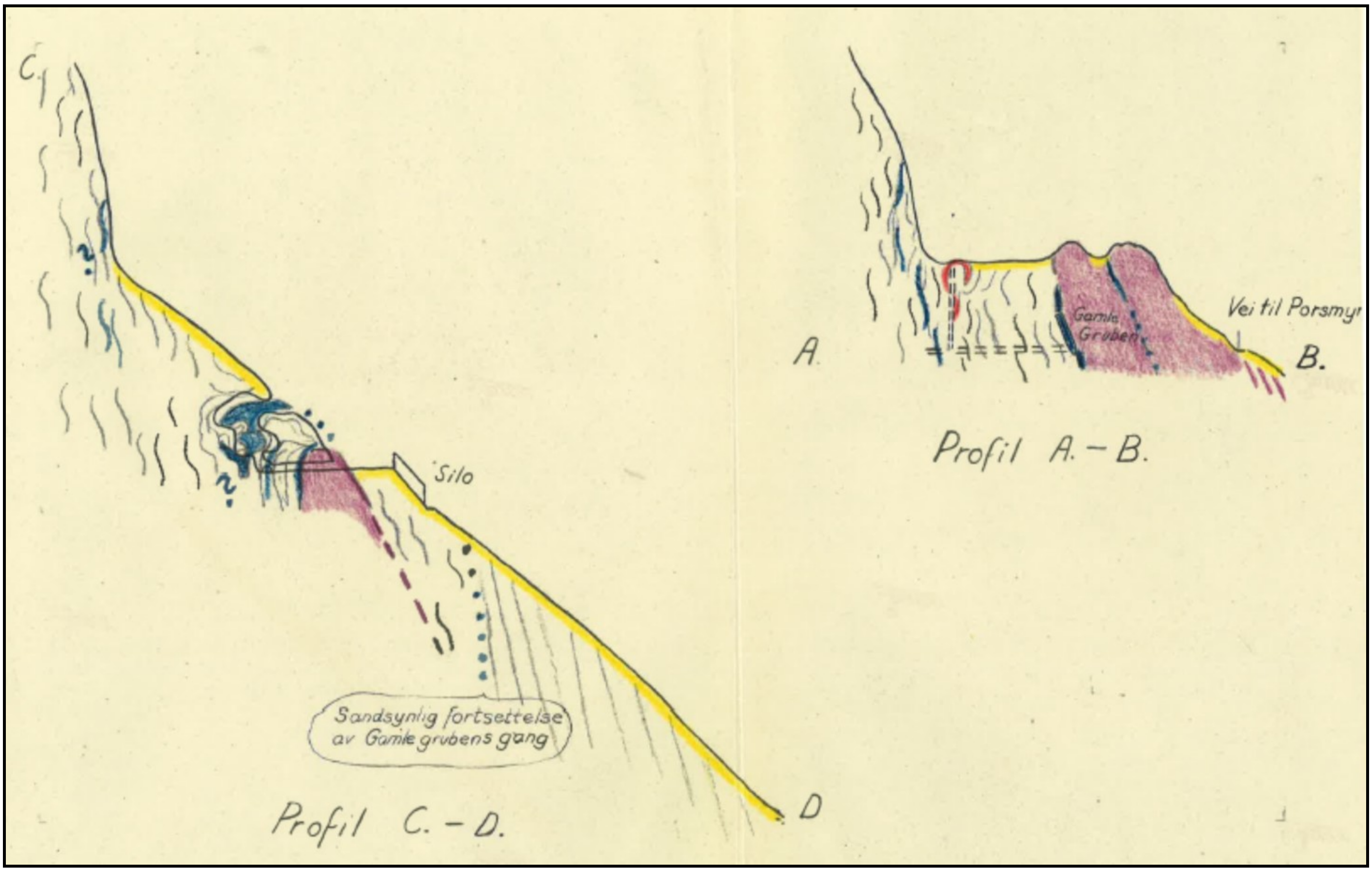


Figure 6: Bugge's two sections.

The first talc production period ran from 1910 to 1914, the second period from 1916 to 1920 and the third and final from 1932 until c. 1960, during which also serpentinite sand was produced. NGU (Norwegian geological survey) has some incomplete data on the talc powder production during and after the war:

Year	Tonnes
1943	484
1944	480
1945	494
1946	1575
1947	7191
1952	5428
1953	3900
1954	6529

Table 1. Incomplete talc production data from NGU.

About Norwegian talc deposits, NGU says:"all Norwegian talc deposits are related to Caledonian ultrabasic lenses hosted in schists or phyllites, and in ophiolites ". Except for the ophiolite part, this also applies to Froastad.

NEAB's field visit in 2015

Approximately two days were spent at Froastad in 2015 and a map of all the old workings was drawn up. It is seen that the old workings related to the pyrite mineralization are higher up than the entrances to the talc mine (figure 7).

The pyrite layer can be followed for c. 250 m but is longer as it is open to the north and also seems to occur in the inaccessible bottom of a hole caused by the recent collapse of the roof over a southern part of the talc mine (figure 7). The layer's thickness reaches 80 cm in the northernmost of the old workings (probably Gamle Grube) but mostly only averages 30-40 cm. The pyrite layer is boudinaged and folded. At one occasion I was accompanied by local farmer and cabin owner Per Rykken from Øystese. We searched for pyrite mineralisation inside most of the talc mine but found only a few rustzones. The reason is probably that the pyrite mineralization has long ago been eroded below and to the east of the old workings. The levels immediately under the entrances to Jakobs Grube can possibly be reached using a very long wooden staircase starting inside the talc mine. Similar to Storhidleren on Varaldsøy, the pyrite layer at Froastad is associated with a chert layer which in one of the old workings is +2 m thick (figure 8). The pyrite ore is either massive or chert-banded – in both cases it is fine-grained (figures 10 and 11). Some parts of the sulphide ore withstand weathering well whereas other parts turns in to grey sand because, as it is said, each pyrite grains is encapsulated in quartz.

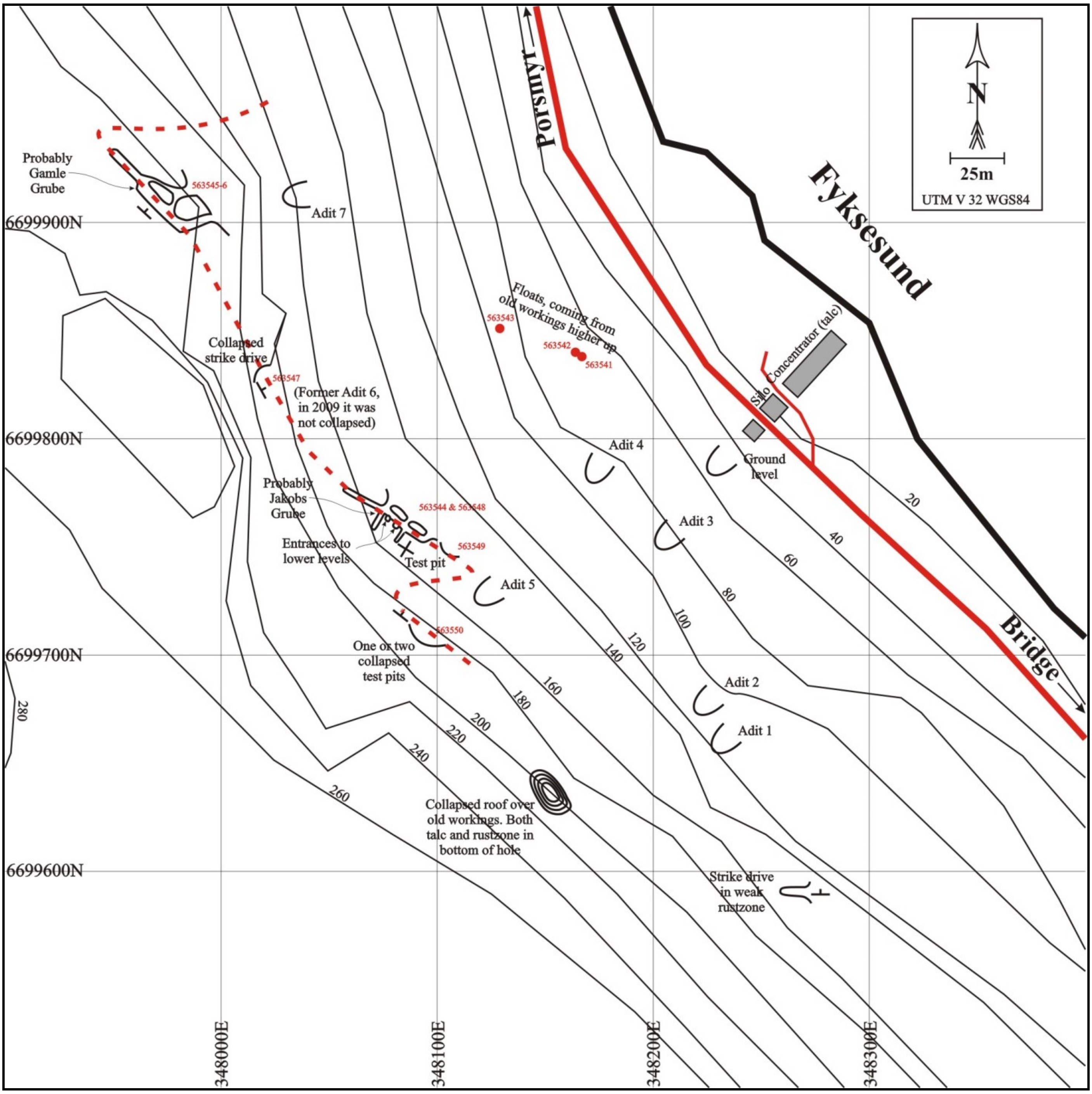


Figure 7: Map showing the old workings related to the mining of pyrite and talc at Froastad. Red numbers are the ten samples taken by NEAB. The location of what is probably Gamle Grube is somewhat inaccurate because the steep topography just west of the old workings resulted in poor GPS-reception. Notice that this map has very little in common with figure 4.

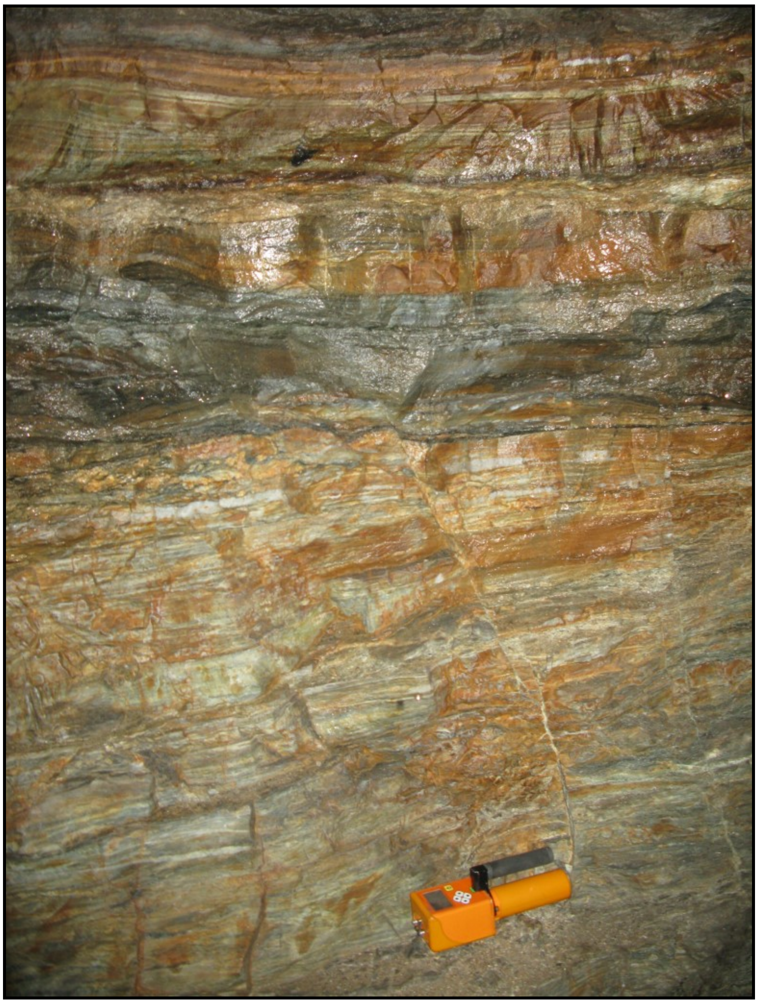


Figure 8: Jakobs Grube. Chert layer with chert-banded pyrite layers in the uppermost part of the photo. The yellow gadget is the Czech-made spectrometer that NEAB had hired. It stated that the chert has 0.35% potassium but no uranium or thorium.

Figure 9: Massive and folded pyrite layer in Gamle Grube.

Figure 10: Chert-banded pyrite. Dark bands are mostly chlorite but probably also chromite.

Figure 11: Massive pyrite. Matrix is chert.

The only ore mineral visible to the naked eye mineral is pyrite. However, minor malachite and magnetic susceptibility locally reaching 140x10-3 SI units, suggests that the ore sometimes also contains traces of chalcopyrite and magnetite, respectively. Ten samples of pyrite ore from different places were analysed (table 3). They surprised in having relatively high grades of nickel, chromium, and in one instance also cobalt. This led to four of the samples being analysed also for platinum and palladium but the samples are devoid of those two metals. As pyrrhotite is not seen, most of the nickel probably substitutes for iron in the pyrite. The chromium will most likely be in the form of chromite. NEAB has sampled almost all known sulphide occurrences in the Hardanger district but none of them have the geochemistry of Froastad.

Being comprised of pyrite and hosted in chert or greenschist, Froastad must be a VMS-style mineralization - despite its relatively high contents of nickel and chromium. These two metals must have been leached from the serpentinite during the formation of the sulphide mineralization. As the nickel and chromium contents are not stellar and the mineralization is most likely small, no further work is recommended at Froastad.

VÅRLINUTEN

Vårlinuten is only known through one report: BA374 (Fasting, H. 1908). The prospect is said to be located c. 2 km west of the Dysvik farm and 300 m above sea level. Host rock is “quartzitic bands striking E-W and dipping 30° S. There are two outcrops, 20 m from each other and “the geological level difference is c. 6 m” between them. The pyrite impregnated band in the western outcrop (figure 13) is half a meter thick but most is poor impregnation while rich impregnation or almost pure pyrite constitutes 20 cm at the most. Including some quartz-veins, the eastern outcrop has a 15-20 cm thick band with pyrite impregnation. Fasting concludes that there is little reason to carry out more surveying and that the chalcopyrite impregnation marked on one of the sections (figure 14) is insignificant.

The topographic map (figure 12) shows the Dysvik farm and 7-800 m WNW a 3-400 m high hill called Vårlihaugen – probably another or newer name for Vårlinuten.

According to NGU’s geological map there is supposed to be greenschist/basalt with thin layers of metaarenite at Vårlihaugen. Strike is approximately SW-NE, and not E-W as Fasting says.

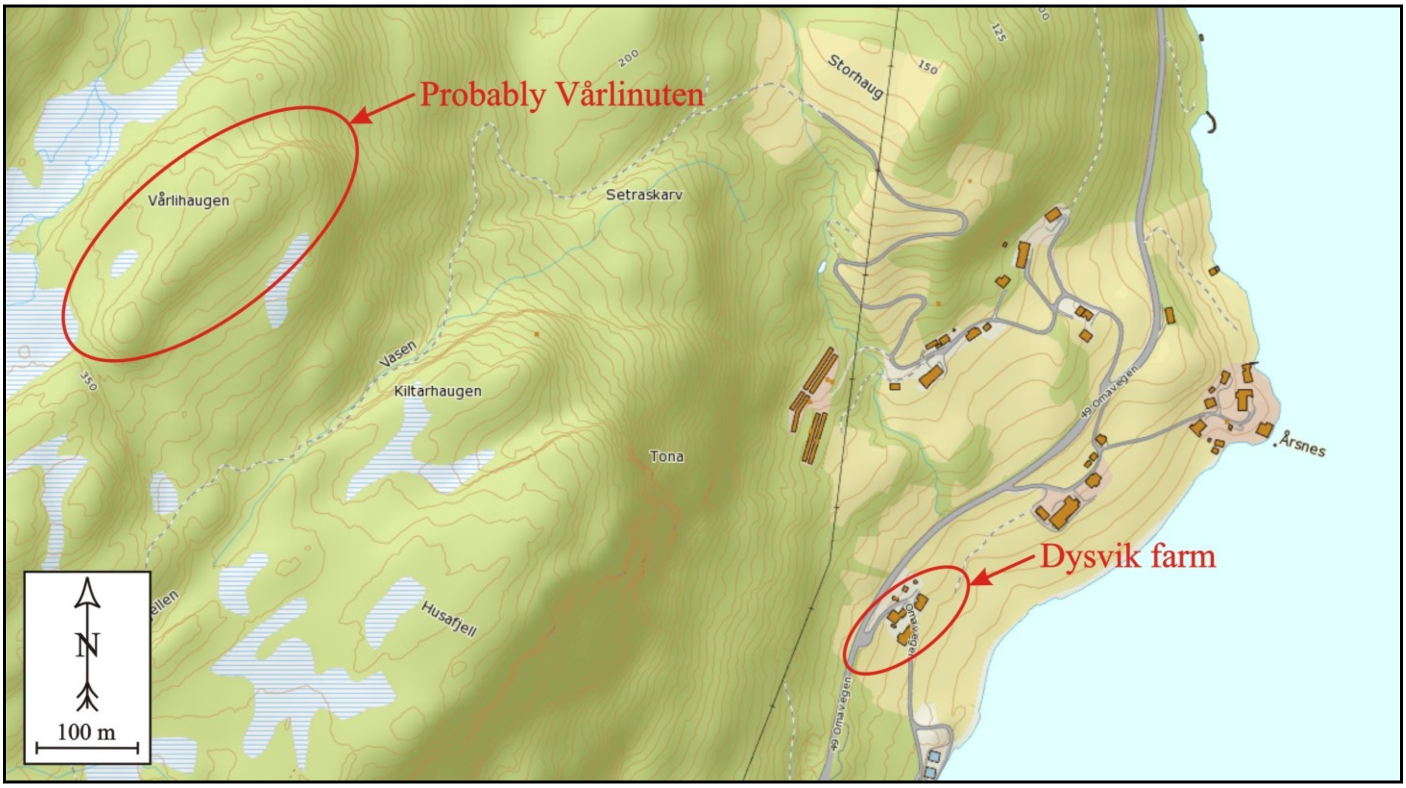


Figure 12: Vårlinuten is probably the same hill which today is called Vårlihaugen.

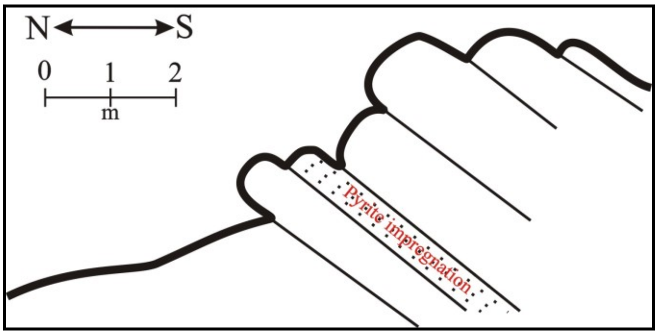


Figure 13: The western outcrop. There is little information in this figure but it appears the mineralization is stratabound.

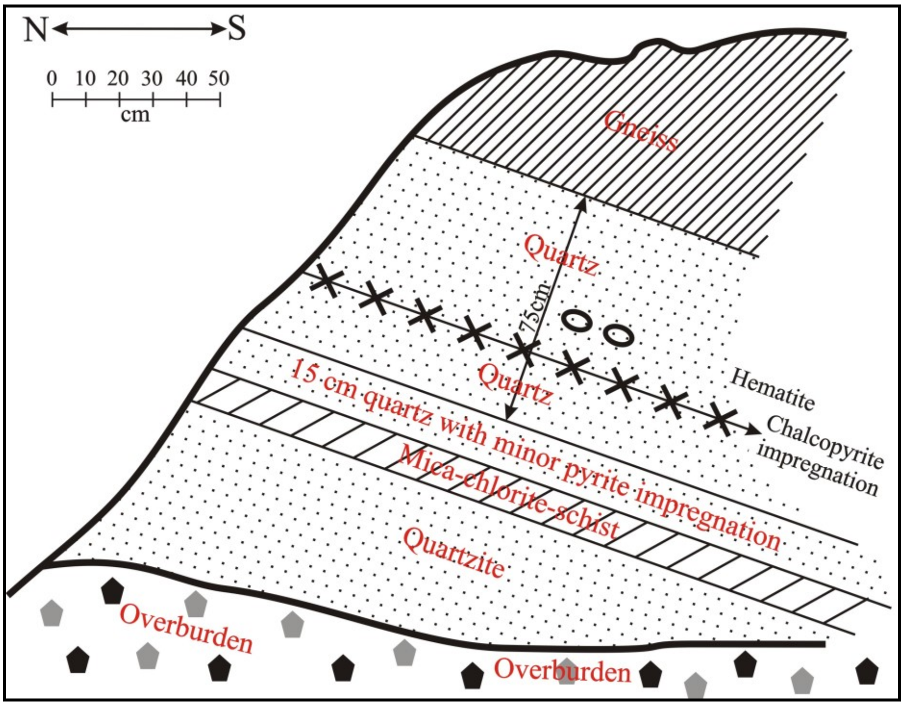


Figure 14: The eastern outcrop. Pyrite, chalcopyrite and hematite in what is said to be "quartz" but is more likely chert – sounds somewhat like Storhidleren (figure 2).

NEAB's field visit

Half a day was spent searching for the outcrop but nothing of interest was found. While walking up to Vårlinuten, several rusty floats were noticed embedded in the footpath at UTM E348107, N 6699750. The floats are chlorite-quartz with pyrite. An analysis show 0.15 ppm gold and >10% sulphur (table 3). Similar mineralization also occur elsewhere in the Hardanger district, e.g. at Vestervik and Varakjelen where there is nothing else but this kind, but also at e.g. Valaheia where it is part of the alteration zone.

AUGASTAD

History

Egge (1906) says that the test pit is c. 2 km west of the Drange farm and 25 m above sea level. The ore should be non-cupriferous pyrite hosted in mica schist with strike/dip being 0°/steeply west.

In Münster's (1909) "Report on Augastad (Drange) Pyrite Occurrence in Hardanger", it is said that the test pit lies c. 1100 m north of Lars Augastad's farm Drange or Augastad and 60-70 m above sea level in a strongly vegetated area with widespread soil cover. There should be three or four cm-thick layers of massive pyrite in the 2x2 m and 2-3 m deep test pit. The massive pyrite has some pyrrhotite and is low in copper but high in sulphur. Figure 15 shows Münsters map of Augastad.

Fasting (1909) concludes that the occurrence is not of interest.

In an undated report, Münster writes that ore from the dump has 48% S, minor graphite and reminds about the ore from the Stordø/Litlabø mines. Münster thinks that the occurrence deserves more attention.

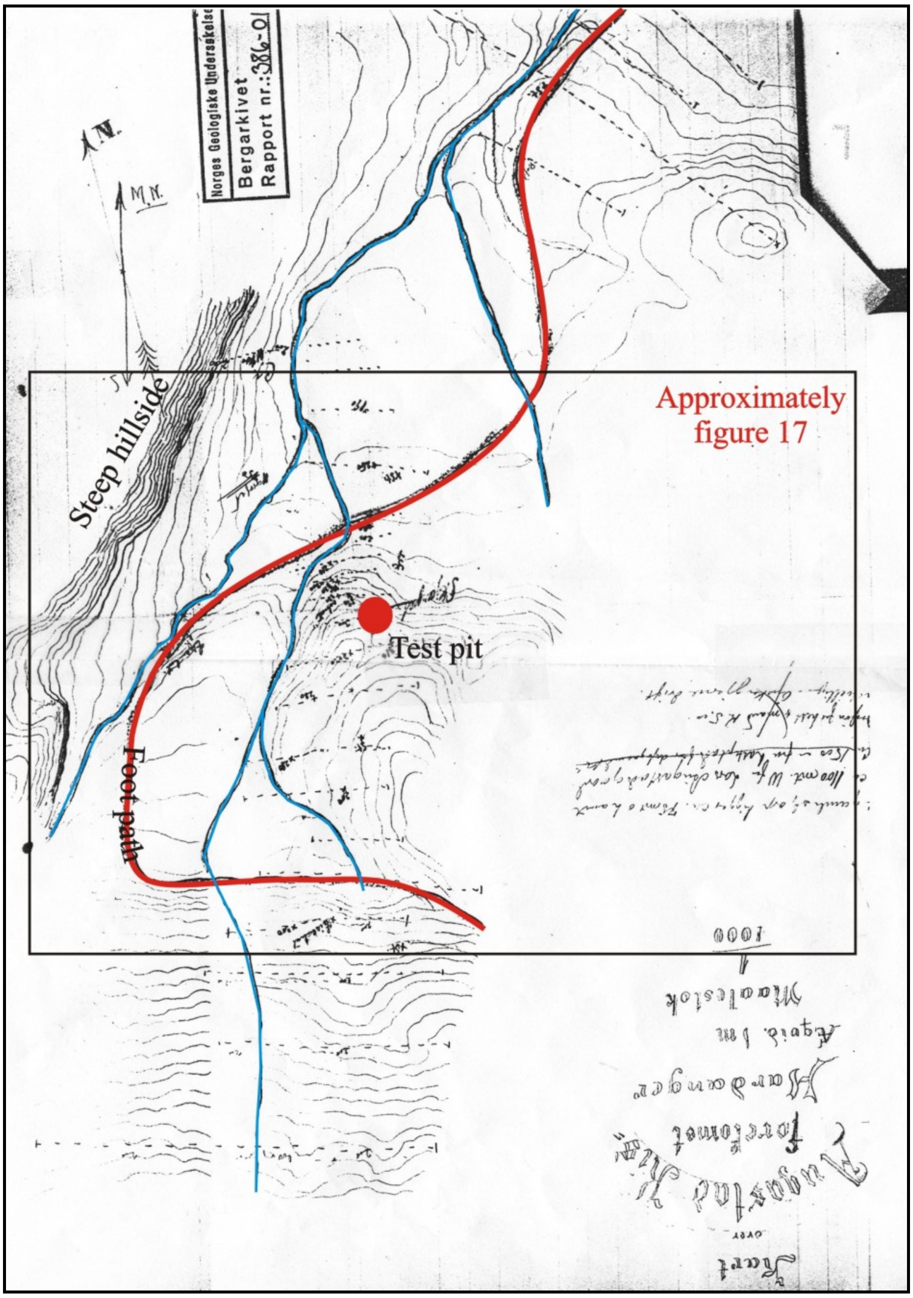


Figure 15: The map's text is turned on its head relative to the north arrow and somebody has written and underlined that "the old test pit is situated 1100 m west of Lars Augastad's farm, 1500 from a deep harbor and 75 m above sea level".

NEAB's 2009 fieldwork at Augastad.

In 2009 NEAB unsuccessfully tried locating the test pit at Augastad. A local property owner, 88 year old Johannes Augastad, showed me the only possible test pit he knew of. There was almost nothing to see as everything is overgrown and the little one can see is of no interest. Johannes Augastad remembered when an NGU-geologist had visited 32 years earlier. After the NGU-geologist´s visit, Johannes Augastad received a letter saying that the test pit had lost its status as a registered prospect. However, Augastad is still to be seen on NGU's website and geological map, and the listed coordinates are very close to the site which I think is the Augastad test pit.

In a roadcut (figure 16) at a tractor road is a minor VMS-style mineralization consisting of three 2-4 cm thick layers of massive, fine-grained pyrite within 35 cm of stratigraphy. Their orientation is c. 130/50˚S. One of the layers is associated with a mm-thick layer of a greenish mica – possibly fuchsite. Host rock is basalt. One sample (563018) was taken. It has 34% iron but no base- or precious metals. The arsenic content is 752 pmm and only surpassed by samples from some of Varaldsøy's gold-rich VMS prospects.

Figure 16: The sulphide layer in the roadcut at Augastad.

NEAB's 2015 fieldwork at Augastad.

Nowadays, detailed topographic maps can be downloaded from the internet so a new attempt to locate the test pit was made by trying to find an area with a pattern of contour lines, creeks and footpaths/tractor roads resembling figure 15. Such a pattern occurs in the area shown in figure 17, which also shows the location of the only man-made hole that could possibly be a test pit. It is overgrown and has been filled with soil and stones. In the test pit's eastern side is a graphitic rustzone with traces of iron-sulphides but else there are no signs of mineralisation.

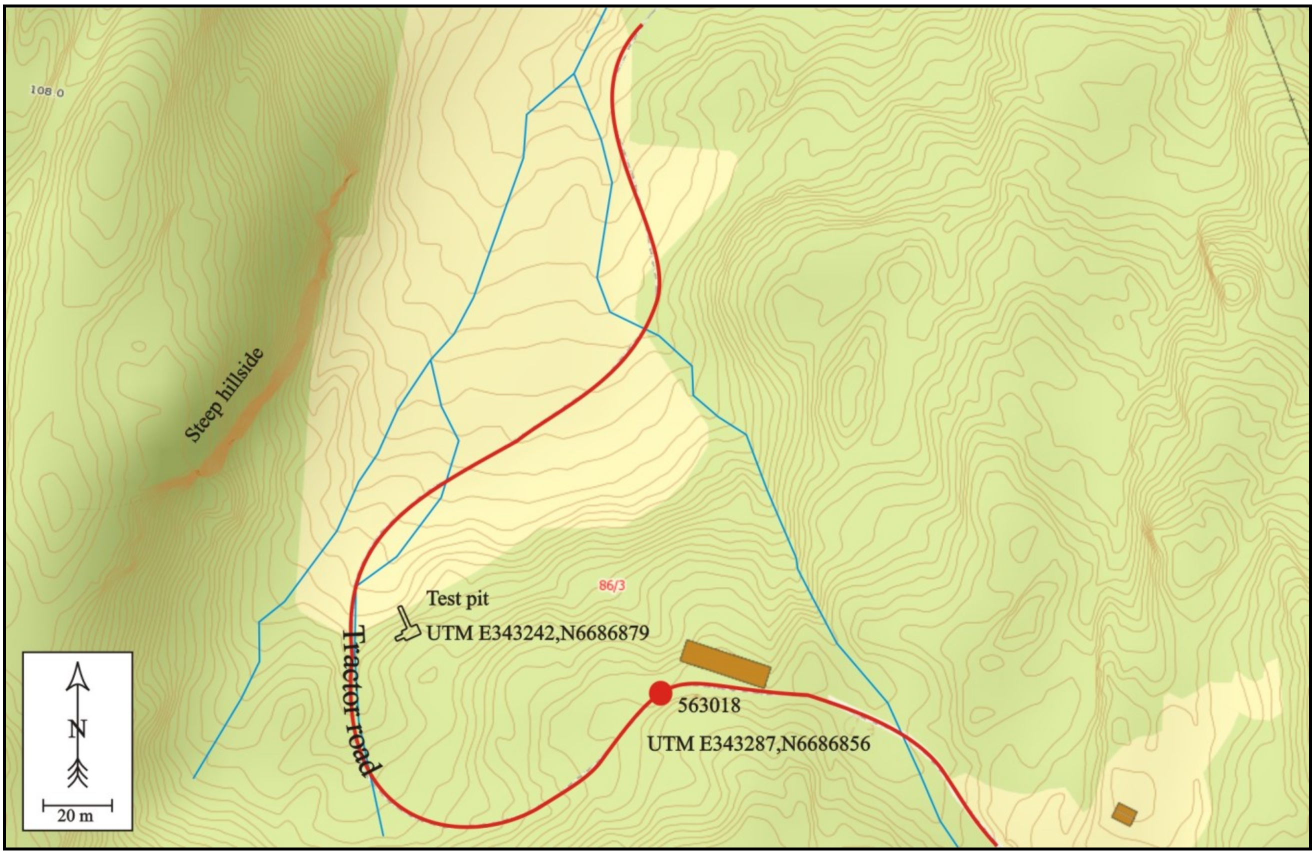


Figure 17: There are no other areas close to Augastad farm that resembles figure 15 than this particular ara. The suggested location of the test pit is c. 60 m above sea level which approximately it should be according to the old reports. There is also, as there should be according to one of the old reports "reasonable flat land towards the harbor". However, there is only about 4-500 m to the Augastad Farm towards ESE, and not the 1100 m or 2000 m as claimed in the old reports. NEAB's sample (563018) from 2009 was taken c. 50 m east of the test pit, at the tractor road.

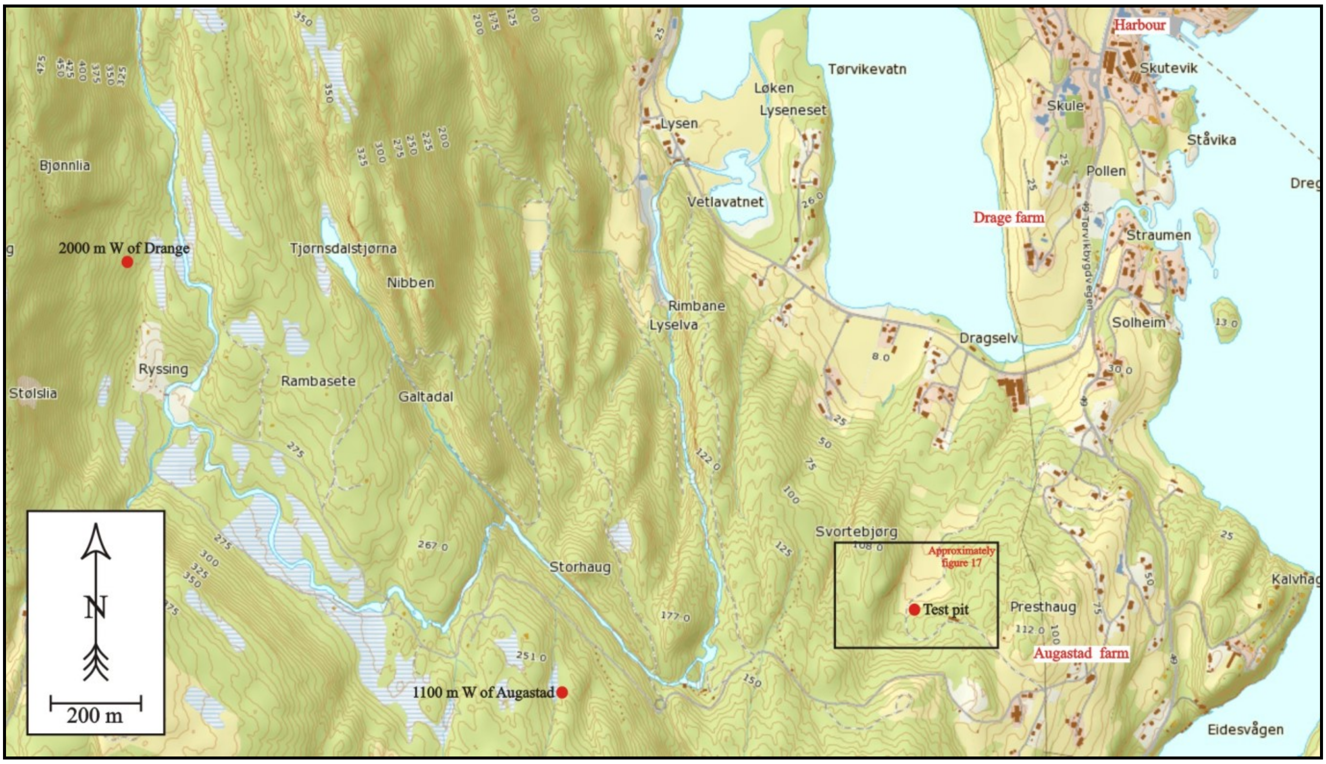


Figure 18: The old reports say that the test pit is 1100 m W of Augastad farm or 2000 m W of "Drange" (probably Drage farm) but at +200 m the altitude of both these places are far too high. Furthermore, there is no "flat land towards the harbour" which is probably the one at Skutevik.

One can of course not be 100% certain that the test pit on figure 17 really is *the* Augastad test pit but no matter what, there is little reason to carry out more work there.

<u>ÅRSNES</u>

In a new roadcut c. 600 m southeast of the ferry harbour at Årsnes are two rusty quartz veins. As the ferry would soon depart, there was only time to sample the most sulphide rich parts of the vein, get the coordinates (UTM E334279, N6660452) and take a few photos. The two veins are c. 0.5 and 3 m thick, respectively, and are hosted in shearzones with approximately the same strike and dip as the 1^{st} order, crustal scale fault under the Hardanger Fiord and the 2^{nd} order Sunnhordland fault. Consequently, the two veins can be part of the fault system which formed the district's auriferous quartz vein on Bømlo and perhaps also on Sveio. The quartz's grain size ranges from fine- to coarse-grained. Unevenly distributed in the quartz veins are pyrite and pyrrhotite. According to the geological map, the host rock is medium-grained granite. The sample (563454) has 0.14% copper but else nothing of interest. No further work.

Figure 19: The larger of the two quartz veins at Årsnes.

Figure 20: The smaller of the two quartz veins at Årsnes.

LØKEDAL

NEAB first visited Løkedal in 2010 when four samples were taken from the dump. One of them, 563241, returned 26.5 g/t gold, 223 g/t silver and 6.2% copper (table 3). In late January 2015, NEAB acquired an exploration licence (figures 21 & 25) covering 9.9 km^2 and in the autumn 5 days were spent locating outcrops and taking 15 samples (figures 22 & 23).

History

In 1978 NGU's geologist Aare Korneliussen investigated Løkedal (Bergvesenet rapport nr. BV 42 A) and analysed five samples (table 2).

Sample ID	Description	Cu%	Zn%
358	Rich ore	1.8	<0.1
359	Rich ore	4.8	1.1
360	Rich ore	1.6	3.0
361	Average ore	0.4	1.4
362	Amphibolite with minor ore minerals	0.4	0.5

Table 2: NGU's five samples. Their copper and zinc contents are equal to NEAB's samples'. Gold contents were not analyzed.

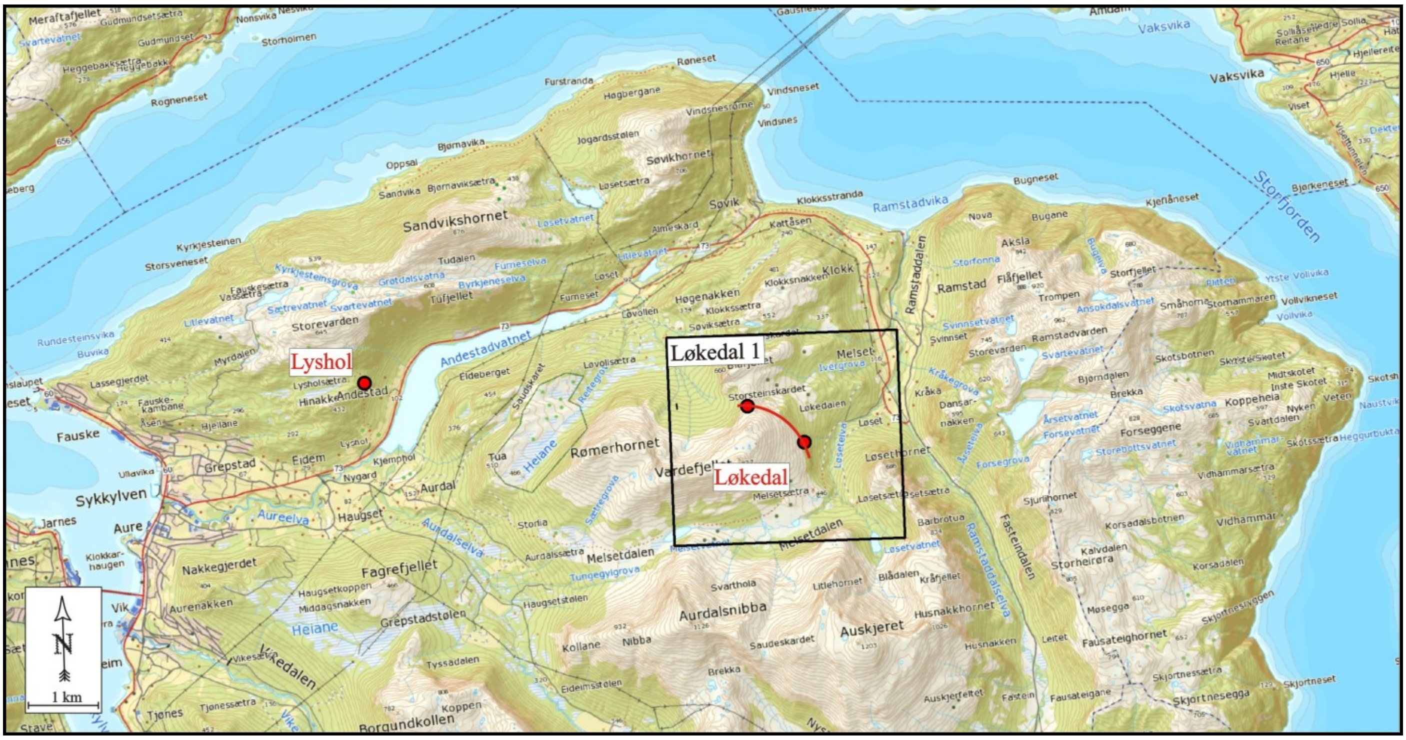


Figure 21: NEAB's Løkedal 1 exploration licence and the area's two known mineralisations; Løkedal and Lyshol, both of which NEAB first investigated in 2010. Løkedal is insignificant in all respects.

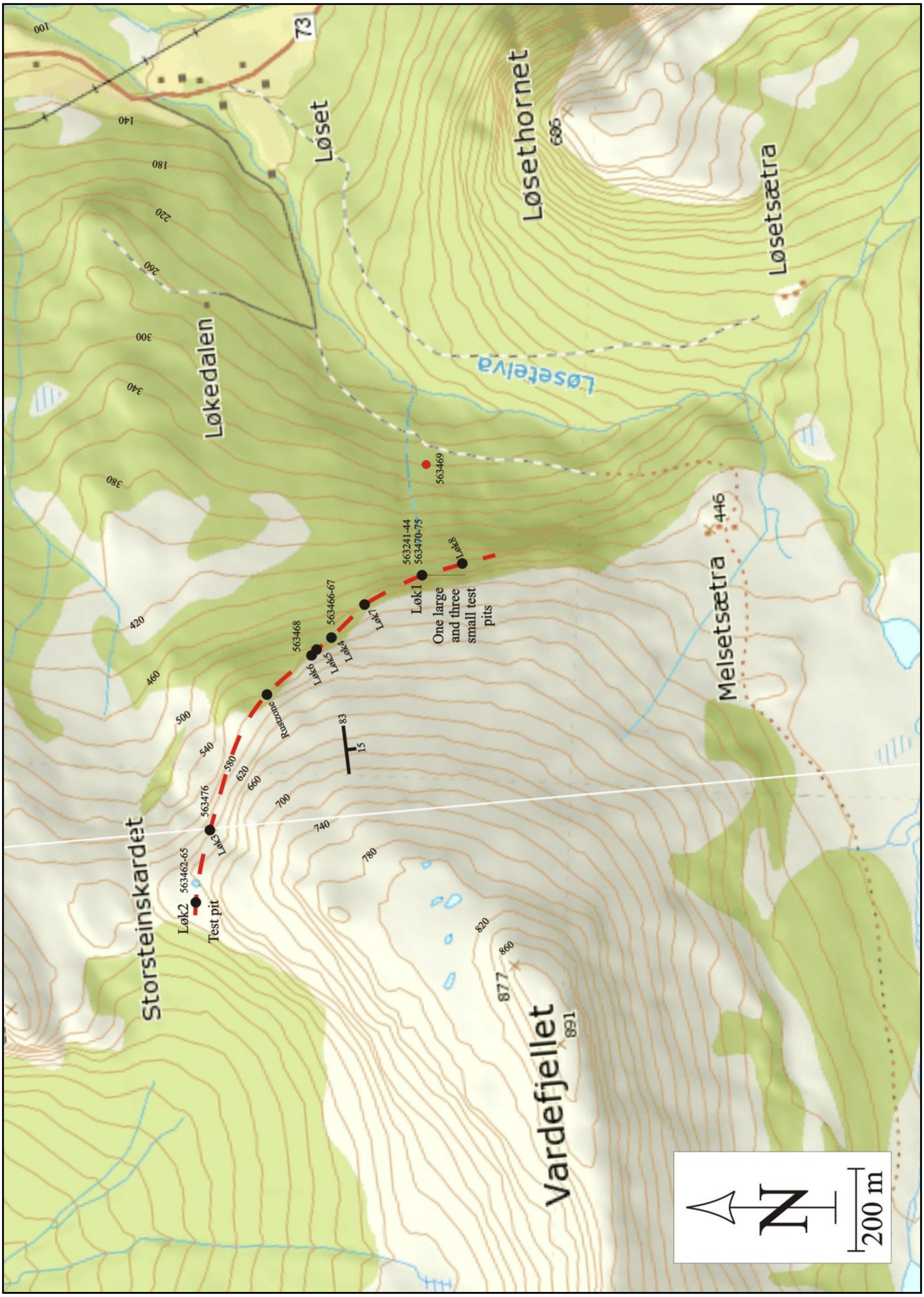


Figure 22: Løkedal. There are old workings at Løk1 and Løk2.Løk3-Løk8 are mineralized outcrops. The locations of NEAB's 19 ore samples are also shown. There is no actual mineralization at "Rustzone", just staining.

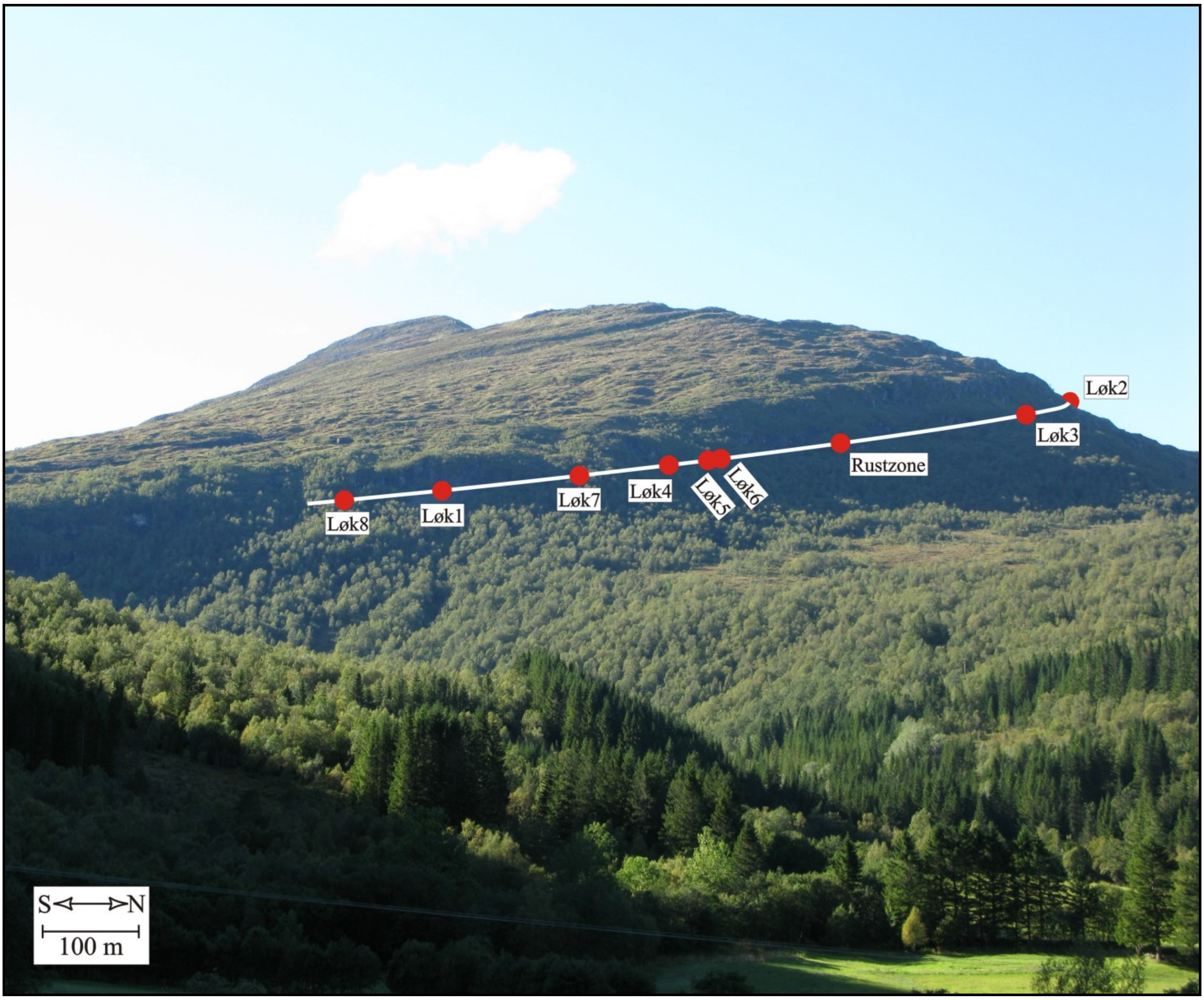


Figure 23: The 891 m high Vardafjellet, photographed from the East. It is seen that the structure hosting the mineralization is concordant with the gneiss' schistosity, and that it occurs in a quite steep part of the mountain.

In 2015 the mineralization was traced for more than one km along strike on Vardafjellet's east and north sides (figures 22 and 23). At the main old workings (Løk1, figure 24) the mineralization is in excess of 6.5 m thick (the uppermost and seeming quite low-grade, part was out of reach) across strike. Unfortunately, much of those 6.5 meters have little mineralization and there are convincing signs of the mineralization having been folded and upturned - at least part of it. Furthermore, it seems to have been thrusted upon itself by a biotite-filled fault which is best seen on the western side of the largest test pit. At the northern test pit (Løk2) the mineralization is c. 1 m thick with almost evenly distributed mineralisation. Elsewhere, at Løk3-Løk8, the mineralization is more or less out of reach (a ladder could in some cases make sampling possible) but my estimate is that it is less than 1 m thick and also of considerably lower grade (judging from the mineralized floats beneath the outcrops) than in the old workings.

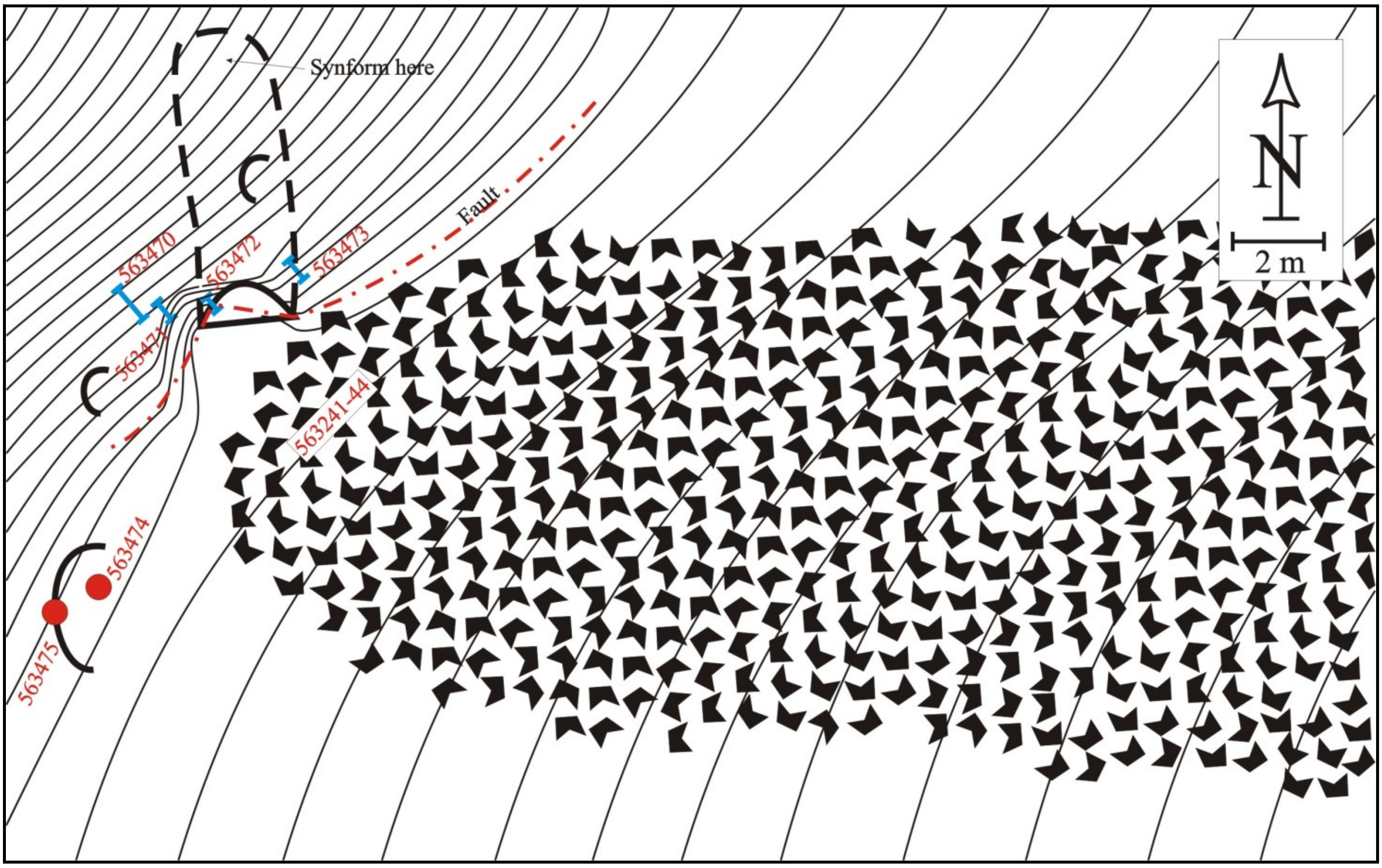


Figure 24: Sketch of the old workings at Løkedal 1. Contour lines are c. 1 m apart. Samples 563241-44 are selected samples from the dump. Samples 563475-6 are chip-samples consisting of selected parts of the mineralization. Samples 563470-3 each represents c. 2 m of mineralization across strike, in total c. 6.5 m. There is minor, inaccessible mineralization above sample 563470.

According to NGU's geological map (figure 25), the country host rock is quartz-dioritic or granitic gneiss. To me, some parts looked close to being a felsic volcanic.

Both in the outcrops and on figure 23, it is seen that the mineralization is concordant with the country rock's schistosity. The primary host rock is a very mafic (no plagioclase at all) dolerite which is unevenly mineralized with sphalerite, chalcopyrite, pyrite and sometimes minor bornite and/or chalcosite. Less common ore types are banded quartz veins with minor chalcopyrite, granitoid veins (pegmatite and aplite and everything in between occur) and quartz-feldspatic apophyses with chalcopyrite, pyrite and minor sphalerite. Overall, most of the sphalerite is in the dolerite while the granitoids and quartz veins have relatively more copper minerals and pyrite. Malachite and azurite is common on the outcrops, especially at Løk1 which can be seen c. 700 m away. Alteration includes silicification, chloritization, amfibolitization, biotitization and carbonatization, and probably more as the mineralization is quite heterogenous. Susceptibility was measured in and around the old workings at Løk1 and Løk2 but is everywhere below 30×10^{-3} SI units – i.e. unmagnetic for all practical purposes.

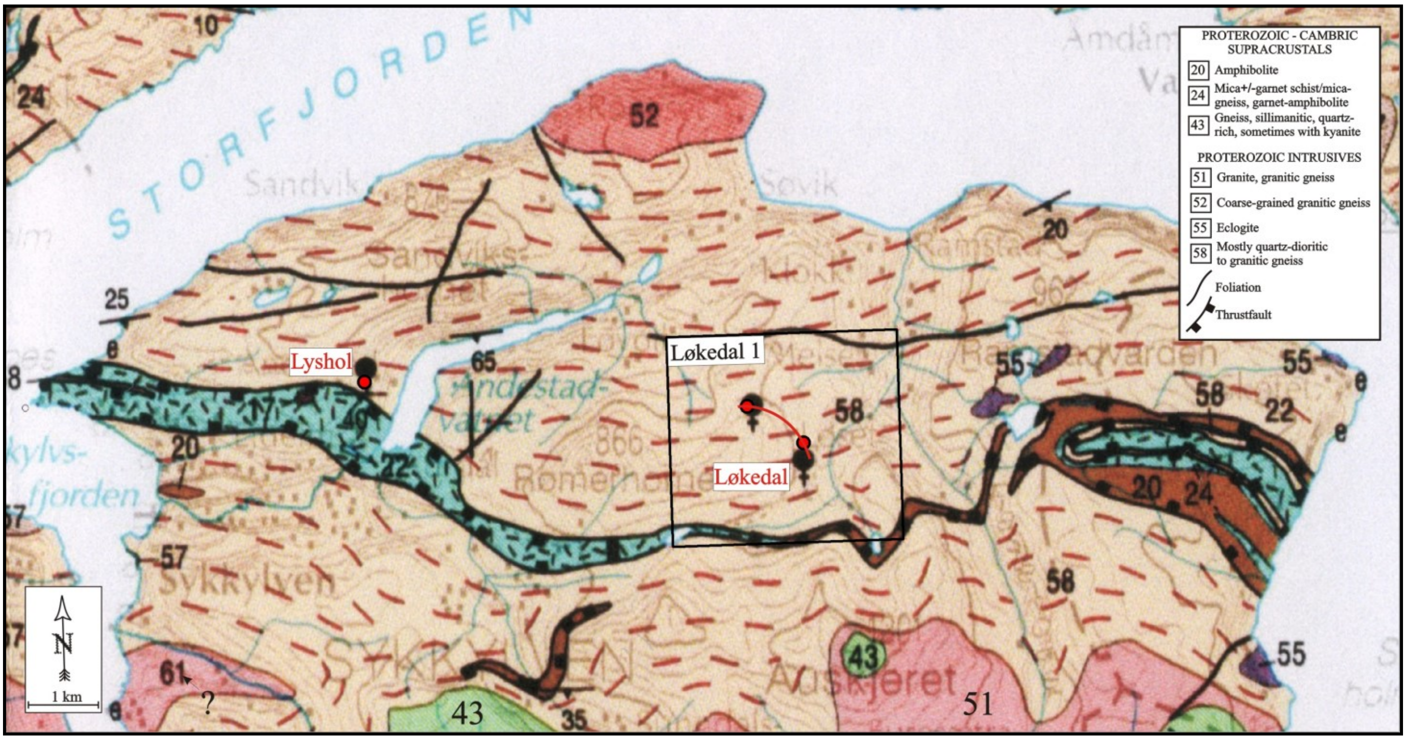


Figure 25: NGU's geological map and NEAB's Løkedal 1 exploration licence.

Figure 26: Sample 563464, dolerite with sphalerite and quartz-feldspatic vein. 0.8 g/t gold, 17 g/t silver, 0.8% copper and 2.4% zinc. The quartz vein looks like a tension gash.

Figure 27: Løkedal, sample 563469, banded quartz vein with 0.1 g/t gold, 324 ppm copper and 824 ppm zinc.

Figure 28: Løkedal, sample 563475. Brecciated quartz-feldspatic apophysis with plenty chalpopyrite and pyrite. It was hoped that this sample would have as much gold as a similar sample from 2010 with 26.5 g/t gold, but it only returned 0.6 g/t gold. Copper and zinc contents are 9.3% and 1.0%, respectively.

The association between dolerites and quartz-veins is quite common and can sometimes result in significant gold mineralization – e.g. on Bømlo (figure 1, island in lower left corner) in the Hardanger district. In Løkedal's case, one of 19 samples has signigicant gold content but on average the gold grade is only around 1 ppm. Some of the samples have reasonably high silver, copper and/or zink contents too but again the average is unimpressive. Løkedal's strike length exceeds 1 km and if it was not for the thick overburden to the west and the steep mountain side to the south, it could probably have been traced for much longer. Unfortunately, the low average thickness and grade of the mineralization makes further work difficult to justify. However, if one could convince oneself that Løkedal could be on the same structure as Lyshol 5.5 km to the west (figure 25), it could be of interest to carry out general reconnoisance and sediment sampling in the creeks between those two occurrences. The terrain in question is mountaineous and with little soil development – not unlike the Greenlandic Kirkespir valley with its Nalunaq gold deposit.

Another company, Norwegian Westpro, had from September 2012 to november 2014 a 2.06 km^2 large exploration licence covering the old workings at Løk1 and Løk2. Westpro's owners are amateur geologists primarily interested in gold panning. One of Westpro's owners, a Nicolaj Blindheim Brekke, told me that they had analysed a few samples from Løk1 but only found low gold grades of gold – much lower than NEAB's 26.5 g/t sample.

CONCLUSION

Regrettably, Vårlinuten was not located but another attempt could be done if NEAB for some other reason returns to the Hardanger district. Froastad, Augastad and Årsnes do not deserve more work but. Løkedal is not completely without interest and if times change for the better NEAB could consider spending a week more there.