NGU REPORT 2017.015

Geological, and ore dressing investigations of graphite occurrences in, Bø, Sortland, Hadsel and Øksnes municipalities, Nordland County, Northern Norway 2015-2016

GEOLOGY FOR SOCIETY

SINCE 1858

GEOLOGICAL SURVEY OF NORWAY

- NGU -

NORGES GEOLOGISKE UNDERSØKELSE
- NGU -

Geological Survey of Norway
P.O.Box 6315 Sluppen
NO-7491 TRONDHEIM
Tel.: 47 73 90 40 00

Report no.: 2017.015	**ISSN: 0800-3416 (print)** **ISSN: 2387-3515 (online)**	**Grading:** Open

Title:
Geological and ore dressing investigations of graphite occurrences in Bø, Sortland, Hadsel and Øksnes,municipalities, Vesterålen, Nordland County, Northern Norway 2015-2016.

Authors: Håvard Gautneb, Janja Knežević, Nils Egil Johannesen, Jan Egil Wanvik, Ane Engvik, Børre Davidsen & Jan Steinar Rønning.	**Client:** NGU / Nordland fylkeskommune
County: Nordland	**Commune:** Sortland, Bø, Øksnes, Hadsel
Map-sheet name (M=1:250.000) Svolvær	**Map-sheet no. and -name (M=1:50.000)** 1132-I Myre, 1322-I Stokmarknes 1232-IV Sortland
Deposit names (see below for grid-references)**:** Møkland, Sommarland, Haugsneset Kvernfjorddalen, Raudhammaren	**Number of pages:** 70 **Price (NOK):** 130,- **Map enclosures:**

Fieldwork carried out:	**Date of report:**	**Project no.:**	**Person responsible:**
2015-2016	14.03.2017	370800	

Summary:
This report describes 21 graphite occurrences in the Lofoten-Vesterålen area, including reviews of previous graphite investigations, the geological setting and analytical data related to analyses of graphite in the described occurrences. The graphite occurrences are situated in high-grade Archaean metamorphic rocks comprising quartzites, intermediate and mafic gneisses, iron formations, dolomites and graphite schist. This suite of rocks is intruded by a number of igneous complexes, mainly intermediate to acid charnockitic rocks and granites. The graphite-bearing units are strongly polyphasally deformed and dissected by the later intrusions. In the field the graphite bearing rocks are poorly exposed. The graphite-bearing layers are, in most cases, steeply dipping (60°-90°) There is a full cover of helicopter EM data and the distribution of the graphite-bearing units is, in general, known. Localities with graphite schist under thin cover were located using shallow-level ground geophysics (EM31) and selected localities were excavated. A total of 285 analyses of graphitic carbon show an average of 16.55 % Cg. The individual localities have average % Cg varying from ca. 6 % to > 23 %. The graphite is of good-quality flake graphite type. In thin section the sizes of individual graphite crystal can be seen to vary from 10 to >1500 microns, but crystals and aggregates of cm size are also common. Bench-scale beneficiation tests are positive and have shown that it is possible to produce a +150 micron flake concentrate containing 98.1 % C with good recovery. It is recommended to do further work (geological sampling, geophysical work and possibly drilling) on the following occurrences: Vikeid (Vedåsen), Raudhammaren, Romsetfjorden, Frøskeland (Grønjorda) and Kvernfjorddalen- Haugsneset. Analytical data for all samples collected related to graphite exploration are presented in tables. Thin section images of a number of localities and graphite schist varieties are also shown.
This report is the first of two: the second report will describe the ground geophysical results and details.

Deposit coordinates (UTM 33N): Møkland 486956 7587163, Sommarland, 487602 7626302 Haugsneset 488356 7619263, Kvernfjordalen, 488628 7622907, Raudhammaren, 505696 7642187.

Keywords: Mineral deposit	Graphite	Carbon
Mapping	Sampling	Electromagnetic measurements
Ore dressing	Mining	Scientific report

Table of Contents

FIGURES

All the photographs are taken by NGU staff unless otherwise stated.

TABLES

APPENDIX

Sammendrag på norsk

Denne rapporten er den ene av to som beskriver grafittundersøkelser utført av NGU i Vesterålen i 2015 og 2016. Den er ment som en oversikt og referanse for gruve-industrien og for prospekteringsselskaper som måtte være interessert i grafittforekomstene i området. Rapportens detaljer forutsetter derfor en viss geologisk kunnskap. Rapport nr. 2 vil omhandle geofysiske målinger. Det er også inkludert analysedata fra undersøkelsene i 1990-1994 for å gi en komplett oversikt over tilgjenglige data.

Som et resultat av NGUs helikoptermålinger i 2012 fikk man en mye bedre oversikt over de kjente grafittforekomstenes utstrekning. I tillegg ble det oppdaget en rekke nye anomalier som høyst sannsynlig er assosiert med grafitt. Disse sistnevnte ble befart på bakken og grafittmalmens utgående under tynt overdekke ble lokalisert med EM31. Interessante anomalier ble deretter grøftet og prøvetatt. Tre områder i Bø og to i Øksnes kommune ble vurdert som interessante. Disse er Møkland, Sommarland og Kvernfjordalen-Haugsneset i Bø og Smines og Raudhammaren i Øknses kommune. I tillegg ble Morfjord grafittforekomst i Hadsel kommune undersøkt. På disse stedene ble det gravd totalt 7 grøfter, prøvetatt og analysert totalt 110 prøver med hensyn til grafittinnhold (det ble også utført geofysiske bakkemålinger med SP, CP og resistivitet som rapporteres senere).

De undersøkte områdene har alle flere km lange geofysiske anomalier og har følgende gjennomsnittlige gehalter av grafitt: Møkland, 9.0 %, Sommarland, 7.7 %, Kvernfjordalen-Haugsneset, 15.2 %, Smines 9.5 %, Raudhammeren 16.5 % og Morfjord 18.5 %. Sammenlignet med nye grafittprosjekter i Canada, Mosambik og Madagaskar er disse gehaltene høye, internasjonalt har de fleste flakgrafitt-forekomstene som er under prosjektering en gehalt på fra 3-10 %.

I hele Vesterålen er de grafittførende bergarter de mest forvitrede og mest overdekkede. Dette vanskeliggjør muligheten for å kunne få et godt inntrykk av grafittens variasjoner langs strøket med hensyn til mektighet og gehalt. Det er derfor ikke gjort noe forsøk på beregninger av tonnasje i denne omgang. Ut fra størrelsen på de geofysiske anomalier kan man imidlertid si at mange av forekomstene i Vesterålen har sammenlignbare dimensjoner med det som er rapportert i nye grafittprosjekter internasjonalt.(www.investorintel.com/?s=graphite).

Det ble også utført benkeskala oppredningsforsøk, og resultatene fra disse er oppløftende. Ved bruk av ett trinn med primær mølling, flotasjon, deretter sekundær mølling og reflotasjon, ble det oppnådd produkter tilsvarende det som i dag produseres på Skaland. De grafittførende bergarter i Vesterålen har derfor gode oppredningsegenskaper. Tynnslipsundersøkelser viser at alle forekomstene har grafitt av flaktype med en kornstørrelse av grafittkrystaller fra 10 til 1500 mikron (noen ganger også større). Ved den rette mølling og frimaling kan en anta at de fleste forekomstene kunne produsere grafittkonsentrater til alle kornstørrelsesklasser som er på markedet i dag.

Den største utfordringen videre vil være å kartlegge tilstrekkelige tonnasjer som kan muliggjøre drift. Det anbefales derfor at undersøkelsene videreføres slik at man kan presentere en så fullstendig pakke med bakgrunnsinformasjon som mulig slik at private gruveselskaper får et godt grunnlag til å utføre nødvendig oppboring og tonnasjeberegning av de mest interessante lokaliteter.

Executive summary

Purposes:

- To investigate previously unknown graphite mineralizations associated with airborne geophysical anomalies.
- To review and compile the most relevant information and earlier data regarding graphite occurrences in the Lofoten-Vesterålen area.

This report is the first of two; a second report describing ground geophysical measurements.

Methods:
A number of showings were located from airborne or ground geophysics. These were sampled on outcrops or in trenches. The collected samples were analyzed for graphitic carbon. Graphite ore samples were tested metallurgically in bench-scale beneficiation trials. All the samples are of flake graphite type.

Findings:
The table below shows the analytical results from the different localities and sub localities:

Locality Sub-locality	**N (No of samples)**	**Average Cg%**	**Max Cg%**	**Min Cg%**	**St.deviation**
Vesterålen(aggregated)	**258**	**16.78**	**44.31**	**0.06**	**11.42**
Frøskeland	**2**	**6.90**	**9.90**	**3.89**	**4.25**
Grønjorda	2	6.90	9.90	3.89	4.25
Jennestad	**157**	**19.76**	**44.31**	**0.06**	**11.82**
Golia	8	17.60	32.78	5.69	11.16
Græva	20	29.52	39.65	1.30	12.25
Hornvann	71	22.07	44.31	0.06	12.55
Koven	10	15.16	26.13	0.85	8.97
Larmark gruve	5	9.72	12.7	3.18	4.11
Lille Hornvann	39	14.04	33.07	4.65	6.88
Vedåsen	4	14.16	16.66	11.50	2.13
Kvernfjord-Haugsnes	**16**	**15.16**	**33.82**	**0.12**	**10.50**
Haugsneset	11	19.30	33.82	10.60	9.44
Kvernfjordalen	5	6.06	13.70	0.12	6.32
Morfjord	**3**	**18.45**	**19.70**	**16.80**	**1.49**
Morfjord	3	18.45	19.70	16.80	1.49
Møkland	**37**	**9.04**	**25.70**	**0.06**	**8.22**
Møkland Trench 2-2015	7	9.29	18.30	0.03	8.70
Møkland trench 1-2015	16	7.91	25.70	0.03	9.31
Møkland Trench 1-2016	6	6.72	14.50	0.47	6.06
Møkland Trench 3-2016	8	13.98	22.30	5.76	5.70
Raudhammaren	**9**	**16.52**	**25.90**	**7.77**	**6.20**
Raudhammaren	9	16.52	25.90	7.77	6.20
Skogsøya	**12**	**19.96**	**34.20**	**0.40**	**10.48**
Skogsøya	10	19.29	34.20	0.40	11.43
Svinøya	2	23.35	24.90	21.80	2.19
Smines	**17**	**9.54**	**25.60**	**0.56**	**6.62**
Romsetfjorden	6	12.41	25.60	3.62	7.86
Smines	11	7.97	17.30	0.56	5.61
Sommarland	**5**	**7.74**	**17.13**	**2.83**	**5.78**
Sommarland	5	7.74	17.13	2.83	5.78

The area is a high-grade metamorphic terrain, which is favourable for formation of flake graphite deposits.

Most of the localities have outcrops of graphite-bearing rocks. It is, however, rare for outcrops alone to provide a good understanding of the thickness of the graphite units and their folding and deformation. The graphite-bearing units normally have steep dips, from 60°- 90°. Drilling would be necessary to get a good understanding of grades and tonnages.

Beneficiation trials have shown that the graphite ore can easily be upgraded to qualities and size fractions similar to those that are on the market today. Fraction sizes of +150 and + 300 micron concentrate have carbon contents > 98% C.

Recommendations

The graphite-bearing units in Lofoten and Vesterålen are, in general, so poorly exposed that further investigations have to include both geological and geophysical work.

We suggest follow-up on the following occurrences:
Vikeid (Vedåsen), Raudhammaren, Romsetfjorden and Frøskeland (Grønjorda), Kvernfjordalen - Haugsneset where geological sampling, geophysical measurements and some drilling is recommended.

In addition we recommend completion/extension of the geophysical work done on:
Møkland, Raudhammaren, Smines and Sommarland.

1. INTRODUCTION

This report is the first of two that describe NGU's investigations of graphite occurrences in the Vesterålen area in 2015 and 2016. A second report will emphasize ground geophysical work that has been done using Charge Potential (CP or Mise à la masse), Self Potential (SP) and resistivity methods on selected localities described in this report. These results will be reported independently in a separate report (Rønning et al. 2017).

Norway has been a major producer of graphite for more than 100 years. The geology in many parts of the country favours the formation of flake graphite deposits. Graphite is a common mineral in Norwegian rocks, but it is rare to find it enriched in economically interesting amounts. There are more than 70 registered graphite occurrences in Norway. They are located in four graphite provinces (Fig. 1). There has been graphite mining in all four provinces in the past. Only one deposit, the Skaland graphite mine on the island of Senja is currently in operation, producing about 9,000 metric tons of concentrate per year (Gautneb et al. 2016).

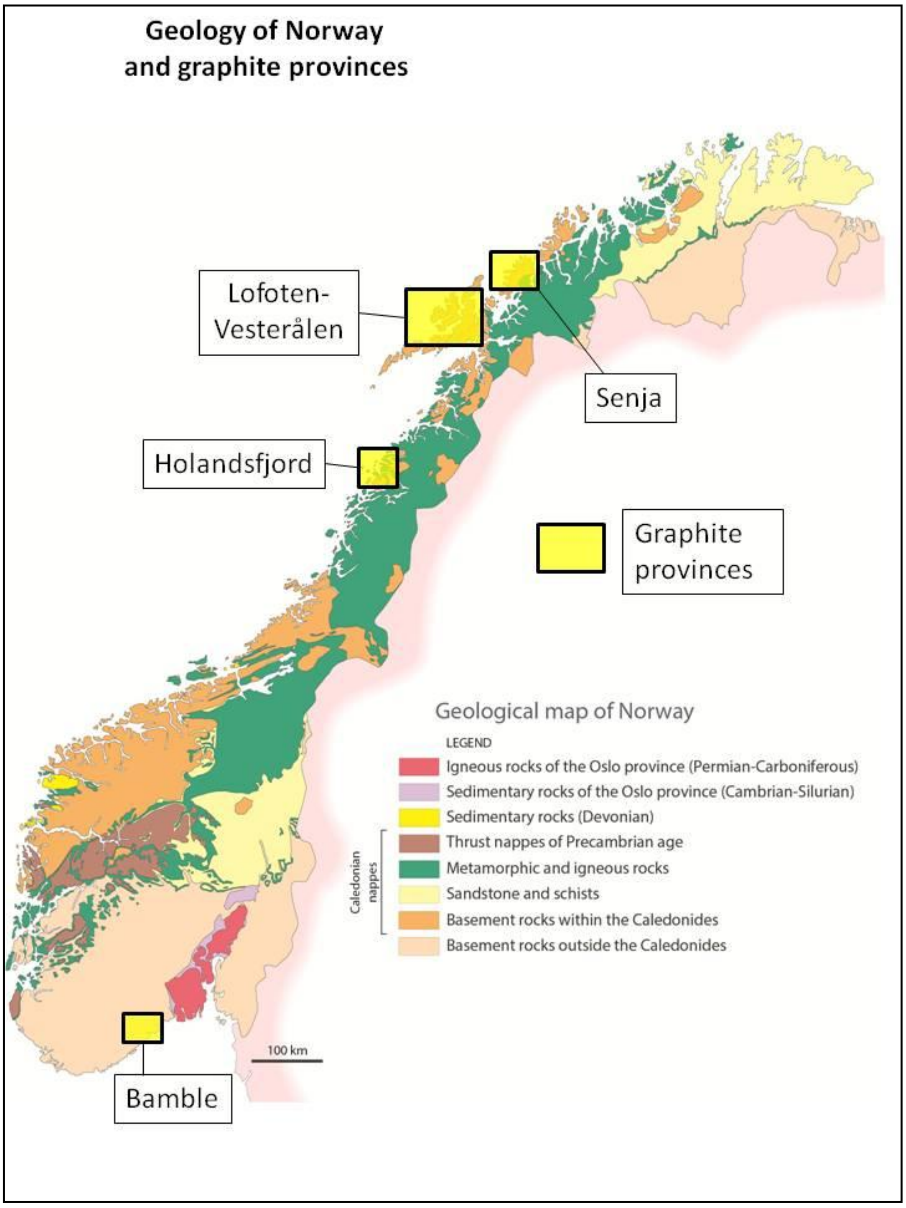


Figure 1. Geology of Norway with graphite provinces.

In this report we will present the data and results from graphite exploration in the Vesterålen graphite province, Nordland county, performed in the years 2015-2016.

For potential readers who are not familiar with this part of Norway and the graphite investigations, we will also give a summary of the previous graphite exploration, airborne geophysics, previous and on-going geological bedrock mapping.

We will, in each chapter, limit our descriptions to what is regarded as relevant for the graphite mineralisations. More academic types of study of the general geology and metamorphic petrology will be reported by others elsewhere.

This report is based directly on work by and cooperation with the following people:

- Håvard Gautneb, graphite geology and analysis, responsible field geologist
- Janja Knežević, graphite geology and ground geophysics, GIS
- Nils Egil Johannessen, ore dressing experiments
- Ane Engvik, geology, drill core logging.
- Jan Egil Wanvik, graphite geology, EM31 traversing (2015 season only)
- Børre Davidsen, regional geology
- Jan Steinar Rønning, geophysics, quality control and project leader.

1.1 Physiography and land ownership

The Lofoten and Vesterålen islands have a typical coastal climate with relatively mild winters. Snow can be expected from October to April. There are about two months of winter darkness and two months of midnight sun during the summer. Mining is possible throughout the year.

The land properties are, with few exceptions, private, and there are a number of small properties that belong to a number of different landowners. Prospectors interested in the area should check http://www.seeiendom.no/ for the cadastral map and the cadastral numbers of individual properties. Local municipality administrations will give information about the names and addresses of individual land owners. Permission is needed from the municipality to use motorised vehicles off-road.

Graphite is defined as a landowner's mineral in Norway and cannot be claimed in the same manner as metals. Permits or agreements with the landowners are needed if exploration is intended.

2. PREVIOUS INVESTIGATIONS

2.1 Investigations of individual deposits

The graphite deposits of Vesterålen were among the first to be described by geologists in Norway. Keilhau (1844) and Helland (1987) described several graphite deposits in Lofoten and Vesterålen, The occurrences had probably been known for some time. The British company, Anglo-Norwegian Mining, started mining in the Jennestad area around 1890 and the mine was in operation until 1914. During the same period a number of other occurrences was explored and subjected to test mining. The Møkland, Sommarland and Morfjord occurrences were trenched and put into small-scale test production in this period.

The location of the different occurrences described in this report is shown on Fig. 2.

All of the graphite occurrences in Northern Norway were investigated in the early 1950s with respect to the co-occurrence of uranium with graphite. The results were negative for most of the uranium occurrences (Neumann 1952).

The Jennestad graphite mines were in operation from 1949 to 1960. About 700 m of tunnels was mined out during this period. A number of unpublished reports describe the geology in the mines and their surroundings (Skjeseth 1952, Vokes 1954) and Heier (1960) describes the regional geology.

In the 1970s W.L. Griffin and co-workers (1978) investigated the crustal evolution of the Lofoten-Vesterålen rocks. They concluded that the graphite-bearing rocks were part of a supracrustal sequence comprising: marbles, acid and basic volcanic rocks, banded iron formation and graphite schist. Polyphasal high grade (up to granulite facies) metamorphism and deformation have obscured most of the characteristics of the primary supracrustals and they are today mapped as various types of gneisses and migmatites (Griffin et al.1978 and references therein).

Part of Langøya was measured with airborne geophysics in 1988 (Mogaard et al. 1988). Only a part of this survey included electromagnetic measurements. Graphite occurrences in the Jennestad area were reinvestigated with sampling, drilling and ground geophysics in the period 1990 - 1994. A total 1100 m of drilling was performed on 15 different drillholes. At the Hornvann sub-locality proven reserves of 240,000 tons with a grade of 25% graphitic carbon (Cg) were mapped. (Gautneb & Tveten 1992, Dalsegg 1994, Gautneb 1993 & 1995, Rønning 1991 & 1993). This work was reviewed by Gautneb & Tveten (2000).

Corfu (2004 & 2007) performed radiometric dating, reviewed earlier work and studied the metamorphic evolution of selected rocks units from the Lofoten-Vesterålen area.

In 2012, the junior mining company *Norwegian graphite* re-investigated the Jennestad area, by mapping and drilling. Their reports are available up on request. The company found indicated reserves of 3.66 Mt with 10% graphitic carbon. The thickness of the graphite-bearing units is reported to be up to 34 meters. *Norwegian graphite* was liquidated in 2016.

NGU, as part of the MINN program (http://www.ngu.no/prosjekter/minn), carried out a new airborne geophysical survey, including electromagnetic measurements over the whole of Langøya (Rodionov et al., 2013). This survey resulted in a large extension of the area with potential graphite deposits, with a number of new geophysical anomalies, and is the basis for the investigations in this report. The airborne geophysical survey is reviewed in more detail in Chapter 2.1.

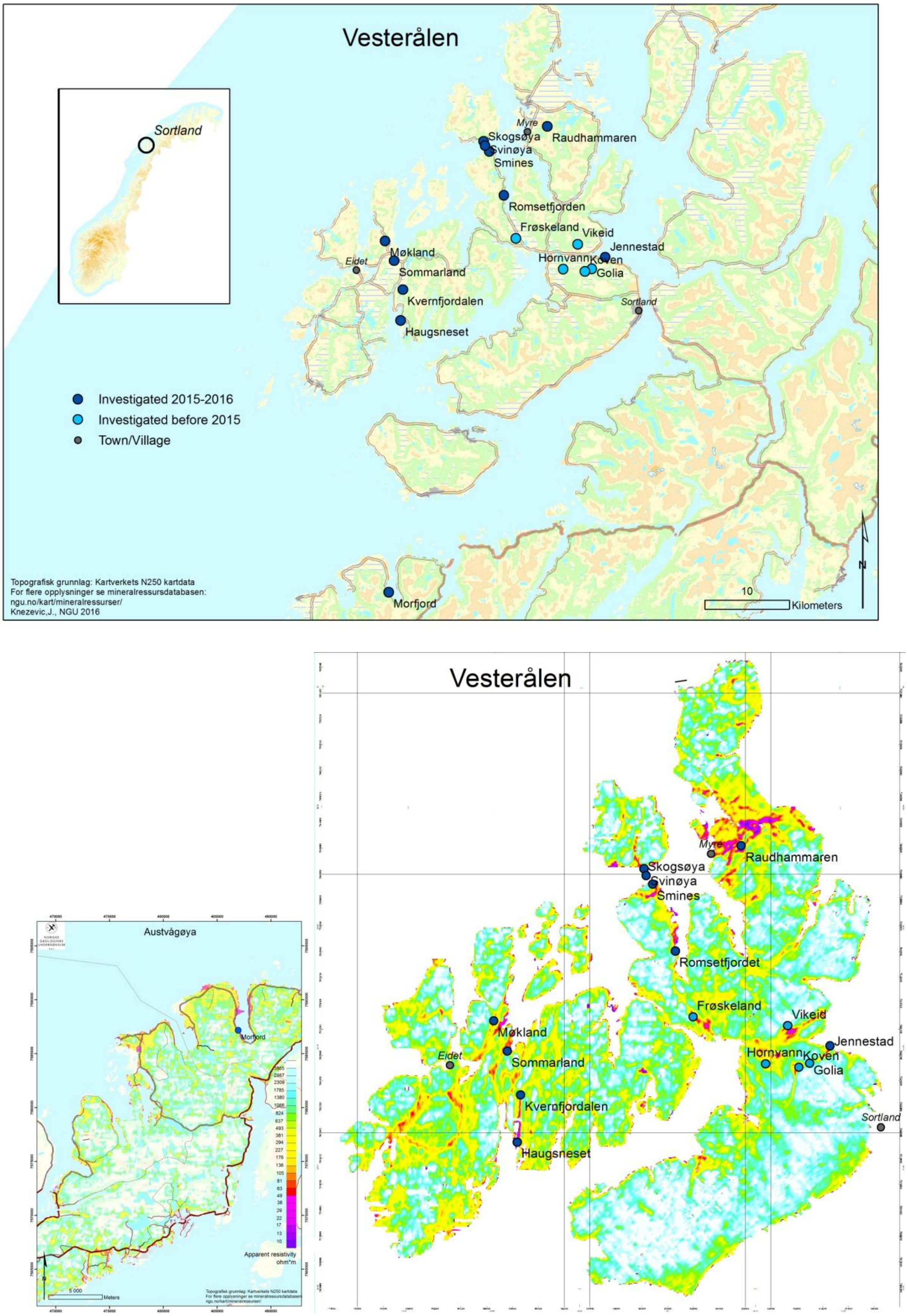


Figure 2. Maps of investigated localities (upper) and their association with geophysical anomalies (lower), The background is apparent resistivity calculated from frequency EM 7000 Hz (See Rodionov et al., 2013 for geophysical details).

NGU has, from 2012 to the present, carried out general geological mapping in the Vesterålen islands in order to get a better understanding of the geological evolution and more precise age determinations. Our present understanding of the geological setting of the graphite-bearing units is reviewed in Chapter 3. Gautneb et al. (2016) present a review of graphite in Norway, including the Lofoten and Vesterålen occurrences.

Palosaari et al. (2016) presented a mineralogical study, using SEM, XRD and Raman spectroscopy of graphite samples from Jennestad area. Their results showed that the graphite is crystallographically well ordered, fully crystalline, and free from internal defects.

2.2 Airborne Geophysics

A new helicopter-borne geophysical survey was performed, from July to August 2012, with a total of 5650 line km covering 1050 km^2. The full technical description, including details on processing of collected data is reported by Rodionov et al. (2013). The survey included the following instrumentation (Table 1). The EM instrumentation is the most useful in graphite exploration. Details about frequencies, coil orientations and coil separation are shown in Table 2.

Table 1. Instrumentation used in the helicopter-borne geophysical survey.

Instrument	Producer/Model	Accuracy	Sampling Frequency/Interval
Magnetometer	Scintrex Cs-2	0,002 nT	5
Base magnetometer	GEM GSM-19	0.1 nT	3
Electromagnetic	Geotech Hummingbird	1 – 2 ppm	10
Gamma spectrometer	Radiation Solutions RSX-5	1024 ch's, 16 liters down, 4 liters up	1 H
Radar altimeter	Bendix/King KRA 405B	± 3 % 0 – 500 feet ± 5 % 500 –2500 feet	1 H
Pressure/temperature	Honeywell PPT	± 0,03 % FS	1
Navigation	Topcon GPS-receiver	± 5 meter	1
Acquisition system	NGU in-house software		

Table 2. Configuration and frequencies of Hummingbird EM recorder.

Coils:	Frequency	Orientation	Separation
A	7700 Hz	Coaxial	6.20 m
B	6600 Hz	Coplanar	6.20 m
C	980 Hz	Coaxial	6.025 m
D	880 Hz	Coplanar	6.025 m
E	34000 Hz	Coplanar	4.87 m

The main results from this geophysical survey were a large extension of the area with potential graphite mineralisations, and a better definition of the areal extent of known occurrences. This was the basis for definition of new graphite targets to be followed up by ground investigations. Several of the occurrences described in this report were not known previously and were found using the airborne geophysics. An example of the EM map is shown in Fig.2 and full data can be downloaded from www.ngu.no.

3. GEOLOGICAL SETTING

The Lofoten-Vesterålen area in northern Norway is normally considered to be a part of the Baltic Shield. The graphite-bearing rocks in Vesterålen occur in sequences belonging to a Precambrian domain comprising Lofoten, Vesterålen and the western islands of Troms County (cf. Fig. 3).

The general outline of the geology was established in the 1960s and 70s, following work by Heier (1960) and W. L. Griffin with co-workers (Griffin et al., 1978 and references therein). In broad terms, the area is composed of an Archaean to possibly Early Proterozoic basement of magmatic and metasedimentary rocks, intruded by an Early Proterozoic magmatic suite composed of anorthosite-mangerite-charnockite-granite (AMCG) rocks. Subsequent radiometric dating has confirmed the presence of Archaean and Early Proterozoic rocks (Corfu 2004, 2007, Davidsen & Skår 2004). Most of the AMCG suite was intruded into the basement within a relatively narrow time interval; 1800 to 1790 Ma (Corfu 2004).

The supracrustal sequences are distributed as patches intermingled with the Archaean domains, with graphite-bearing rocks occurring with marbles, quartzites, banded iron formations and presumed felsic and mafic volcanic rocks. Polyphase high-grade metamorphism and deformation have obliterated most of the primary supracrustal features, and the sequence is now represented by various schists, gneisses and migmatites (Griffin et al., 1978 and references therein). The metamorphic event(s) reached peak conditions at P= 0.8-0.9 GPa and T= 860-880 °C (Engvik et al., 2016). The metasedimentary rocks and associated graphitic schists were thought to be of Early Proterozoic age (Griffin et al., 1978), but results from ongoing studies are less conclusive and hold open the possibility of an Archaean age for this sequence. The mapping resulted in the publication of the 1:250.000 map sheet Svolvær, covering the Lofoten and Vesterålen area (Tveten 1978).

NGU has, subsequent to the studies of W. L. Griffin and co-workers, continued local mapping activities, leading to the publication of the preliminary 1:50,000 map sheet Sortland (Tveten 1990) and the 1:250,000 map sheet Andøy (Tveten and Henningsen, 1998). In 1988 most of the island of Langøya was measured with airborne geophysics (Mogaard et al., 1988).

Some of these activities have been conducted as a part of the exploration for graphite resources in Vesterålen (Gautneb & Tveten 1992, Gautneb 1993). This work was reviewed by Gautneb & Tveten (2000).

Renewed activities in the Vesterålen area started in 2011 under the MINN programme at NGU (**M**ineral resources **I**n **N**orthern **N**orway), comprising general bedrock mapping and studies, airborne geophysics (Rodionov et al., 2013), and targeted mineral exploration. These activities have led to the discovery of several new graphite occurrences.

The units containing the graphite-bearing rocks are thus believed to be intermingled with Archaean rocks. This relationship is, however, not easy to observe in the field. Polyphasal deformation combined with granulite-facies metamorphism locally with anatexis, have obscured most primary contacts. The supracrustal units containing the graphite schists are also often intruded by younger intrusions. These field relationships are important as they have the consequence that the graphite layers and lenses in Lofoten – Vesterålen, even though airborne geophysical data can indicate a considerable size, are commonly cut by later intrusions and folds into parts with a limited size (areal extent). However, aggregated areas commonly represent interesting dimensions and conditions such as metamorphic grade are favourable for high quality graphite formation.

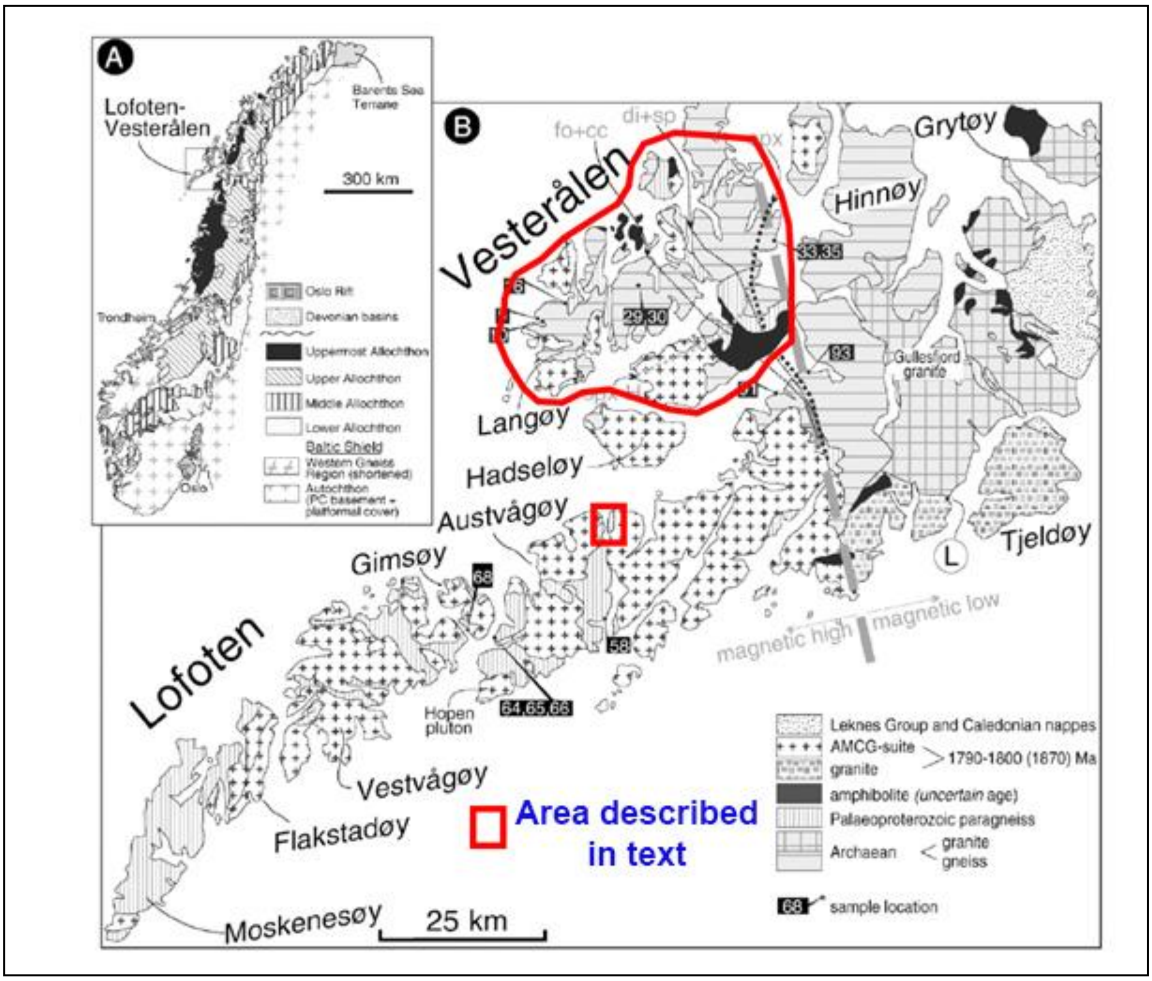


Figure 3. Simplified geological map of the Lofoten-Vesterålen islands (modified from Corfu 2007).

4. METHODS

4.1 Geophysical and geological methods

Electromagnetic measurements from helicopters in the Vesterålen – Lofoten area (Rodionov et al. 2013) show a lot of anomalies that can be caused by graphite. Some of these coincide with known graphite showings, others do not. Since the area is largely covered by soil, detailed geophysical measurements were necessary to locate possible new graphite mineralization. In our first attempt to map known and possibly unknown graphite deposits we used a Geonics EM31 instrument, which measures the apparent electric conductivity down to 6 – 7m. This is a very effective method for locating unexposed graphite deposits, and we experienced almost 100 % success rate through excavation.

Trenches were excavated based on EM31 data and the underlying graphite deposits were unveiled. The graphite schist is always deeply weathered and it is very rare to find unweathered rocks in the trenches. Several samples, as representative as possible, were collected from each trench and also from graphite exposures.

Figure 4. Pictures showing the EM31 electromagnetic recorder and trenching where conductors are located below soil cover (Photo: left Bladet Vesterålen, right NGU).

At localities where topographic relief makes it impossible for excavators to operate and where geophysical traversing is difficult, collection of graphite samples found in scree material was the only way to get an indication of the graphite content in the unexposed ore. This method was used particularly on the Raudhammaren occurrence (Chapter 5.6).

4.2 Analytical methods

Samples from trenches and outcrops were crushed using standard methods. The powders where analyzed for total carbon (TC) and total sulphur (TS) using a Leco SC-632 analyzer. The detection limits are 0.06 % and 0.02 % for carbon and sulphur respectively. The analytical uncertainty at 2 σ level is +/-15 % relative. The aggregate results for all samples are shown in Appendix 2 and are also attached as an Excel file.

The graphite industry uses the term "graphitic carbon" (Cg) when reporting graphite occurrences. This type of analysis is essentially the same as "total organic carbon" (TOC) but includes an extra step in which inorganic carbonate minerals and organic matter are removed by the use of acid and by roasting the sample before using a Leco carbon analyzer. In rock types with little or no carbonate minerals and organic matter, analyses of total carbon (TC) would be similar or close to TOC and graphitic carbon (Cg) but the former is much cheaper and faster. The commercial laboratory procedures for TC, TOC and Cg analyses are described by, e.g. www.alsglobal.com . The justification for use %TC as a proxy for %Cg is given in chapter 5.1.2.

Whole-rock major elements where determined by XRF using standard methods.

A number of standard thin sections where made from different occurrences. The modal content of graphite in the thin sections was measured using the ZEN 2 pro program from Zeiss.

Analytical results are listed in Appendix 1 and 2.

5. INVESTIGATED LOCALITIES

The investigated localities and investigated graphite provinces are shown in Fig. 2. These localities were selected for further investigation based on one or more of the following criteria: a) Airborne geophysics indicating new mineralisation, b) Exposed rocks showing a good grade of graphite and c) Localities with a favourable location relative to houses and infrastructure.

5.1 The Møkland area

5.1.1 Trenching and sampling

The Møkland area is situated 1.5 km NW of Kråkberget. A small country road goes through the area, making access fairly easy. Apart from one small showing, the graphite mineralisation in the Møkland area is completely covered by soil. Close to this locality the remains of the Møkland claim, from the exploration in the 1890s, can be seen. This claim is briefly described by Neuman (1952). It consists of a nearly 5 m long trench dug perpendicular to the strike of the graphite schist.

The following work was done at selected places over a distance of about 2.5 km:

- Traversing with EM31
- Excavation of six trenches (graphite ore where found in four)
- Trench sampling
- Drilling of two 50m long drillholes (only one reached the graphite, described in Chapter 5.1.2)
- Analyses of collected graphite ore

Three trenches was excavated in 2015 and three in 2016, their numbers are 1-, 2-, 3-2015 and 1-, 2-, 3-2016 respectively.

The locations of the trenches, sample points and EM31 traverses are shown in Figures 5 and 6. It is clearly seen that an EM31 anomaly follows the apparent resistivity anomalies from helicopter measurements show in the background. We found graphite schist with apparent thicknesses from 3 - 8 m in the different trenches (except 2-2015 and 2-2016). The contact with the country rock is usually very poorly exposed. The internal variation between high and lower contents of graphite within the graphite-bearing zones is rarely exposed in detail. However, it is clear that the mineralised zones typically consist of a mixture of very graphitic zones and lower-grade ore. The gangue minerals are dominated by quartz and feldspar. The ratio between quartz+feldspar and graphite is the relationship that determines the carbon content in the rock. In the trenches the graphite schist is in generally very weathered (Fig. 7) and it is rare to find unweathered samples. Before unweathered rock can be found, 1-2 m of weathered rock would probably have to be blasted away. Outcrop of graphite schist was found at only one surface outcrop (close to trench 1-2015): at this locality the graphite content (% Cg) was ca.19 % (Fig. 8).

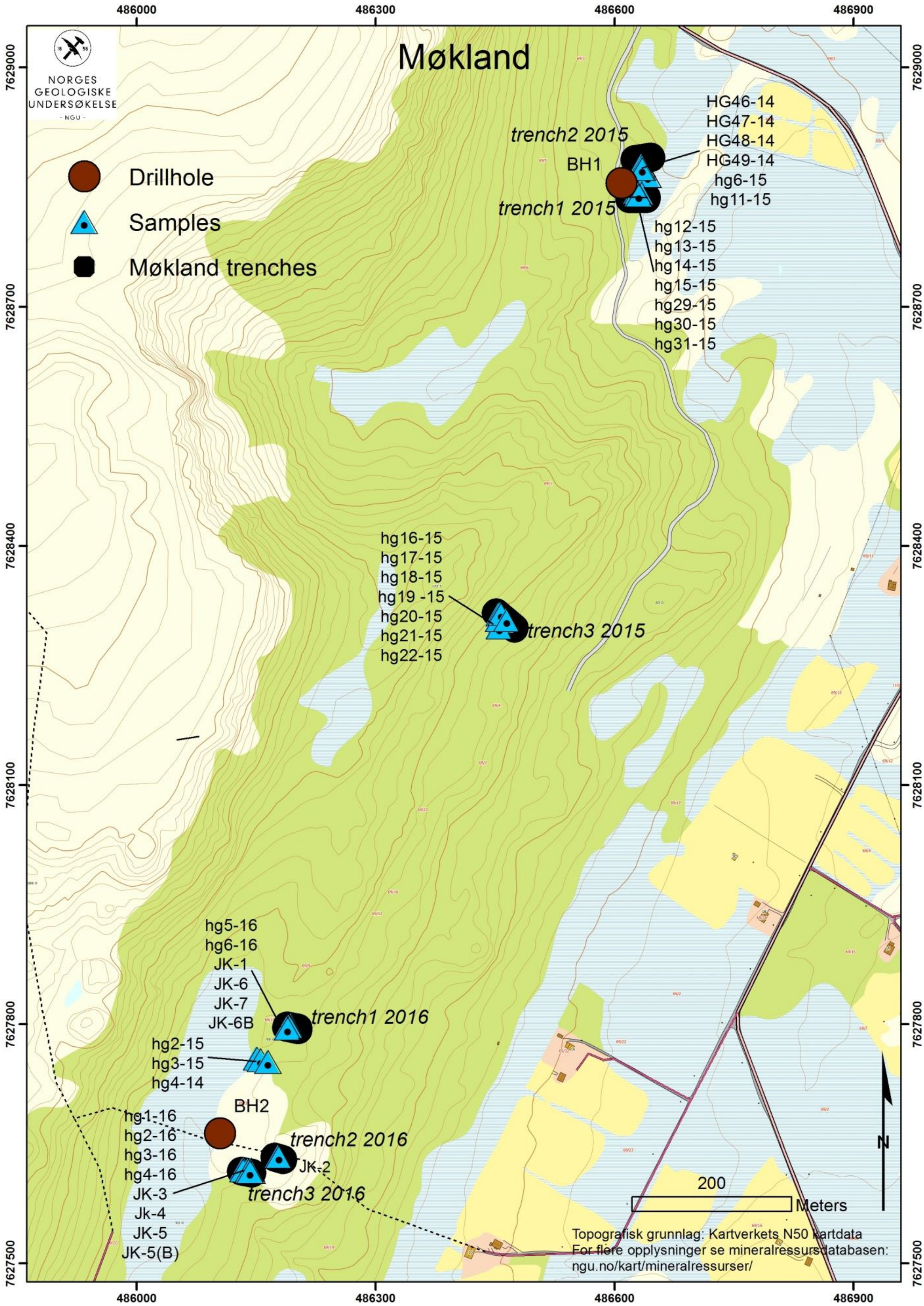


Figure 5. Map of the exploration area on Møkland, with the location of trenches, sample points and drill holes

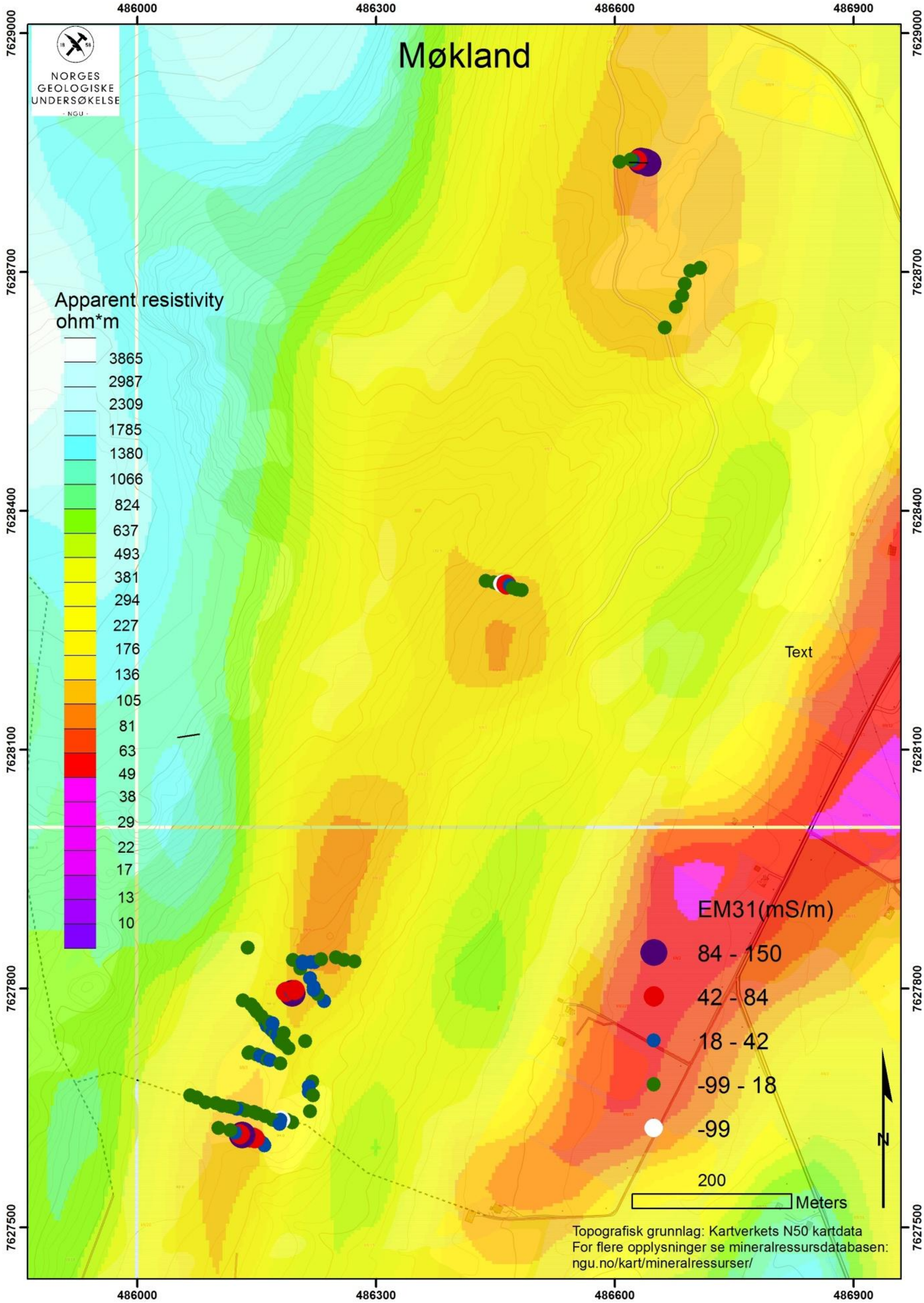


Figure 6. Map EM31 traversing, background is apparent resistivity calculated from frequency EM 7000 Hz (modified from Rodionov et al. 2013). For the EM31, a reading of -99 means a negative peak value.

Figure 7. Photos showing typical weathered graphite rocks, as they appear in the Møkland trenches.

A total of 38 samples of graphite ore from the different trenches in the Møkland area were collected in 2015 and 2016. These samples have average contents of graphitic carbon (Cg) of about 9 % (Tab. 3). Our samples include both very rich ore samples and low grade zones within large graphite veins and show a spread in graphitic carbon from 25 % to 0.03 % Cg. Low grade samples < 1 % Cg would obviously not be regarded as graphite ore, they are included to illustrate the heterogeneity of the graphite-bearing zones and will contribute to a more realistic average in this and the other localities that are described below.

Figure 8. Outcrop of graphite schist close to trench 1-2015 at Møkland.

Table 3. Analysis of graphitic carbon (Cg) from the Møkland area.

Locality Sublocality	**N**	**Average**	**Max.**	**Min.**	**St. dev.**
Møkland (aggregate)	**37**	**9.04**	**25.70**	**0.06**	**8.22**
Møkland Trench 1-2015	16	7.91	25.70	0.03	9.31
Møkland Trench 2-2015	7	9.29	18.30	0.03	8.70
Møkland Trench 1-2016	6	6.72	14.50	0.47	6.06
Møkland Trench 3-2016	8	13.98	22.30	5.76	5.70

5.1.2 Core drilling

One hole, close to trench 1-2015, was drilled with the purpose of penetrating the exposed ore in the trench and outcrop (Fig. 5) and to get fresh samples for study. NGUs truck-mounted drilling equipment has the ability to drill down to a maximum of 50 m at localities where there are road access. One single drillhole cannot be used in any resource estimation.

The coordinates of the drillhole are given in Table 4 and the drill core description and analysis given in Tables 5 and 6 respectively.

Table 4. Collar information, drill hole BH1 at trench 1, Møkland

Easting	**Northing**	**Altitude m.a.s.l.**	**Azimuth**	**Dip**
486609	7628855	58	090 deg	60 deg

Table 5. Description, Drill hole BH1 from Møkland

From (meter)	To (meter)	Description
0	7	Quartz-feldspar rock
7	10	Pyroxene and amphibole rock
10	23.8	Quartz-feldspar rock
23.8	26	Fault gouge
26	27.3	Massive graphite schist
27.3	33	Quartz-feldspar rock, graphite-bearing
33	50	Quartz-feldspar rock

Both the hanging wall and the footwall of the graphite ore consist of what has been called quartz-feldspar rock. This rock type is a medium-grained rock containing abundant quartz and orthoclase and secondary biotite, ortho- and clinopyroxene and variable amounts of graphite. It is characteristic for all occurrences of graphite schist that it is associated with the occurrence of quartz-feldspar-rich rocks that has, by some workers, been described as granitoid gneiss. This rock was most probably initially organic-rich, arkosic sandstone (Griffin et al. 1978).

Table 6. Analyses of TS, TC and TOC from BH1, close to trench 1-2015.

Sample name	Depth	TS	TC	TOC
BH1BØ2.70	2.70	0.01	0.03	0.05
BH1BØ7.70	7.70	0.01	0.03	0.05
BH1BØ9.30	9.30	2.80	0.0620	0.05
BH1BØ18.50	18.50	2.70	0.120	0.05
BH1BØ26.30	26.30	0.950	13.0	15.0
BH1BØ26.50	26.50	3.00	0.380	0.390
BH1BØ28.90	28.90	1.00	5.90	6.10
BH1BØ30.10	30.10	2.20	14.0	14.0
BH1BØ30.60	30.60	1.90	32.0	32.0
BH1BØ32.60	32.60	6.10	0.290	0.120
BH1BØ35.30	35.30	0.200	0.061	0.05
BH1BØ36.40	36.40	3.00	0.200	0.100
BH1BØ42.10	42.10	0.130	0.03	0.05
BH1BØ43.90	43.90	0.01	0.03	0.05

From about 26 - 31 m below the collar there is good quality graphite schist, reaching levels of total carbon of up to 32%. From these analyses it is also evident that analyses of TC and TOC are either similar or differ within analytical uncertainty for most samples. The rock thus contain very little carbonate and TC can be used synonymously for Cg.

Drill hole 2 (BH2) did not reach the expected graphite lenses that where trenched in trench 3-2016 and contains homogenous pyroxene-gneiss. Consequently it was not sampled, or analyzed.

5.2 The Sommarland area

Neumann (1952) describes that he found remains of several old and overgrown trenches south of the Sommarland farms: none of these were found today. The area is heavily covered with soil and provides pasture for several nearby farms.

5.2.1 Geological observations

A small outcrop is found ca.150m W of the Sommarland farm. Five samples with an average content of graphitic carbon of 7.74 % and a max-min spread from 17.13 % to 2.83 %. The overburden makes additional observations difficult, but it is clear that the graphite schist is part of a rock unit that mainly consists of pyroxene gneisses. NGU's drilling equipment did not allow (did not reach) penetration to the outcropping graphite ore at depth. The agricultural fields and other vegetated areas in the Sommarland area coincide with a quite large geophysical anomaly that is more or less continuous from Kråkberget to South of Sommarland (Fig. 2). The fact that Neumann (1952) found the abandoned trenches from earlier exploration and new geophysical data (chapter 2.1 and Rodinov et al.2013) show that there are, in all probability, more graphite-bearing rocks in this area, though with unknown dimensions and contents of graphite. A resistivity profile revealed a conducting structure that could be the dominant electric conductor just W of the Sommarland exposure (Rønning et al. 2017). The extensive overburden makes it difficult to investigate this in detail, unless one uses more detailed ground geophysical measurements, and subsequent drilling and or trenching.

5.3 Kvernfjorddalen-Haugsneset area

5.3.1 Geological observations

The Kvernfjordalen-Haugsneset area (Fig. 2) is a ca. 4 km long, almost continuous geophysical anomaly. In our database (www.prospecting.no) there are several occurrences; Kvernfjordalen, Haugsnesdalen and Haugsneset, all situated along strike in a N-S direction, on the same geophysical anomaly defined by helicopter-borne electromagnetic measurements (Fig. 9,10 and 11). Part of the area is relatively isolated and protected from residential areas. A 3-6 m wide, massive graphite ore body outcrops at several places in the southernmost part of the area and can be traced under thin cover several hundred metres along strike, using EM31 (Fig. 10). Just N of the Haugneset peninsula the graphite-bearing zone follows a ca. 1 km long small depression in the terrain that coincides with the asphalted road. Along this road the graphite ore can be seen in several road cuts. A single small outcrop is visible in the northernmost part of the area and the strike and distribution of the ore has to be found by ground geophysics: this will be reported in the second report (Rønning et al. 2017).

The samples collected along the strike of this ore body show that the ore is of good quality, coarse-grained and with a relatively high content of graphitic carbon (Table 10). The average Cg for the whole area is 15.2 % with maximum and minimum of 33.8 and 0.25 % respectively.

Figure 9. The Kvernfjord-Haugsnset area with sample points.

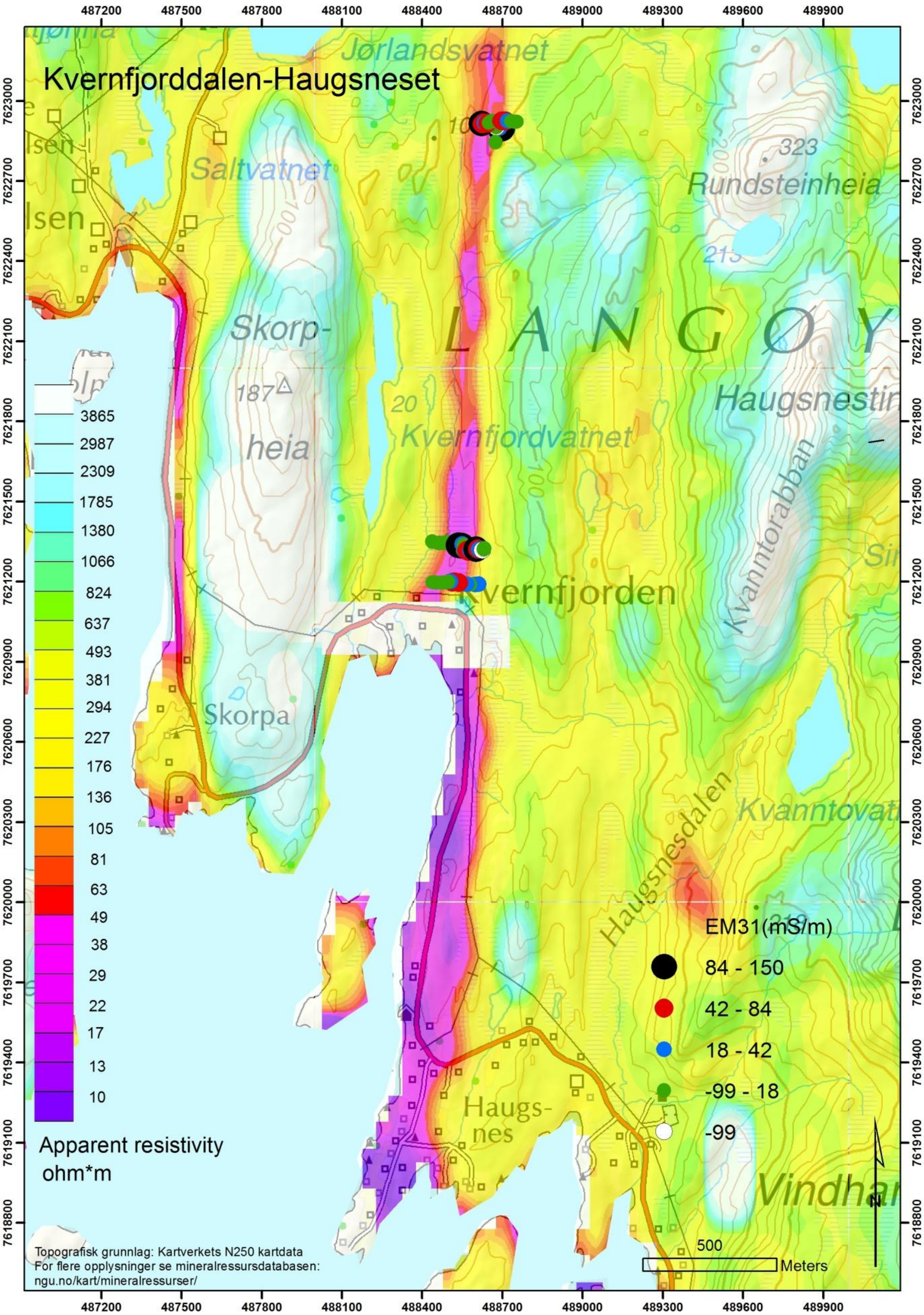


Figure 10. The Kvernfjord-Haugsneset area with EM31 profiles. -99 mean peak negative value. The background is apparent resistivity calculated from frequency EM 7000 Hz (modified from Rodionov et al. 2013).

Figure 11. Outcrop of massive graphite schist on Haugsneset

Table 7. Content of graphitic carbon at different localities in the Kvernfjord-Haugsneset area.

Locality Sublocality	No. of samples	Average	Max.	Min.	St. dev.
Kvernfjord-Haugsnes	**16**	**15.16**	**33.82**	**0.12**	**10.50**
Haugsneset	11	19.30	33.82	10.60	9.44
Kvernfjordalen	5	6.06	13.70	0.12	6.32

5.4 Smines

5.4.1 Geological observations

The location of Smines is shown on Fig. 2. This graphite occurrence was not known previous to its discovery when the 2012 airborne geophysical data became available. Apart from some small seaside exposures the graphite-bearing rocks are completely covered by soil. Traversing EM31 indicated several graphite-bearing conductors under thin cover and a trench was made in the area that was most accessible Fig. 12). Several zones of graphite schist were found: in the trench they have a width of about 6 m (Fig. 13).

Eleven samples from the trench show an average grade of 7.74 % Cg with a maximum of 17.13 %.

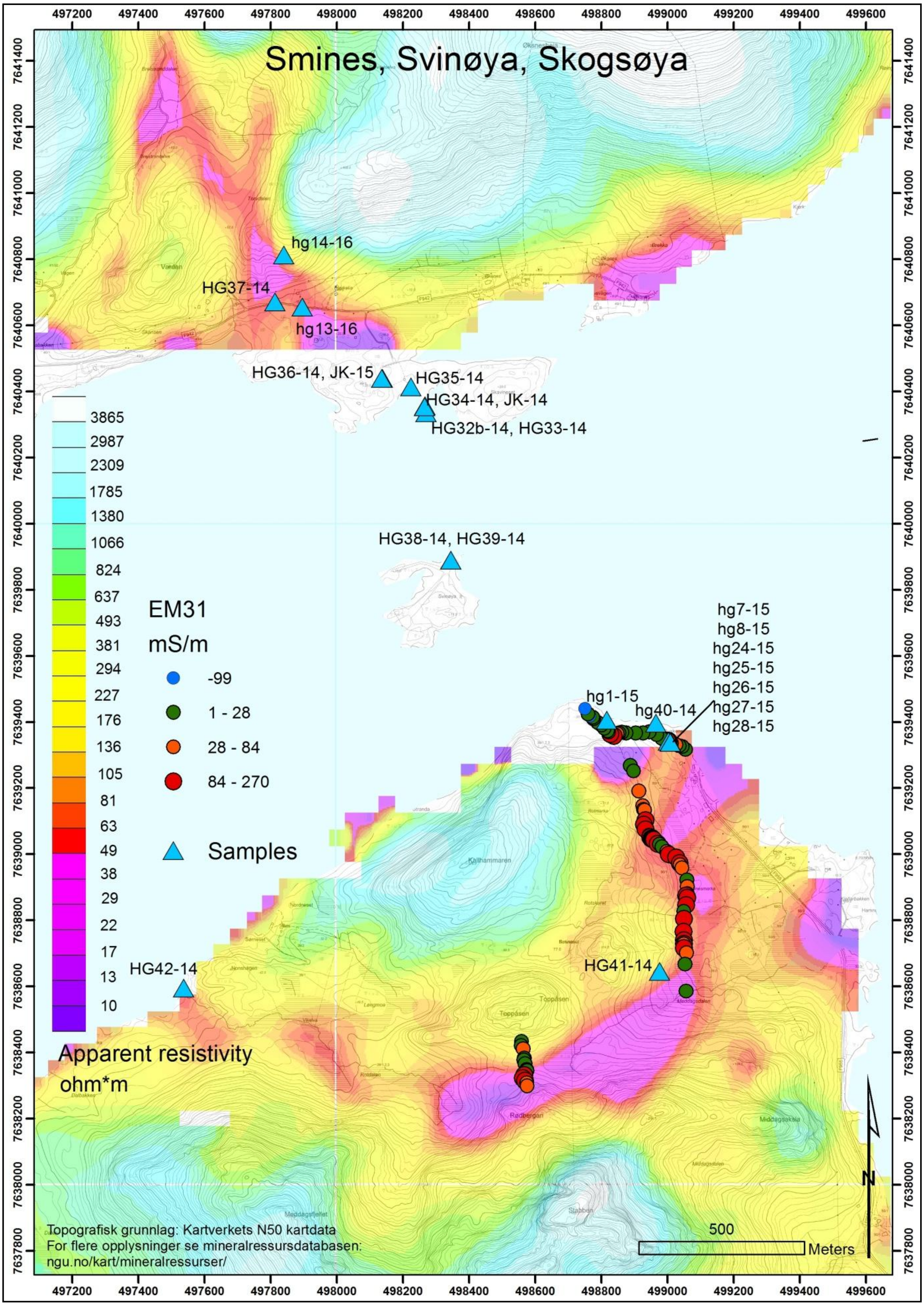


Figure 12. Map showing the sample points and EM31 traversing, The background is apparent resistivity from frequency EM 7000 Hz (modified from Rodionov et al. 2013). For the EM31, a reading of -99 means a negative peak value.

Figure 13 Trench at Smines with the graphite-bearing zone indicated

5.5 Skogsøya and Svinøya

Skogsøya and Svinøya are islands situated about 6 km SW of Myre and 1 km N of Smines. Graphite ore is found on the southern side of Skogsøya in outcrops along the shore. Graphite ore is found on the northern side of the small island, Svinøya (Fig. 12 and 14). These two localities are separated by about 300 m of sea.

Figure 14. Pictures showing the outcrops of the graphite ore on Skogsøya (left) and Svinøya (right). The graphite ore is approximately vertical and is outlined in red.

Svinøya is too small for the graphite mineralization to be of any economical significance. The localities shown in Fig. 14 are among the few places where a clear-cut relationship between the graphite ore and the country rock can be seen in the field. At these localities, the graphite ore is part of a rock unit comprising quartz-feldspar rich rocks (meta-arenites), which are, in part, quite sulphide-rich. These rocks occur as rafts within various gneissic rocks, which again are intruded by several generations of monzonitic and granitic rocks. Graphite bodies that otherwise would be continuous for several hundreds of metres are dissected and broken up into smaller parts by later intrusions. The outcrops at Svinøya and Skogsøya are among the few places where this important field relationship can be seen clearly.

The graphite ores at these two localities are high grade, showing an average carbon content of 19.96 %, with a maximum of 34.20 % Cg (Tab. 8)

Table 8. Content of graphitic carbon in samples from Skogsøya and Svinøya.

Locality/sublocality	N	Average	Max.	Min.	St. dev.
Skogsøya	**12**	**19.96**	**34.20**	**0.40**	**10.48**
Skogsøya	10	19.29	34.20	0.40	11.43
Svinøya	2	23.35	24.90	21.80	2.19

5.6 Raudhammeren area

Raudhammaren is a 400 m high mountain situated about 3 km SE of the town of Myre.

Graphite mineralization around the mountain has been known for some time and is briefly described in Gautneb & Tveten (1992). There is a strong geophysical EM anomaly around the top. The graphite-bearing rocks are almost completely covered, but a distinctive brownish color can be seen in soil and scree in the area corresponding to the geophysical anomaly. Graphite ore can be found as loose scree material over a quite large area on the western side of the mountain, particularly on the northern side of the airborne EM anomaly (Fig. 15 and 16). The geophysical anomaly has a size of about 500 x 400 m^2, however, this may consist of several graphite bodies.

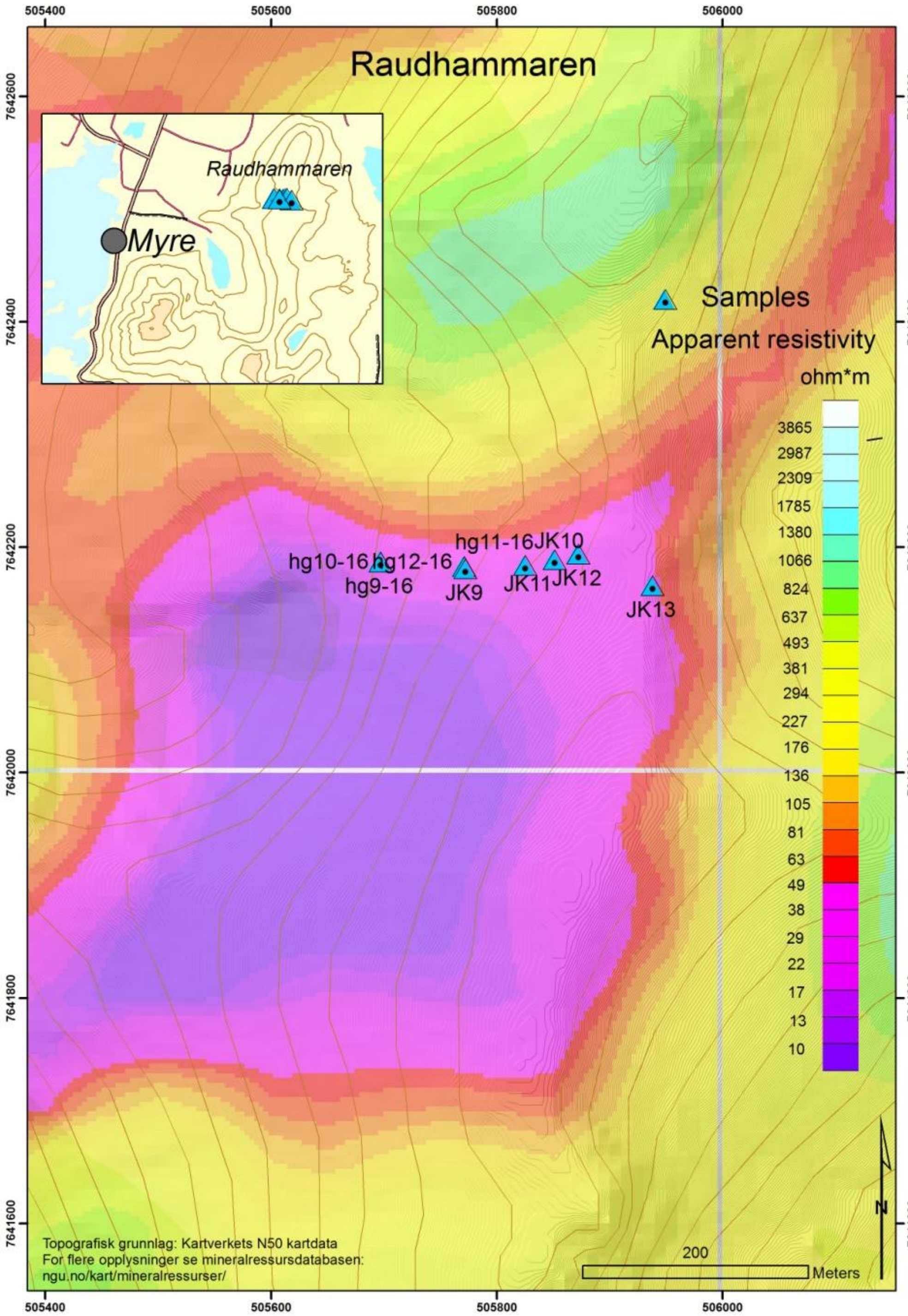


Figure 15. Sample points on the western slope of Raudhammaran mountain, The background is apparent resistivity calculated from frequency EM 7000 Hz (modified from Rodionov et al. 2013).

Samples from the scree show an average Cg of 16.5 %, with a maximum, minimum and standard deviation of 25.90 %, 7.77 % and 6.20 % respectively (Chapter 5.8 and Table 10).

The Raudhammaren area is obviously an interesting target for future investigations. Ground geophysics and drilling would be the appropriate methods for future investigations.

Figure 16. Top of Raudhammeren mountain with rusty, strongly weathered graphite-bearing rocks.

5.7 Other localities

5.7.1 Frøskeland (Grønjorda)

Close to Grønjorda farm W of lake Selnesvatnet, about 2.5 km W of Frøskeland (Fig. 2) a 1km-long helicopter-borne EM-anomaly was found. The area is almost 100 % covered. Graphite is found in some small road cuts along a forest road and in trenches close to the farm. The average carbon content is 6.90 % Cg. No ground geophysical data are available at present. The size of the anomaly makes this area interesting for more detailed work in future.

5.7.2 Jennestad area

The Jennestad area (Fig. 2) was the site of the mining from 1890 to 1914 and from 1946 to 1960. The area was described in detail by Gautneb & Tveten (1992 & 2000), Gautneb (1995), Dalsegg (1994) and Rønning (1991 & 1993). We have included data from 1990 to 1993 in Table 9 and Appendix 2, in order to make a complete data set available to readers. The area was also the main target area for the company Norwegian graphite's exploration activity in 2012-2013. Norwegian graphite's reports are available on request to the first author. Norwegian graphite was liquidated in 2016.

Table 9. Analysis of graphitic carbon collected from different localities in the Jennestad area in 1990 – 1993 and 2012-2016.

Locality Sublocality	**N (No of samples)**	**Average Cg%**	**Max Cg%**	**Min Cg%**	**St.dev.**
Jennestad (aggregated)	**157**	**19.76**	**44.31**	**0.06**	**11.82**
Golia	8	17.60	32.78	5.69	11.16
Græva	20	29.52	39.65	1.30	12.25
Hornvann	71	22.07	44.31	0.06	12.55
Koven	10	15.16	26.13	0.85	8.97
Larmark gruve	5	9.72	12.74	3.18	4.11
Lille Hornvann	39	14.04	33.07	4.65	6.88
Vikeid (Vedåsen)	4	14.16	16.66	11.50	2.13

The Hornvann and Græva deposits have 240,000 tons of proven reserves with an average grade of 25 %, reported in Gautneb (1995).

The Golia mine probably represents one the best localities for observing the geological setting of the graphite ore (Fig. 17): amphibolites and carbonates can be seen here as country rocks of the graphite schist.

Figure 17. Picture from the abandoned Golia mine.

At Koven, a newly built forest road has exposed a new graphite mineralisation (Fig.18).

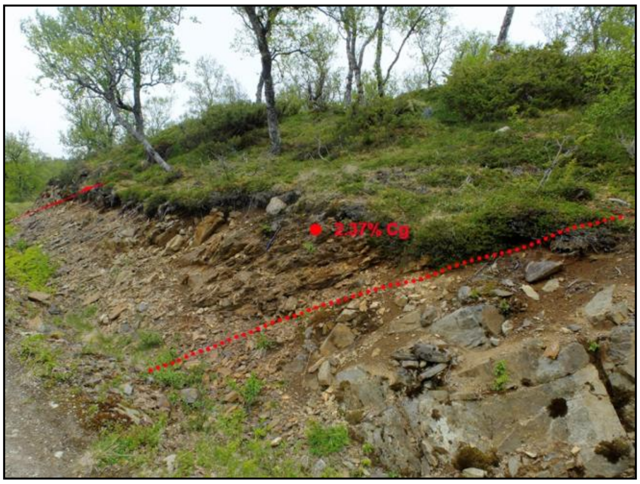


Figure 18. Road-cut at Koven with exposed graphite mineralisation and % Cg in a sample collected.

We believe that the Jennestad area, even though it was fairly well investigated previously, may still represent an attractive target for exploration.

5.7.3 Romsetfjorden

The Romsetfjorden graphite occurrences, found in several road cuts along the road from Frøskeland to Smines (Fig. 2), have not been reported before. Good quality flake graphite is found at several localities: our present data set includes samples with an average Cg of 12.41% and a spread from 25.60% to 3.62% (Fig. 19). Apart from the road sections and some profiles along the sea the area is almost completely soil covered. The high grade and good quality found should make this area a target for ground geophysics in the future.

Figure 19. Picture from one of the road cuts in Romsetfjorden, an example of the outcropping graphite schist.

5.7.4 Morfjord

The Morfjord mine is the only described locality on Austvågøy island (Fig.2). It is a mine that was in operation during the same period as the Jennestad mine (1890-1914). Today it can be seen as a ca. 30 m long adit (Fig. 20 and 21) which follows a ca. 2 m thick graphite ore. A clear airborne geophysical anomaly is associated with this locality and the ore can also be traced using EM31 for several hundred metres along strike: it is apparent that there are at least three mineralized zones. Further east, several dm-thick graphite zones are found in outcrop: they stop when intruded by mangeritic rocks. Neuman (1952) recommended that this occurrence should be investigated with ground geophysics.

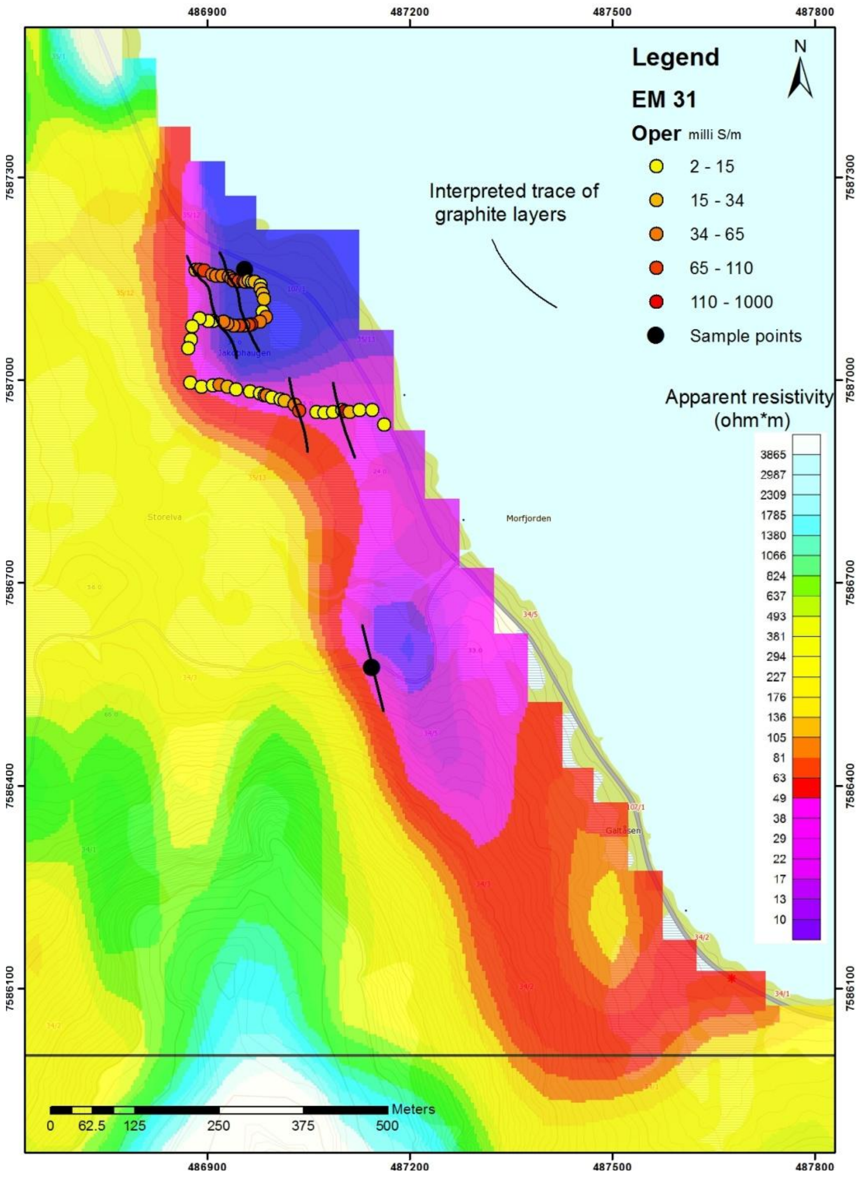


Figure 20. Map of the Morfjord mine area with interpreted mineralized zones, from EM31 measurements.

Figure 21. The Morfjord mine, Austvågøy.

5.8 Summary of chemistry and carbon analyses

In Table 10 we show a pivot table that summarizes all the analytical data from the different areas and their sub-localities.

These data show that there is quite a large variation in the content of graphitic carbon at almost all the localities. Variation from > 20% to below detection limit is normal. This is a consequence of our sampling in which we have tried to get a representative sample collection from the different locations within the same locality, Since the graphite ores are, in general, very inhomogeneous, samples with (almost) zero graphitic carbon that occur within otherwise high-grade ore lenses make the average lower. We believe that inclusion of the extreme outliers (in both directions) among the samples, will give more realistic average composition, and be a proxy for what could be expected in a mining situation when no drilling data are available.

Table 10. Pivot table showing the overview of all analyses of graphitic carbon from Vesterålen.

Locality Sublocality	No. of samples	Average (% Cg)	Max (% Cg)	Min (% Cg)	St.dev.
Vesterålen (aggregated)	**258**	**16.78**	**44.31**	**-0.06[1]**	**11.42**
Frøskeland	**2**	**6.90**	**9.90**	**3.89**	**4.25**
Grønjorda	2	6.90	9.90	3.89	4.25
Jennestad	**157**	**19.76**	**44.31**	**0.06**	**11.82**
Golia	8	17.60	32.78	5.69	11.16
Græva	20	29.52	39.65	1.30	12.25
Hornvann[2]	71	22.07	44.31	0.06	12.55
Koven[2]	10	15.16	26.13	0.85	8.97
Larmark gruve[2]	5	9.72	12.74	3.18	4.11
Lille Hornvann[2]	39	14.04	33.07	4.65	6.88
Vedåsen(Vikeid)[2]	4	14.16	16.66	11.50	2.13
Kvernfjord-Haugsnes	**16**	**15.16**	**33.82**	**0.12**	**10.50**
Haugsneset	11	19.30	33.82	10.60	9.44
Kvernfjordalen	5	6.06	13.70	0.12	6.32
Morfjord	**3**	**18.45**	**19.70**	**16.80**	**1.49**
Morfjord	3	18.45	19.70	16.80	1.49
Møkland	**38**	**9.04**	**25.70**	**-0.06**	**8.22**
Møkland Trench 2 2015	7	9.29	18.30	0.03	8.70
Møkland trench 1 2015	16	7.91	25.70	0.03	9.31
Møkland Trench 1 2016	6	6.72	14.50	0.47	6.06
Møkland Trench 3 2016	8	13.98	22.30	5.76	5.70
Raudhammaren	**9**	**16.52**	**25.90**	**7.77**	**6.20**
Raudhammaren	9	16.52	25.90	7.77	6.20
Skogsøya	**12**	**19.96**	**34.20**	**0.40**	**10.48**
Skogsøya	10	19.29	34.20	0.40	11.43
Svinøya	2	23.35	24.90	21.80	2.19
Smines	**17**	**9.54**	**25.60**	**0.56**	**6.62**
Romsetfjorden	6	12.41	25.60	3.62	7.86
Smines	11	7.97	17.30	0.56	5.61
Sommarland	**5**	**7.74**	**17.13**	**2.83**	**5.78**
Sommarland	5	7.74	17.13	2.83	5.78

[1]Detection limit is 0.06 %, error is +/- 10 % relative. [2]Includes data collected 1990-1993, See Gautneb & Tveten (2000) for references.

6. PETROGRAPHY OF THE GRAPHITE ORE

6.1 Mineralogy from thin sections.

Thin sections of a selected number of samples were made in order to understand the mineralogy of the graphite-bearing rocks. The graphite schist shows a considerable variation in grain size and texture, the latter mainly due to difference in degree of weathering.

Sample JK9 from the Raudhammaren deposit is representative, and illustrates particularly well the mineralogical characteristics of the graphite schist as seen in thin section (Fig. 22)

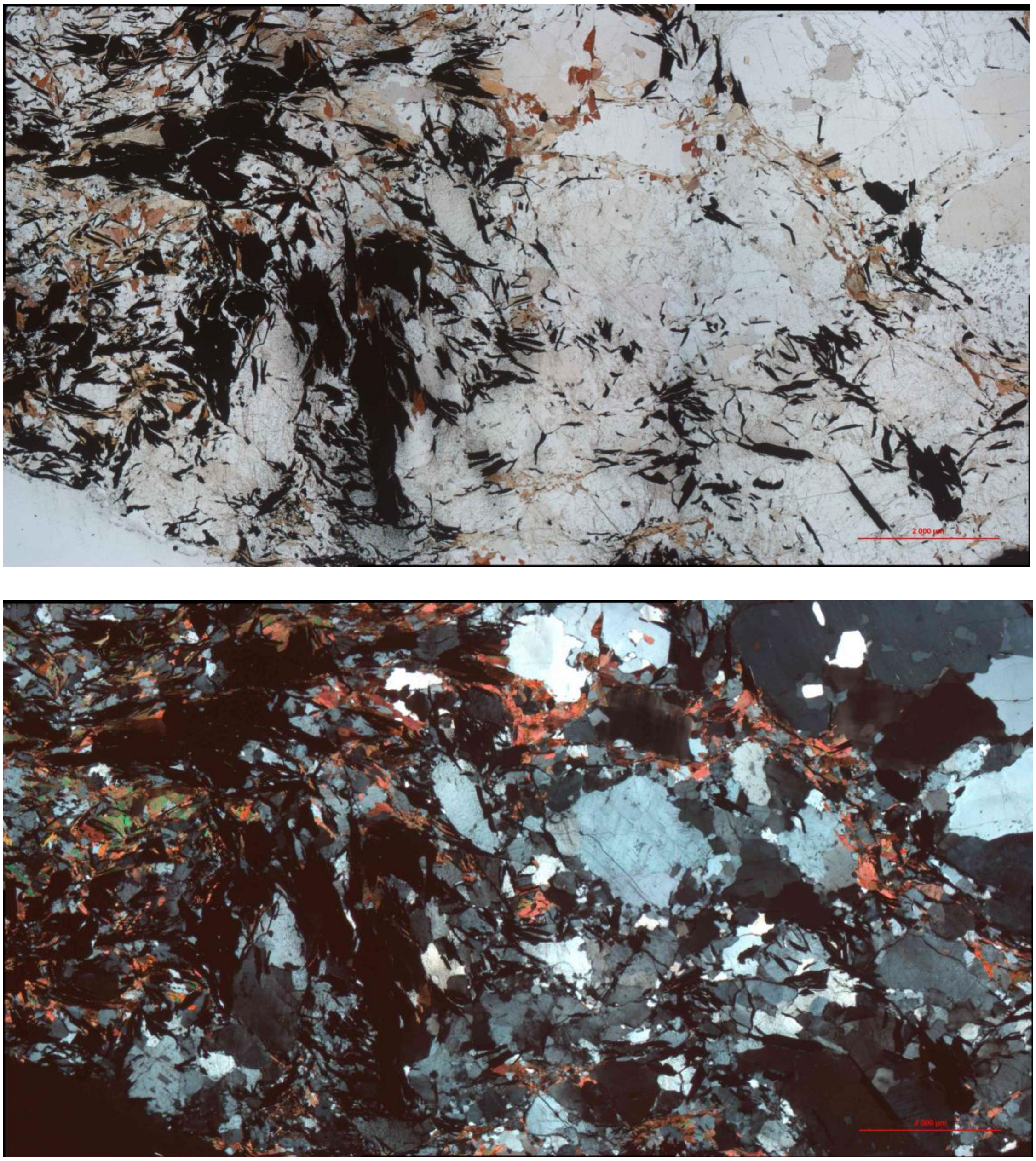


Figure 22. Thin section photos taken in parallel light and polarized light (bottom) (see text for discussion).

The photo in parallel light (Fig. 22 top) shows that the graphite crystals (black) characteristically show a large variation in grain size and an uneven distribution within a small area, in this case about 1.5 cm^2. The graphite crystals have well-developed crystal faces and partly occur as aggregates and partly as individual single crystals. The flake size (longest axis) of individual graphite crystals varies in general from 10 to ca. 1500 microns, but it is not uncommon to see aggregates of graphite crystals up to 1 cm in length. With the correct crushing and liberation methods the investigated rocks should permit production of all size fractions of flake graphite that are on the market today. The silicate minerals consist of quartz and feldspar (colorless) and subordinate amount of biotite (brownish colors). These silicate minerals are the main gangue minerals in the graphite ore. In polarized light (Fig. 20 bottom) the silicates are clearly visible and the grain size distribution of them can be seen more clearly.

6.2 Modal content of graphite in selected samples

Measurements of modal mineral content (volume %) with the use of image processing requires that the mineral in question is distinguishable from other minerals in the rock and that it has a uniform and characteristic color. This is the case in graphite schist since the graphite is opaque and because the percentages of other opaque minerals (sulphides and oxides) are, in general, very low compared to the amount of graphite.

We used the ZEN 2 pro program from Zeiss: the analysis involves the following steps:

- A picture in parallel light is taken: in our case we made a mosaic of several pictures to cover a larger area (a mosaic of 6 pictures covers an area of 1.5 cm^2 which corresponds to about one third of a standard thin section)
- The picture is segmented, that is the colors for graphite in the picture are selected. After several steps of correction and noise removal the modal (volume) percentage of graphite is calculated automatically.

This method is accurate and fast but one has to be an aware that only a small area of a thin section is examined, and the thin section again only represents a small (about 3 cm^2) area of a sample.

Other factors being equal, the volume percentage of graphite will always be different from (larger than) the weight percentage of graphite (% Cg in our analytical tables). Lists of the modal content of graphite in selected rocks from some of the described deposits are given in Table 11 and the pictures are shown in Appendix 3.

Table 11. Modal content and analyzed content of graphitic carbon from selected samples.

Sample	Locality	Modal graphite	% Cg
Hg31b_14	Frøskeland	27.80	17.7
Hg19_12	Haugsneset	15.92	15.17
Hg9_15	Koven	17.10	18.3
Hg20_15	MøklandTrench 2-2015	22.33	9.9
HG11_15	Møkland trench 1-2015	24.47	19
Hg47_14	Møkland trench 1-2015	29.41	26
jk1	Møkland Trench 1-2016	17.20	24.9
Jk7	Møkland Trench 1-2016	15.34	13.8
Jk5	Møkland Trench 3-2016	16.13	4.67
Jk11	Raudhammaren	18.29	13.3
Jk12	Raudhammaren	18.61	13.4
jk13	Raudhammaren	28.75	12.3
jk9	Raudhammaren	23.13	24.1
hg33_14	Skogsøya	25.92	11.2
hg36b_14	Skogsøya	39.08	24.5
jk14	Skogsøya	29.96	29.2
jk15	Skogsøya	18.37	18.8
hg40_14	Smines	32.27	13.8
HG7_15	Smines	24.32	18.1
hg38_14	Svinøya	15.86	0.43

It is evident that the Vesterålen graphite schist represents, in general, very rich (high-graphite content) rocks but that their graphite contents are very inhomogeneous. Samples of 1-2 kg size that have both a bulk Cg analysis and a thin section can show large internal differences. It is important that sampling is done so as to acquire a representative collection of samples at any investigated locality, which is not easy given the poor exposure and relatively deep weathering at most localities. The averages and statistics described in this chapter should be used with care and will, in all probability, be changed to more accurate data when systematic drilling has been carried out at any given locality.

7. GRAPHITE ORE BENEFICIATION TRIALS[1]

7.1 Introduction

A sample from the Møkland occurrence was sent to Sibelco for graphite ore beneficiation trials (Johannessen 2015). Sibelco was asked to perform a bench-scale beneficiation test, with the aim of getting an indication if this graphite ore could be beneficiated to produce valuable graphite concentrates.

- Two bench-scale trials with different crushing and flotation sequences were performed in 2015 at the Sibelco facilities at Glamsland in Lillesand.

[1] This chapter was translated to English from a memorandum originally written in Norwegian N.E Johannessen.

Thin sections show (Chapter 6) that the rock contains a high proportion of coarse-grained graphite, but also fine-grained graphite that would need a longer milling time for optimal liberation.

7.2 Beneficiation trials

The material received was crushed in a jaw crusher to < ca. 8mm and homogenised (Fig. 23). The sample was easily crushed and gave a visually observed enrichment of light coloured minerals in the finer grain fractions.

Figure 23. Crushed graphite schist before beneficiation trials.

Crushed rock was further split into 2.3 kg samples that were transferred to a rod mill. A 35 litre rod mill with 30 kg rust-free rods was used, with a pulp containing 45% solids. The milling time was 12 minutes (Fig. 24).

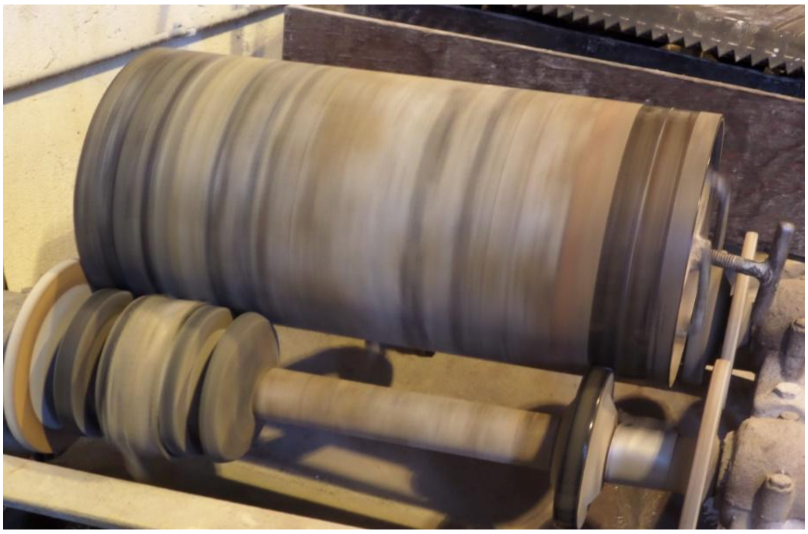


Figure 24. Laboratory rod mill used as primary mill in the trials.

Two milling runs were used for seven different flotation experiments, with the aim being to find the correct frother and dosage of the frother to get optimal graphite flotation and recovery. Aerophile minerals such as talc and graphite are very sensitive to the type and amount of frother added and the amount of paraffin used as froth enhancer. It is also important to create a froth that gives hydrophilic minerals the opportunity to sink back into the pulp. The flotation trials were performed in a Denver Lab machine (Fig. 25).

Figure 25. Denver Lab flotation machine.

Three of the flotation trials are described in more detail below:
- Trial no 5717: feed from 1.
- Trials No 5915 and 6015: feed from 2.

Steps in the flotation trials:
- Rougher flotation (tailing from rougher flotation is the main tailing)
- Flotation-cleaning step (cleaner tailing)
- Ball-mill crushing of concentrate (20 min for trial 5715 and 30 min for 5915 and 6015)
- Cleaner flotation, 2 steps from the milled products (tailing from cleaning steps)

The secondary ball-mill crushing was done in a polyurethane drum with steel balls. The pulp contained 40% solids and the speed was 70% of critical rpm. (Fig. 26).

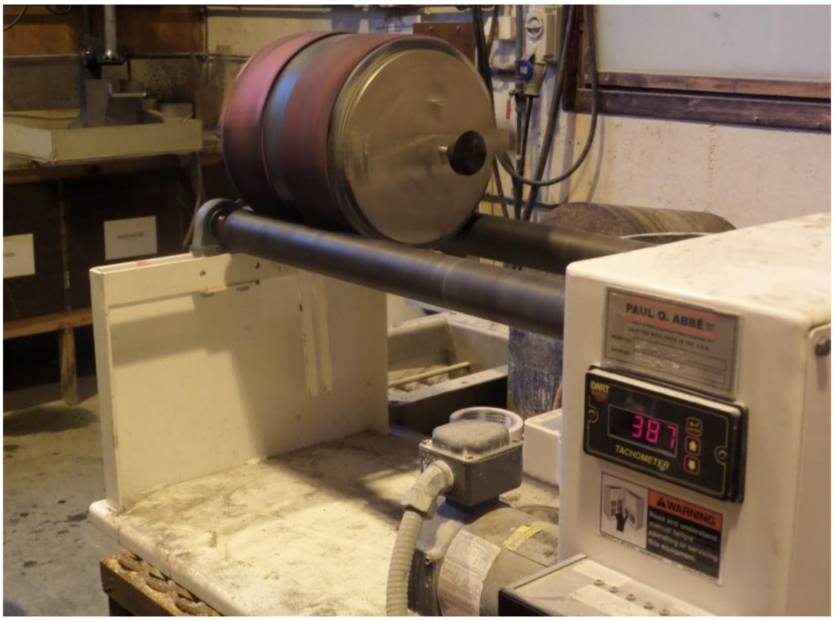


Figure 26. Secondary steel ball mill.

In the first trials two different polyglycol ethers with somewhat different compositions were used:

- Dowfroth 400 E
- Nashfroth 620

Dowfroth 400 E gave the best selected concentrates and was used in the later trials (Table 12).

Table 12. Dosage and different collectors used in flotation trials.

Trial no.:	**5715**		**5915**		**6015**	
Dosage g/ton:	Dowfroth	Paraffin	Dowfroth	Paraffin	Dowfroth	Paraffin
Rougher flot	450	335	335	335	335	335
Rougher clean	250	250	250	250	165	165
Flot clean 1	250	250	165+85	165	85+85	85
Flot clean 2	165	165	85	85	0+85	0+85

A long flotation time is required due to the high proportion of graphite with a large surface area. The challenge is then to keep the froth active during the whole flotation process.

7.3 Results

The crushed head feed from the rod mills from trial 5715 was sieved and carbon (C) was analysed in the different fractions.

The results show that there is a considerable selective enrichment of graphite in the coarsest fraction. Theoretically the fraction >300 (23.2) micron could be sieved as a high-grade product directly (Tab. 13).

Table 13. Milled feed for trial 5715 with fraction analysis.

Micron	Weight %	Weight % cum	% C	Recovery. C %	Recovery. C cum %
500	0,2	0,2	91,0	1,0	1,0
300	4,5	4,7	86,0	22,2	23,2
150	13,0	17,7	46,4	34,6	57,8
75	40,5	58,2	10,6	24,7	82,5
63	9,3	67,5	8,02	4,3	86,8
45	10,3	77,8	7,62	4,5	91,3
<45	22,2	100,0	6,84	8,7	100,0
Feed	100,00			**100,0**	

The head sample before sieving (fractionation) was first analysed to contain 17.7% C. Later the samples were re-analysed to 18.9% C. The milled feed for trials 5915 and 6015 was analysed to contain 19.7% C. These results agree with the calculated feed from the mass balance from the different trials which, in trial 5715, is calculated to 18.4 % C in the head sample: in trials 5915 and 6015 the numbers are 19.7% C and 20.4% C respectively.

The difference in the carbon content of the two feed samples is most probably related to inhomogeneous samples from a relatively coarse material. However, it can be concluded that the rock contains a carbon or graphite content of 19 to 20%.

A cleaner flotation (3 steps) was done without the secondary ball milling. It was not, however, possible to get a concentrate with a content of carbon higher than 65%. The results of these tests are therefore not reported. As expected, secondary milling is essential before the concentrate can go further to cleaner flotation.

The results of the flotation trials using secondary ball milling are shown in Table 14. In test no. 6015, with 30 minutes of ball milling and cleaner flotation, with a variable dosage of frother, a concentrate of 90.9% C with 97.9% recovery of the graphite was achieved (Tab. 15).

Table 14. Results of flotation trials after secondary milling.

Test no.:	5715			5915			6015		
	Weight %	% C	Recovery. % C	Weight %	% C	Recovery. % C	Weight %	% C	Recovery. % C
Slime	2,6	4,62	0,64	2,7	7,02	0,96	2,7	7,02	0,96
Tail rougher flot	60,3	0,203	0,67	58,8	0,147	0,45	59,9	0,147	0,44
Tail. refloat cons. before secondary milling	3,7	0,843	0,17	4,1	0,727	0,15	4,0	0,802	0,16
Tail. clean 1	7,9	0,56	0,24	9,1	0,409	0,19	9,9	0,571	0,28
Tail. clean 2	1,7	1,47	0,14	1,9	1,29	0,12	1,8	2,8	0,25
Graphite concentrate	**23,8**	**75,9**	**98,14**	**23,4**	**82,4**	**98,13**	**21,7**	**90,9**	**97,91**
	100		100,00	100		100,00	100		100,00
Calc, % C in feed Anal. % C in feed		18,4 18,7			19,7 19,7			20,1 19,7	

Table 15. Test no.: 6015 – Fractionation of the graphite concentrate.

Micron	Weight %	Weight cum %	% C	% C Recovery	% C cum recovery
300	7,1	7,1	98,2	7,7	7,7
150	31,7	38,8	98,1	34,5	42,2
75	29,8	68,6	90,4	29,9	72,1
63	7,4	76,0	80,7	6,6	78,7
45	8,4	84,4	78,0	7,3	86,0
<45	15,6	100,0	80,7	14,0	100,0
Concentrate	100,0		90,1	**100,0**	

The fraction >150 micron is only 38.8% of the total and has a very high carbon content of 98% C. The fraction <75 micron has a carbon content of about 80%.
It is evident that graphite is enriched in the coarsest fractions during the crushing and processing, with increased levels of gangue minerals in the finer-sized fractions (Fig. 27).

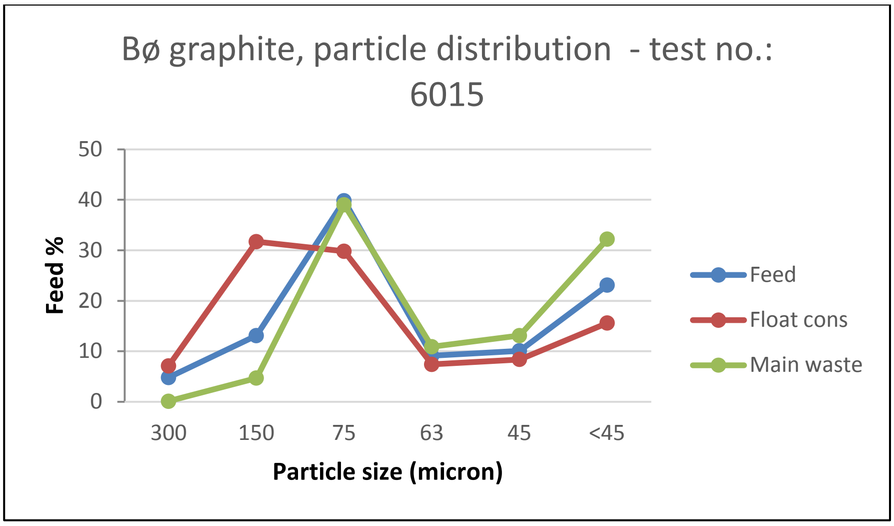


Figure 27. Particle distribution test, flotation test no. 6015.

7.4 Conclusions and recommendations based on the beneficiation trials

These relatively simple beneficiation trials indicate that the tested material can be upgraded to high-grade graphite concentrates with a good recovery. The quality of concentrates from test 6015 is comparable to what Skaland graphite is presently producing, with only one secondary milling. Skaland graphite normally uses two extra milling steps in ball mills or primary milling in an autogenous mill. We believe that further process optimisation will permit an increase in the graphite content in the finer fractions to >85%. It would be important to use mineralogical tools, such as MLA (Mineral Liberation Analysis) for mineral characterisation.

From the texture of the ore it was a surprise, particularly in the last flotation run, that very good results with regard to graphite content in the concentrates was achieved. The reason for the good results was probably that the head sample consisted of slightly altered rock which was easily crushed. This again resulted in a considerable selective concentration of graphite in the coarser fractions of the concentrates.

The graphite content of the head sample was 19%. In run 6015 a bulk concentrate with a content of carbon just above 90% was achieved at a recovery of 98%.The results show that it will be possible, from this graphite, to produce high value graphite concentrates with a high proportion of coarse flakes.

Since the rougher tailings appear, visually, to contain silicate minerals with low Fe contents they should also be tested further to assess whether additional products could be produced.

It should also be emphasised that the mineralogy of the graphite-bearing rocks occurring in the graphite provinces of both Lofoten-Vesterålen and Senja, are similar. In all probability the results in the experiments described above should also be valid also for other occurrences in this part of Norway.

Any future tests should include more process mineralogical studies and further mineral characterization including MLA (Mineral Liberation Analysis) studies. One should also look at the tailings which consist mainly of light silicate minerals. (Pale-coloured or low-density)

8. CONCLUSIONS AND RECOMMENDATIONS

This report presents the results of geological investigations of twenty-one different graphite occurrences in the Lofoten-Vesterålen area, including graphite analyses of 258 samples. All the occurrences have contents of graphitic carbon (%Cg) above 6%, and several have values above 15%. Most localities show a large spread in graphite content. The area is largely covered by a thin (usually < 2m) soil layer and geophysical methods are essential for finding outcrops or localities where the graphite ore can be trenched. In trenches and outcrops graphite-bearing units show a rapid change between parts that contain substantial amounts of graphite and parts that are barren. This is also observed in thin sections where the distribution of graphite crystals can be very irregular. This is a feature that is common for flake-graphite deposits. Our estimates of averages, etc. for individual occurrences may therefore have an un-estimated statistical uncertainty.

The contents of graphitic carbon are, on average, large compared with those in many internationally known deposits. The main aim for further investigations would be to document resources large enough for profitable exploitation.

Some EM-anomalies from the 2012 helicopter-borne survey have not been followed up so far: work on these is necessary in order to evaluate their economic relevance. Among the deposits investigated in these report, the following are recommended for further work:

Table 16. Localities where follow-up work is regarded as necessary.

Locality	Recommended work
Vikeid,Vedåsen	EM profiling, electrical profiling, trenching and sampling
Raudhammaren	EM profiling, electrical profiling, trenching and sampling
Møkland	Extension of existing measured area
Smines	Completion of existing geophysical measurements
Romsetfjorden	EM profing, electrical profiling, trenching and sampling
Kvernfjorddal-Haugsnes	EM profiling. Trenching and drilling

The mineralogy of the graphite-bearing rocks combined with ore dressing trials show that the Lofoten-Vesterålen graphite-bearing rocks can, with all probability, be upgraded to qualities that are on the market today.

9. REFERENCES

Corfu, F. 2004: U-Pb age, setting and tectonic significance of the anorthosite-mangerite-charnockite -Granite suite, Lofoten-Vesterålen, Norway. Journal of Petrology, 45, 1799-1819.

Corfu, F. 2007: Multistage metamorphic evolution and nature of the amphibolite–granulite facies transition in Lofoten–Vesterålen,Norway, revealed by U–Pb in accessory minerals. Chemical Geology, 241, 108-128.

Dalsegg, E. 1994: CP, SP og ledningsevnemålinger ved grafittundersøkelser ved Hornvann, Sortland Nordland NGU report 94.003

Davidsen, B. & Skår, Ø. 2004: Lofoten and Vesterålen: A Precambrian puzzle. (Abstract). The 26th Nordic Geological Winter Meeting, January 6th – 9th 2004, Uppsala, Sweden. Geologiske Föreninges Førhandlingar. vol 126, 20-21.

Engvik, A.K.,Davidsen B.,Coint, N., Lutro, O., Tveten, E. and Schiellerup, H. 2016: High-grade metamorphism of the Archean to Palaeoproterozoic gneiss complex in Vestersterålen, NorthNorway. (Abstract) 32nd Geological Winter Meeting Helsinki, Bulletin of the Geological Society of Finland, special issue, 153-154

Gautneb, H. & Tveten, E. 1992: Grafittundersøkelser og geologisk kartlegging på Langøya, Sortland Kommune Nordland NGU report 92.155.

Gautneb, H. 1992: Grafittundersøkelser i Hornvannområdet, Sortland, Sortland Kommune Nordland NGU report 92.293.

Gautneb H. 1993: Grafittundersøkelser i Hornvannområdet, Sortland, Sortland Kommune Nordland NGU report 93.134

Gautneb H. 1995: Grafittundersøkelser Hornvann 1994 , Sortland Sortland Kommune Nordland NGU report 95.076.

Gautneb, H. & Tveten, E. 2000: The geology, exploration and characterization of graphite desposits in the Jennestad area, Vesterålen area northen Norway. Norges geologiske Undersøkelse bulletin. 436, 67-74.

Gautneb, H. Wanvik J.E., Rodinov, A., Ofstad F., Stampolidis, A. & Tassis G. 2016: Graphite deposits in Norway a review. (Abstract) 32nd Geological Winter Meeting Helsinki, Bulletin of the Geological Society of Finland. 112-113.

Griffin, W.L., Taylor, P.N., Hakkinen, J.W., Heier, K.S., Iden, I., Krogh, E-J., Malm, O., Olsen, K.I., Ormåsen D.E. & Tveten, E.1978: Archean and Proterozoic crustal evolution in Lofoten-Vesterålen N Norway. Journal of the Geological Society of London 135, 629-647.

Helland A. 1987: Lofoten og Vesteraalen. Norges geologiske undersøkelse, vol. 23, 1-246.

Heier, K.S. 1960: Petrology and geochemmistry of high-grade metamorphic and igneous rocks on Langøya Northern Norway. Norges geologiske undersøkelse bulletin 207, 1-246.

Johannessen, N.E. 2015: Prosess evaluering Grafittskifer fra Bø i Vesterålen, Unpublished note Sibelco Nordic, 9pp.

Keilhau, B. M. 1844: Beretning om en geonostisk reise i norlandene i 1855. Nyt Magazin for naturvidenskaberne. 11, nr.3.

Mogaard; J.O., Olsen, O., Rønning S, Blokkum, O. 1988: Geofysiske undersøkelser fra Helikopter over Langøya, Vesterålen: NGU report 88.151

Neumann, H. 1952: Dagbok fra Nord-Norge 26.5-19.8 1952 Ba report 7709.

Palosaari, J., Latonen, R-M., Smått, J.H., Blomquist, R. & Eklund, O. 2016: High quality flake graphite occurrences in a high-grade metamorphic region in Sortland, Vesterålen, northern Norway. Norwegian Journal of Geology, 96, 19-26.

Rodinov, A., Ofstad, F., Stampolidis, A. & Tassis G. 2013: Helicopter-borne magnetic, electromagnetic and radiometric geophysical survey at Langøya in Vesterålen, Nordland. NGU report 2013.044.

Rønning J.S. 1991: CP målinger ved grafittundersøkelser på Vikeid, Sortland kommune Nordland. NGU report 91.262.

Rønning J.S. 1993: CP og SP målinger ved grafittundersøkelser på Vikeid, Sortland kommune Nordland. NGU report 93.262.

Rønning, J.S., Larsen, B.E., Elvebakk, H., Gellein, J., Knežević, J., & Ofstad, F. 2017: Geophysical investigations of graphite occurrences in Bø and Øksnes municipalities, Vesterålen, Nordland County, Northern Norway 2015-2016. NGU Report 2017.014

Skjeseth S. 1952: Foreløpig rapport fra geologiske undersøkelser av Jennestad grafittfelt. Report BA5232 Norges geologiske undersøkelse.

Vokes F.M. 1954: Rapport over befaring av Jennestad grafittfelt . Report BA5340 Norges geologiske undersøkelse

www.alsglobal.com(http://www.alsglobal.com/Our-Services/Minerals/Geochemistry/Service-Schedule) accessed September 2016.

Tveten, E. 1978: Berggrunnskart over Norge; Svolvær 1:250.000. Norges geologiske undersøkelse.

Tveten, E. & Henningsen, T. 1998: Berggrunnskart over Norge; 1:250.000 Andøy. Norges Norges geologiske undersøkelse.

www.investorintel.com/?s=graphite (accessed Feb. 2017)

Appendices

Appendix 1. Chemical analysis of S, TC TOC and main elements from the drill core at trench 1-2015 at Møkland

sampleNo	m below collar	S	TOC	TC	SiO2*	Al2O3*	Fe2O3*	TiO2*	MgO*	CaO*	Na2O*	K2O*	MnO*	P2O5*	LOI	SUM
BH1BØ2.70	2.70	0.01	0.03	0.05	59.2	15.1	1.80	0.940	10.7	3.27	6.00	0.540	0.028	0.150	1.18	98.9
BH1BØ7.70	7.70	0.01	0.03	0.05	46.6	11.5	3.56	0.820	24.2	1.08	1.21	3.98	0.061	0.037	5.54	98.5
BH1BØ9.30	9.30	2.80	0.0620	0.05	46.0	18.5	8.72	1.20	10.4	4.09	3.80	3.21	0.022	0.098	2.16	98.1
BH1BØ18.50	18.50	2.70	0.120	0.05	49.3	16.3	8.36	1.09	7.96	7.85	4.99	0.804	0.118	0.104	1.58	98.5
BH1BØ26.30	26.30	0.950	13.0	15.0	44.0	5.77	3.10	0.393	12.1	14.3	1.81	0.275	0.088	0.032	16.6	98.4
BH1BØ26.50	26.50	3.00	0.380	0.390	45.4	19.8	5.96	1.27	7.07	8.36	3.88	2.42	0.030	0.092	3.36	97.6
BH1BØ28.90	28.90	1.00	5.90	6.10	49.0	5.79	4.10	0.299	12.2	16.2	2.27	0.311	0.126	0.039	7.84	98.2
BH1BØ30.10	30.10	2.20	14.0	14.0	52.4	7.42	4.81	0.385	6.25	7.97	2.56	2.06	0.058	0.144	15.0	99.0
BH1BØ30.60	30.60	1.90	32.0	32.0	44.4	7.13	3.20	0.430	3.16	4.01	2.42	1.98	0.026	0.070	25.0	91.8
BH1BØ32.60	32.60	6.10	0.290	0.120	64.3	7.83	13.1	0.384	2.07	3.23	2.43	2.73	0.037	0.018	2.74	98.8
BH1BØ35.30	35.30	0.200	0.0610	0.05	68.0	14.2	2.29	1.03	0.822	2.14	4.33	4.87	0.057	0.299	0.420	98.5
BH1BØ36.40	36.40	3.00	0.200	0.100	41.6	20.9	6.88	1.42	11.7	6.16	2.07	4.36	0.025	0.099	2.13	97.4
BH1BØ42.10	42.10	0.130	0.03	0.05	55.4	14.8	3.42	0.838	12.2	3.05	5.11	1.57	0.041	0.646	1.24	98.3
BH1BØ43.90	43.90	0.01	0.03	0.05	58.2	14.9	4.50	0.810	9.84	4.00	6.05	0.462	0.041	0.071	0.400	99.3

Appendix 2. Total sulphur and total carbon (graphitic carbon) of analyzed samples, DEP ID refers to "NGU mineralressurser database".

This data set includes all graphite analyses from Vesterålen per 2017. Data collected before 1994 have less accurate coordinates. Data in Excel format is available upon request. Appendix 2 also contain some samples that are not from the described localities and thus not included in the calculated averages.

TS, TC and TOC are analyses of total sulphur total carbon and total organic carbon
Samplers: HG = Håvard Gautneb, JK = Janja Knezevic, JW = Jan Egil Wanvik, BD= Børre Davidsen, HS = Henrik Schiellerup, NC = Nolwenn Coint

NGU_no	Year	Area	Locality	samplepoint	Easting	Northing	DEP ID	Sam-pler	Sampleno	Text	TS	TC	TOC
71951	2012	Jennestad	Golia		510982	7625361	NO0407	HG	HG1-12	Bandet graphite schist from the mine entrance		9.33	
71952	2012	Jennestad	Golia		510785	7625331	NO0407	HG	HG2-12	High grade graphite schist from bedrock exposure		24.41	
71985	2012	Jennestad	Golia		510982	7625362	NO0407	JW	JW12-1	Bandet graphite schist from the mine entrance		7.4	
71986	2012	Jennestad	Golia		510982	7625362	NO0407	JW	JW12-2	Bandet graphite schist from the mine entrance		5.69	
71987	2012	Jennestad	Golia		510785	7625343	NO0407	JW	JW12-3	High grade graphite schist from bedrock exposure		18.37	
9132	1991	Jennestad	Golia		510 980	7625361	NO0407	HG	9132	Graphite schist		10.2	
9136a	1991	Jennestad	Golia		510 980	7625361	NO0407	HG	9136a	Graphite schist		32.78	
9138	1991	Jennestad	Golia		510 980	7625361	NO0407	HG	9138	Graphite schist		32.6	
90-7a	1990	Jennestad	Græva		507 225	7625671	NO0343	HG	90-7a	Graphite schist		8.5	
90-7b	1990	Jennestad	Græva		507 225	7625671	NO0343	HG	90-7b	Graphite schist		35.86	
90-7c	1990	Jennestad	Græva		507 225	7625671	NO0343	HG	90-7c	Graphite schist		36.88	
90-5d	1990	Jennestad	Græva		507 225	7625671	NO0343	HG	90-5d	Graphite schist		39.65	
9148	1991	Jennestad	Græva		507 225	7625671	NO0343	HG	9148	Graphite schist		38.79	
9160	1991	Jennestad	Græva		507 225	7625671	NO0342	HG	9160	Graphite schist		1.3	
9221	1993	Jennestad	Græva	trench 1-93	507 271	7625612	NO0343	HG	9221	Graphite schist	0.01	34.63	
9221b	1993	Jennestad	Græva	trench 1-93	507 271	7625612	NO0343	HG	9221b	Graphite schist	0.01	37.71	
9221c	1993	Jennestad	Græva	trench 1-93	507 271	7625612	NO0343	HG	9221c	Graphite schist	0.51	35.06	
9221d	1993	Jennestad	Græva	trench 1-93	507 271	7625612	NO0343	HG	9221d	Graphite schist	0.01	37.76	
9221e	1993	Jennestad	Græva	trench 1-93	507 271	7625612	NO0343	HG	9221e	Graphite schist	0.22	38.08	
9221f	1993	Jennestad	Græva	trench 1-93	507 271	7625612	NO0343	HG	9221f	Graphite schist	0.15	34.89	
9221g	1993	Jennestad	Græva	trench 1-93	507 271	7625612	NO0343	HG	9221g	Graphite schist	0.01	21.31	
9221h	1993	Jennestad	Græva	trench 1-93	507 271	7625612	NO0343	HG	9221h	Graphite schist	0.01	32.31	
9221i	1993	Jennestad	Græva	trench 1-93	507 271	7625612	NO0343	HG	9221i	Graphite schist	0.06	22.83	
9222A	1993	Jennestad	Græva	trench 2 93	507 283	7625602	NO0343	HG	9222A	Graphite schist	0.01	30.83	

9222b	1993	Jennestad	Græva	trench 2 93	507 283	7625602	NO0343	HG	9222b	Graphite schist	0.02	28.75	
9223	1993	Jennestad	Græva	trench 3 93	507 299	7625584	NO0343	HG	9223	Graphite schist	0.01	35.1	
9148	1991	Jennestad	Græva		507 225	7625671	NO0343	HG	9148	Graphite schist		38.79	
9160	1991	Jennestad	Græva		507 225	7625671	NO0343	HG	9160	Graphite schist		1.3	
90432	2014	Frøskeland	Grønjorda		502109	7628640	NO0245	HG	HG31b-14	Graphite schist	4.07	9.9	
90433	2014	Frøskeland	Grønjorda		501851	7629256	NO0245	HG	HG32a-14	Graphite schist	0.01	3.89	
71964	2012	Kvernfjord-Haugsnes	Haugsneset		488356	7619263	NO0339	HG	HG14-12	Massive and high grade graphite schist		33.82	
71965	2012	Kvernfjord-Haugsnes	Haugsneset		488356	7619263	NO0339	HG	HG15-12	Massive and high grade graphite schist		14.71	
71966	2012	Kvernfjord-Haugsnes	Haugsneset		488356	7619263	NO0339	HG	HG16-12	Massive and high grade graphite schist		33.68	
71967	2012	Kvernfjord-Haugsnes	Haugsneset		488356	7619263	NO0339	HG	HG17-12	Massive and high grade graphite schist		33.71	
71968	2012	Kvernfjord-Haugsnes	Haugsneset		488238	7618895	NO0339	HG	HG18-12	Massive and high grade graphite schist		14.21	
71969	2012	Kvernfjord-Haugsnes	Haugsneset		488238	7618895	NO0339	HG	HG19-12	Massive and high grade graphite schist		15.17	
71970	2012	Kvernfjord-Haugsnes	Haugsneset		488238	7618895	NO0339	HG	HG20-12	Massive and high grade graphite schist		13.73	
71971	2012	Kvernfjord-Haugsnes	Haugsneset		488274	7618822	NO0339	HG	HG21-12	Massive and high grade graphite schist		12.36	
90478	2015	Kvernfjord-Haugsnes	Haugsneset		488623	7622905	NO0338	HG	hg23-15	Graphite schist	0.01	10.6	
140124	2016	Kvernfjord-Haugsnes	Haugsneset		488563	7620431	NO0338	HG	hg24-16	medium grade graphite schists	0.07	17.7	
140133	2016	Kvernfjord-Haugsnes	Haugsneset		488236	7618894	NO0339	JK	JK8	Graphite schits	0.09	12.6	
71957	2012	Jennestad	Hornvann		508574	7625822	NO0184	HG	HG7-12	Graphite schist from the remains at Lille Hornvann		15.57	
71958	2012	Jennestad	Hornvann		508574	7625822	NO0184	HG	HG8-12	Graphite schist from the remains at Lille Hornvann		9.01	
71955	2012	Jennestad	Hornvann		507225	7625670	NO0343	HG	HG5-12	High grade graphite schist from the dump outside the showing		39.11	
71956	2012	Jennestad	Hornvann		507225	7625670	NO0343	HG	HG6-12	High grade graphite schist from the dump outside the showing		36.7	
71990	2012	Jennestad	Hornvann		507580	7625322	NO0342	JW	JW12-6	Massiv and hig grade graphite schist		36.68	
71991	2012	Jennestad	Hornvann		507580	7625322	NO0342	JW	JW12-7	Massiv and hig grade graphite schist		28.62	
90-8	1990	Jennestad	Hornvann		507 570	7625318	NO0342	HG	90-8	Graphite schist		1.71	
90-9a	1990	Jennestad	Hornvann		507 570	7625318	NO0342	HG	90-9a	Graphite schist		26.22	
90-9b	1990	Jennestad	Hornvann		507 570	7625318	NO0342	HG	90-9b	Graphite schist		37.23	
90-9c	1990	Jennestad	Hornvann		507 570	7625318	NO0342	HG	90-9c	Graphite schist		39.23	

90-9d	1990	Jennestad	Hornvann		507 570	7625318	NO0342	HG	90-9d	Graphite schist		44.31	
90-10	1990	Jennestad	Hornvann		507 570	7625318	NO0342	HG	90-10	Graphite schist		8.25	
9153a	1991	Jennestad	Hornvann		507 570	7625318	NO0342	HG	9153a	Graphite schist		38.42	
93-1a	1993	Jennestad	Hornvann	Trench 10 93	507 438	7625659	NO0342	HG	93-1a	Graphite schist	0.58	18.03	
93-1b	1993	Jennestad	Hornvann	Trench 10 93	507 438	7625659	NO0342	HG	93-1b	Graphite schist	0.24	12.26	
93-1c	1993	Jennestad	Hornvann	Trench 10 93	507 438	7625659	NO0342	HG	93-1c	Graphite schist	0.36	12.78	
93-1d	1993	Jennestad	Hornvann	Trench 10 93	507 438	7625659	NO0342	HG	93-1d	Graphite schist	1.30	7.56	
93-le	1993	Jennestad	Hornvann	Trench 10 93	507 438	7625659	NO0342	HG	93-le	Graphite schist	0.50	12.18	
93-lf	1993	Jennestad	Hornvann	Trench 10 93	507 438	7625659	NO0342	HG	93-lf	Graphite schist	0.18	14.15	
93-2a	1993	Jennestad	Hornvann	trench 11 93	507 412	7625699	NO0342	HG	93-2a	Graphite schist	0.20	13.4	
93-2b	1993	Jennestad	Hornvann	trench 11 93	507 412	7625699	NO0342	HG	93-2b	Graphite schist	0.20	14.21	
93-2c	1993	Jennestad	Hornvann	trench 11 93	507 412	7625699	NO0342	HG	93-2c	Graphite schist	0.60	15.53	
93-2d	1993	Jennestad	Hornvann	trench 11 93	507 412	7625699	NO0342	HG	93-2d	Graphite schist	0.20	9.64	
93-3a	1993	Jennestad	Hornvann	trench 12 93	507 378	7625725	NO0342	HG	93-3a	Graphite schist	0.18	29.9	
93-3b	1993	Jennestad	Hornvann	trench 12 93	507 378	7625725	NO0342	HG	93-3b	Graphite schist	0.34	21.69	
93-3c	1993	Jennestad	Hornvann	trench 12 93	507 378	7625725	NO0342	HG	93-3c	Graphite schist	0.28	31.91	
93-3d	1993	Jennestad	Hornvann	trench 12 93	507 378	7625725	NO0342	HG	93-3d	Graphite schist	0.12	33.48	
93-3e	1993	Jennestad	Hornvann	trench 12 93	507 378	7625725	NO0342	HG	93-3e	Graphite schist	0.01	29.55	
93-3f	1993	Jennestad	Hornvann	trench 12 93	507 378	7625725	NO0342	HG	93-3f	Graphite schist	0.21	30.72	
93-3g	1993	Jennestad	Hornvann	trench 12 93	507 378	7625725	NO0342	HG	93-3g	Graphite schist	0.15	26.44	
93-3h	1993	Jennestad	Hornvann	trench 13 93	507 251	7625822	NO0342	HG	93-3h	Graphite schist	0.22	26.73	
93-4a	1993	Jennestad	Hornvann	trench 13 93	507 251	7625822	NO0342	HG	93-4a	Graphite schist	0.80	17.42	
93-4b	1993	Jennestad	Hornvann	trench 13 93	507 251	7625822	NO0342	HG	93-4b	Graphite schist	0.72	29.36	
93-4c	1993	Jennestad	Hornvann	trench 13 93	507 251	7625822	NO0342	HG	93-4c	Graphite schist	0.79	25.91	
93-4D1	1993	Jennestad	Hornvann	trench 13 93	507 251	7625822	NO0342	HG	93-4D1	Graphite schist	0.01	14.52	
93-4e	1993	Jennestad	Hornvann	trench 13 93	507 251	7625822	NO0342	HG	93-4e	Graphite schist	0.20	14.05	
93-4f	1993	Jennestad	Hornvann	trench 13 93	507 251	7625822	NO0342	HG	93-4f	Graphite schist	0.01	9	
93-5a	1993	Jennestad	Hornvann	trench 14 93	507 192	7625886	NO0342	HG	93-5a	Graphite schist	1.57	10.48	
93-5b	1993	Jennestad	Hornvann	trench 14 93	507 192	7625886	NO0342	HG	93-5b	Graphite schist	1.04	10.54	
93-5c	1993	Jennestad	Hornvann	trench 14 93	507 192	7625886	NO0342	HG	93-5c	Graphite schist	3.20	8.03	
93-5d	1993	Jennestad	Hornvann	trench 14 93	507 192	7625886	NO0342	HG	93-5d	Graphite schist	4.91	12.27	
93-5e	1993	Jennestad	Hornvann	trench 14 93	507 192	7625886	NO0342	HG	93-5e	Graphite schist	0.80	13.05	
93-5f	1993	Jennestad	Hornvann	trench 14 93	507 192	7625886	NO0342	HG	93-5f	Graphite schist	2.19	6.88	
93-6a	1993	Jennestad	Hornvann	trench 15 93	507 173	7625918	NO0342	HG	93-6a	Graphite schist	1.16	22.29	

93-6b	1993	Jennestad	Hornvann	trench 15 93	507 173	7625918	NO0342	HG	93-6b	Graphite schist	1.35	19.52	
93-6c	1993	Jennestad	Hornvann	trench 15 93	507 173	7625918	NO0342	HG	93-6c	Graphite schist	2.26	19.5	
93-6d	1993	Jennestad	Hornvann	trench 15 93	507 173	7625918	NO0342	HG	93-6d	Graphite schist	1.67	20.07	
93-6e	1993	Jennestad	Hornvann	trench 15 93	507 173	7625918	NO0342	HG	93-6e	Graphite schist	1.92	11.65	
93-6f	1993	Jennestad	Hornvann	trench 15 93	507 173	7625918	NO0342	HG	93-6f	Graphite schist	1.52	17.39	
9224a	1993	Jennestad	Hornvann	trench 4 93	507 447	7625565	NO0342	HG	9224a	Graphite schist	3.00	0.06	
9224b	1993	Jennestad	Hornvann	trench 4 93	507 447	7625565	NO0342	HG	9224b	Graphite schist	3.20	7.678	
9224c	1993	Jennestad	Hornvann	trench 4 93	507 447	7625565	NO0342	HG	9224c	Graphite schist	3.50	9.071	
9225a	1993	Jennestad	Hornvann	trench 5- 93	507 448	7625537	NO0342	HG	9225a	Graphite schist	3.08	7.368	
9225b	1993	Jennestad	Hornvann	trench 5- 93	507 448	7625537	NO0342	HG	9225b	Graphite schist	3.37	7.081	
9225c	1993	Jennestad	Hornvann	trench 5- 93	507 448	7625537	NO0342	HG	9225c	Graphite schist	2.36	2.895	
9226a	1993	Jennestad	Hornvann	trench 6 93	507 453	7625509	NO0342	HG	9226a	Graphite schist	0.15	7.801	
9226b	1993	Jennestad	Hornvann	trench 6 93	507 453	7625509	NO0342	HG	9226b	Graphite schist	0.66	7.485	
9227a	1993	Jennestad	Hornvann	trench 7 93	507 477	7625456	NO0342	HG	9227a	Graphite schist	0.80	37.5	
9227b	1993	Jennestad	Hornvann	trench 7 93	507 477	7625456	NO0342	HG	9227b	Graphite schist	0.45	33.89	
9227c	1993	Jennestad	Hornvann	trench 7 93	507 477	7625456	NO0342	HG	9227c	Graphite schist	0.26	40.49	
9227d	1993	Jennestad	Hornvann	trench 7 93	507 477	7625456	NO0342	HG	9227d	Graphite schist	0.07	28.67	
9227e	1993	Jennestad	Hornvann	trench 7 93	507 477	7625456	NO0342	HG	9227e	Graphite schist	0.54	29.91	
9228a	1993	Jennestad	Hornvann	trench 8 93	507 489	7625440	NO0342	HG	9228a	Graphite schist	0.39	38.35	
9228b	1993	Jennestad	Hornvann	trench 8 93	507 489	7625440	NO0342	HG	9228b	Graphite schist	0.15	38.23	
9228c	1993	Jennestad	Hornvann	trench 8 93	507 489	7625440	NO0342	HG	9228c	Graphite schist	0.09	31.68	
9228d	1993	Jennestad	Hornvann	trench 8 93	507 489	7625440	NO0342	HG	9228d	Graphite schist	0.05	39.67	
9229a	1993	Jennestad	Hornvann	trench 9 93	507 521	7625411	NO0342	HG	9229a	Graphite schist	0.20	40.73	
9229b	1993	Jennestad	Hornvann	trench 9 93	507 521	7625411	NO0342	HG	9229b	Graphite schist	0.11	41.68	
92229c	1993	Jennestad	Hornvann	trench 9 93	507 521	7625411	NO0342	HG	92229c	Graphite schist	0.05	32.26	
9229d	1993	Jennestad	Hornvann	trench 9 93	507 521	7625411	NO0342	HG	9229d	Graphite schist	0.23	42.83	
9153a	1991	Jennestad	Hornvann		507 570	7625318	NO0343	HG	9153a	Graphite schist		38.42	
71953	2012	Jennestad	Koven		510079	7625023	NO0347	HG	HG3-12	Weathered but coarse flake graphite schist		23.02	
71954	2012	Jennestad	Koven		510102	7625026	NO0347	HG	HG4-12	Weathered but coarse flake graphite schist		18.89	
90464	2015	Jennestad	Koven		510277	7625132	NO0347	HG	hg9-15	Sample from trench koven	0.73	13.3	
90465	2015	Jennestad	Koven		510277	7625132	NO0347	HG	hg10-15	Sample from trench koven	0.26	12.7	
140116	2016	Jennestad	Koven		510039	7624973	NO0347	HG	hg16-16	Medium grade graphite schits	0.09	0.847	
140117	2016	Jennestad	Koven		510039	7624973	NO0347	HG	hg17-16	Medium grade graphite schits	0.06	2.37	
71988	2012	Jennestad	Koven		510084	7625026	NO0347	JW	JW12-4	Weathered but coarse flake graphite schist		21.14	

71989	2012	Jennestad	Koven		510084	7625026	NO0347	JW	JW12-5	Weathered but coarse flake graphite schist		24.03	
9139	1991	Jennestad	Koven		510 079	7625023	NO0347	HG	9139	Graphite schist		9.16	
9147	1991	Jennestad	Koven		510 079	7625023	NO0347	HG	9147	Graphite schist		26.13	
90445	2014	Kvernfjord-Haugsnes	Kvernfjordalen		488628	7622908	NO0336	HG	HG43-14	Graphite schist	0.02	0.122	
90446	2014	Kvernfjord-Haugsnes	Kvernfjordalen		488628	7622906	NO0336	HG	HG44-14	Graphite schist	0.01	0.473	
90447	2014	Kvernfjord-Haugsnes	Kvernfjordalen		488628	7622906	NO0336	HG	HG45-14	Graphite schist	0.01	13.7	
140107	2016	Kvernfjord-Haugsnes	Kvernfjordalen		486190	7627797	NO0336	HG	hg7-16	Good quality graphite schits	0.09	11.7	
140108	2016	Kvernfjord-Haugsnes	Kvernfjordalen		488618	7622873	NO0336	HG	hg8-16	disseminated graphite schits	0.03	4.28	
La-1	1990	Jennestad	Larmark gruve		510 369	762405	NO0402	HG	La-1	Graphite schist		12.32	
La-2	1990	Jennestad	Larmark gruve		510 369	762405	NO0402	HG	La-2	Graphite schist		12.74	
9162	1991	Jennestad	Larmark gruve		510 369	7625405	NO0402	HG	9162	Graphite schist		8.13	
9164	1991	Jennestad	Larmark gruve		510 369	7625405	NO0402	HG	9164	Graphite schist		3.18	
9166	1991	Jennestad	Larmark gruve		510 369	7625405	NO0402	HG	9166	Graphite schist		12.23	
90/20	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	90/20	Graphite schist		24.25	
90-20a	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	90-20a	Graphite schist		14.86	
90-21b	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	90-21b	Graphite schist		16.57	
90-21c	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	90-21c	Graphite schist		25.77	
LH-1	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	LH-1	Graphite schist		18.02	
LH-2	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	LH-2	Graphite schist		18.18	
LH-3	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	LH-3	Graphite schist		14.79	
LH-4	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	LH-4	Graphite schist		14.52	
LH-5	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	LH-5	Graphite schist		11.95	
LH-6	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	LH-6	Graphite schist		12.22	
LH-7	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	LH-7	Graphite schist		14.25	
LH-8	1990	Jennestad	Lille Hornvann		508 592	7625860	NO0343	HG	LH-8	Graphite schist		17.68	
9111B2	1991	Jennestad	Lille Hornvann		508 592	7625860	NO0184	HG	9111B2	Graphite schist		18.89	
9121a	1991	Jennestad	Lille Hornvann		508 554	7625752	NO0184	HG	9121a	Graphite schist		12.8	
9121b	1991	Jennestad	Lille Hornvann		508 554	7625752	NO0184	HG	9121b	Graphite schist		4.65	
9121c	1991	Jennestad	Lille Hornvann		508 554	7625752	NO0184	HG	9121c	Graphite schist		8.7	
9121d	1991	Jennestad	Lille Hornvann		508 554	7625752	NO0184	HG	9121d	Graphite schist		11	
9121e	1991	Jennestad	Lille Hornvann		508 554	7625752	NO0184	HG	9121e	Graphite schist		9.23	

9122b	1991	Jennestad	Lille Hornvann		508 545	7625722	NO0184	HG	9122b	Graphite schist		16.93	
9123a	1991	Jennestad	Lille Hornvann		508 473	7625750	NO0184	HG	9123a	Graphite schist		21.28	
9123b	1991	Jennestad	Lille Hornvann		508 473	7625750	NO0184	HG	9123b	Graphite schist		27.41	
9123c	1991	Jennestad	Lille Hornvann		508 473	7625750	NO0184	HG	9123c	Graphite schist		30.46	
9123d	1991	Jennestad	Lille Hornvann		508 473	7625750	NO0184	HG	9123d	Graphite schist		33.07	
9125	1991	Jennestad	Lille Hornvann		508 448	7625722	NO0184	HG	9125	Graphite schist		7.8	
9126	1991	Jennestad	Lille Hornvann		508 427	7625680	NO0184	HG	9126	Graphite schist		9.92	
9128a	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9128a	Graphite schist		15.9	
9128b	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9128b	Graphite schist		6.62	
9128c	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9128c	Graphite schist		7	
9128d	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9128d	Graphite schist		12.58	
9128e	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9128e	Graphite schist		10.55	
9128f	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9128f	Graphite schist		6.64	
9128g	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9128g	Graphite schist		5.64	
9128h	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9128h	Graphite schist		7.81	
9129	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9129	Graphite schist		10.6	
9130a	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9130a	Graphite schist		9.22	
9130b	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9130b	Graphite schist		9.8	
9130c	1991	Jennestad	Lille Hornvann		508 438	7625617	NO0184	HG	9130c	Graphite schist		9.27	
9159a	1991	Jennestad	Lille Hornvann		508 592	7625860	NO0184	HG	9159a	Graphite schist		9.62	
9159b	1991	Jennestad	Lille Hornvann		508 592	7625860	NO0184	HG	9159b	Graphite schist		10.93	
71972	2012	Morfjord	Morfjord		487144	7586575	NO0296	HG	HG22-12	Dissiminated graphite schist		16.8	
71973	2012	Morfjord	Morfjord		487144	7586575	NO0296	HG	HG23-12	Dissiminated graphite schist		19.7	
71992	2012	Morfjord	Morfjord		486956	7587163	NO0296	JW	JW12-8	Dissiminated graphite schist		18.86	
90471	2015	Møkland	Møkland Trench 3 2015		486457	7628305	NO0330	HG	hg16-15	meget grovflakig grafitt fra øverste røsk jord tipp	0.05	14.7	
90472	2015	Møkland	Møkland Trench3 2015		486454	7628298	NO0330	HG	hg17-15	grov til dels amorf grafitt øverste røsk	0.14	18.1	
90473	2015	Møkland	Møkland Trench 3 2015		486454	7628314	NO0330	HG	hg18-15	qz fsp bergart side bergart til grafittskifer øverste røsk	2.89	0.157	
90474	2015	Møkland	Møkland Trench3 2015		486456	7628313	NO0330	HG	hg19 -15	sidebergart til grafittskifer øverste røsk	4.78	0.345	
90475	2015	Møkland	Møkland Trench 3 2015		486453	7628307	NO0330	HG	hg20-15	meget grovflakig grafittskifer øverste røsk	0.04	18.3	
90476	2015	Møkland	Møkland Trench 3 2015		486456	7628315	NO0330	HG	hg21-15	meget fet grafitt råtten bergart	0.14	13.4	
90477	2015	Møkland	Møkland Trench		486463	7628307	NO0330	HG	hg22-15	amfibolittisk mørkbergart ligg b ergart til	0.08	0.03	

			3 2015							grafittskifer			
90448	2014	Møkland	Møkland trench 2 2015		486633	7628877	NO0330	HG	HG46-14	Graphite schist	0.01	16.7	
90449	2014	Møkland	Møkland trench2 2015		486633	7628877	NO0330	HG	HG47-14	Graphite schist	0.01	16.1	
90450	2014	Møkland	Møkland trench2 2015		486640	7628864	NO0330	HG	HG48-14	Graphite schist	0.01	25.7	
90451	2014	Møkland	Møkland trench 2 2015		486640	7628864	NO0330	HG	HG49-14	Graphite schist	0.05	21.1	
90457	2015	Møkland	Møkland trench 2 2015		486149	7627757	NO0330	HG	hg2-15	Grafittskifer løsmaterialet fra veifylling	0.52	1.13	
90458	2015	Møkland	Møkland trench 2 2015		486154	7627755	NO0330	HG	hg3-15	Grafittskifer løsmaterialet fra veifylling	0.05	6.19	
90459	2015	Møkland	Møkland trench 2 2015		486163	7627753	NO0330	HG	hg4-14	Grafittskifer løsmaterialet fra veifylling	0.03	4.48	
90461	2015	Møkland	Møkland trench 2 2015		486631	7628873	NO0330	HG	hg6-15	flakgrafitt god kvalitet møkland	0.03	16.9	
90466	2015	Møkland	Møkland trench 2 2015		486633	7628873	NO0330	HG	hg11-15	Rik grafitt malm fra blottning	0.01	17.7	
90467	2015	Møkland	Møkland trench 1 2015		486631	7628839	NO0330	HG	hg12-15	grafittskifer øvrerøsk	0.08	0.116	
90468	2015	Møkland	Møkland trench 1 2015		486632	7628842	NO0330	HG	hg13-15	grafittskifer øvrerøsk	3.83	0.105	
90469	2015	Møkland	Møkland trench 1 2015		486627	7628843	NO0330	HG	hg14-15	grafitt skifer øvre røsk	1.53	0.166	
90470	2015	Møkland	Møkland trench 1 2015		486627	7628843	NO0330	HG	hg15-15	grafitt skifer øvre røsk	3.07	0.03	
90484	2015	Møkland	Møkland trench 1 2015		486629	7628840	NO0330	HG	hg29-15	samleprøve fra utsprengt øvregrøft Møkland	1.58	0.03	
90485	2015	Møkland	Møkland trench 1 2015		486629	7628840	NO0330	HG	hg30-15	samleprøve fra utsprengt øvregrøft Møkland	2.93	0.03	
90486	2015	Møkland	Møkland trench 1 2015		486629	7628840	NO0330	HG	hg31-15	samleprøve fra utsprengt øvregrøft Møkland	1.70	0.0861	
140105	2016	Møkland	Møkland Trench 1 2016		486193	7627799	NO0330	HG	hg5-16	Rotten weathered graphite schist	0.07	7.32	
140106	2016	Møkland	Møkland Trench 1 2016		486192	7627796	NO0330	HG	hg6-16	Good quality graphite schits	0.10	2.16	
140125	2016	Møkland	Møkland Trench 1 2016		486190	7627797	NO0330	JK	JK-1	Weathered graphite schist	0.17	13.4	
140131	2016	Møkland	Møkland Trench 1 2016		486188	7627795	NO0330	JK	JK-6	Weathered graphite schist	0.09	2.45	
140132	2016	Møkland	Møkland Trench 1 2016		486190	7627797	NO0330	JK	JK-7	Weathered graphite schist	0.92	0.473	

140141	2016	Møkland	Møkland Trench 1 2016		486188	7627795	NO0330	JK	JK-6B	Weathered graphite schist	0.10	14.5	
140126	2016	Møkland	Møkland Trench 2 2016		486177	7627634	NO0330	JK	JK-2	Amphibolite with graphit and sulfides	4.23	-0.06	
140101	2016	Møkland	Møkland Trench 3 2016		486140	7627616	NO0330	HG	hg1-16	Rotten weathered graphite schist	0.04	22.3	
140102	2016	Møkland	Møkland Trench 3 2016		486142	7627618	NO0330	HG	hg2-16	Rotten weathered graphite schist	0.15	12.4	
140103	2016	Møkland	Møkland Trench 3 2016		486134	7627619	NO0330	HG	hg3-16	Rotten weathered graphite schist	0.13	16.6	
140104	2016	Møkland	Møkland Trench 3 2016		486132	7627617	NO0330	HG	hg4-16	Rotten weathered graphite schist	0.03	10.6	
140127	2016	Møkland	Møkland Trench 3 2016		486139	7627617	NO0330	JK	JK-3	Weathered graphite schist	0.03	5.76	
140128	2016	Møkland	Møkland Trench 3 2016		486143	7627615	NO0330	JK	Jk-4	Weathered graphite schist	0.05	7.97	
140129	2016	Møkland	Møkland Trench 3 2016		486141	7627615	NO0330	JK	JK-5	Weathered graphite schist	0.14	18.1	
140130	2016	Møkland	Møkland Trench 3 2016		486141	7627615	NO0330	JK	JK-5(B)	Weathered graphite schist (wall)	0.02	18.1	
140109	2016	Raudhammaren	Raudhammaren		505696	7642187	NO0226	HG	hg9-16	Graphite schists loose bolder	-0.02	25.9	
140110	2016	Raudhammaren	Raudhammaren		505696	7642187	NO0226	HG	hg10-16	Graphite schists loose bolder	-0.02	17.1	
140111	2016	Raudhammaren	Raudhammaren		505770	7642183	NO0226	HG	hg11-16	Graphite schists loose bolder	0.08	19.8	
140112	2016	Raudhammaren	Raudhammaren		505770	7642183	NO0226	HG	hg12-16	Graphite schists loose bolder	0.04	11.7	
140134	2016	Raudhammaren	Raudhammaren		505824	7642184	NO0226	JK	JK10	Graphite schists loose bolder	0.05	7.77	
140135	2016	Raudhammaren	Raudhammaren		505850	7642189	NO0226	JK	JK11	Graphite schists loose bolder	0.08	12.3	
140136	2016	Raudhammaren	Raudhammaren		505871	7642194	NO0226	JK	JK12	Graphite schists loose bolder	0.03	24.1	
140137	2016	Raudhammaren	Raudhammaren		505937	7642166	NO0226	JK	JK13	Graphite schists loose bolder	0.64	11.2	
140138	2016	Raudhammaren	Raudhammaren		505771	7642181	NO0226	JK	JK9	Graphite schists loose bolder	0.05	18.8	
140118	2016	Smines	Romsetfjorden		500587	7634047	NO0283	HG	hg18-16	weathered sulphite rich graphiite schist	1.33	3.62	
140119	2016	Smines	Romsetfjorden		500587	7634047	NO0283	HG	hg19-16	weathered sulphite rich graphiite schist	1.62	5.44	
140120	2016	Smines	Romsetfjorden		500620	7634013	NO0283	HG	hg20-16	weathered sulphite rich graphiite schist	1.20	11.9	
140121	2016	Smines	Romsetfjorden		500622	7634010	NO0283	HG	hg21-16	weathered sulphite rich graphiite schist	4.03	25.6	
140122	2016	Smines	Romsetfjorden		500625	7634004	NO0283	HG	hg22-16	weathered sulphite rich graphiite schist	10.90	15.4	
140123	2016	Smines	Romsetfjorden		500634	7633995	NO0283	HG	hg23-16	weathered sulphite rich graphiite schist	0.16	12.5	
90434	2014	Skogsøya	Skogsøya		498270	7640336	NO0278	HG	HG32b-14	Graphite schist	0.32	29.1	
90435	2014	Skogsøya	Skogsøya		498270	7640336	NO0278	HG	HG33-14	Graphite schist	0.06	19	
90436	2014	Skogsøya	Skogsøya		498267	7640357	NO0278	HG	HG34-14	Graphite schist	0.01	34.2	
90437	2014	Skogsøya	Skogsøya		498225	7640414	NO0278	HG	HG35-14	Graphite schist	0.01	16.7	

90438	2014	Skogsøya	Skogsøya		498139	7640440	NO0278	HG	HG36-14	Graphite schist	1.76	26.4	
90439	2014	Skogsøya	Skogsøya		497813	7640671	NO0278	HG	HG37-14	Graphite schist	0.51	6.46	
140113	2016	Skogsøya	Skogsøya		497896	7640656	NO0278	HG	hg13-16	low grade graphite schist	2.58	0.395	
140114	2016	Skogsøya	Skogsøya		497840	7640813	NO0278	HG	hg14-16	Low grade graphite schist	0.08	6.91	
140139	2016	Skogsøya	Skogsøya		498266	7640354	NO0278	JK	JK-14	well exposed graphite outcrop, 348/80E	0.05	24.5	
140140	2016	Skogsøya	Skogsøya		498136	7640440	NO0278	JK	JK-15	graphite schist, old trench	0.14	29.2	
90442	2014	Smines	Smines		498966	7639397	NO0135	HG	HG40-14	Graphite schist	0.86	13.8	
90443	2014	Smines	Smines		498977	7638646	NO0135	HG	HG41-14	Graphite schist	0.15	3.92	
90444	2014	Smines	Smines		497537	7638596	NO0135	HG	HG42-14	Graphite schist	0.03	0.562	
90456	2015	Smines	Smines		498817	7639406	NO0135	HG	hg1-15	flakgrafitt Smines	1.54	17.3	
90462	2015	Smines	Smines		499008	7639342	NO0135	HG	hg7-15	grafittskifer smines	0.06	10.5	
90463	2015	Smines	Smines		499004	7639342	NO0135	HG	hg8-15	grafittskifer smines	2.39	2.71	
90479	2015	Smines	Smines		499009	7639339	NO0135	HG	hg24-15	samleprøve fra utsprengt materialet Smines	1.03	12.8	
90480	2015	Smines	Smines		499009	7639339	NO0135	HG	hg25-15	samleprøve fra utsprengt materialet Smines	0.78	10.6	
90481	2015	Smines	Smines		499009	7639339	NO0135	HG	hg26-15	samleprøve fra utsprengt materialet Smines	3.05	4.38	
90482	2015	Smines	Smines		499009	7639339	NO0135	HG	hg27-15	samleprøve fra utsprengt materialet Smines	3.10	1.46	
90483	2015	Smines	Smines		499009	7639339	NO0135	HG	hg28-15	samleprøve fra utsprengt materialet Smines	2.15	9.66	
71959	2012	Sommarland	Sommarland		487621	7626290	NO0334	HG	HG9-12	Graphite schist from various exposures just north of the abandoned house at Sommarland		9.26	
71960	2012	Sommarland	Sommarland		487621	7626290	NO0334	HG	HG10-12	Graphite schist from various exposures just north of the abandoned house at Sommarland		17.13	
71961	2012	Sommarland	Sommarland		487589	7626310	NO0334	HG	HG11-12	Graphite schist from various exposures just north of the abandoned house at Sommarland		4.05	
71962	2012	Sommarland	Sommarland		487589	7626310	NO0334	HG	HG12-12	Graphite schist from various exposures just north of the abandoned house at Sommarland		2.83	
71963	2012	Sommarland	Sommarland		487589	7626310	NO0334	HG	HG13-12	Graphite schist from various exposures just north of the abandoned house at Sommarland		5.44	
90440	2014	Skogsøya	Svinøya		498345	7639890	NO0333	HG	HG38-14	Graphite schist	0.02	24.9	
90441	2014	Skogsøya	Svinøya		498345	7639890	NO0333	HG	HG39-14	Graphite schist	0.02	21.8	
140115	2016	Jennestad	Vedåsen		510984	7628557	NO0350	HG	hg15-16	loose bolder weathered graphite schist	0.03	11.5	
90-15a	1990	Jennestad	Vedåsen		508 704	7627725	NO0350	HG	90-15a	Graphite schist		13.88	
90-15b	1990	Jennestad	Vedåsen		511 140	7628483	NO0350	HG	90-15b	Graphite schist		16.66	
90/19	1990	Jennestad	Vedåsen		511 140	7628483	NO0350	HG	90/19	Graphite schist		14.61	
82075		smines	Kaldhammaren		498 963	7639395		BD	ØKS 1323B-1	Graphite schist	3.05	15.5	
		smines	Kaldhammaren		498 963	7639395		BD	ØKS 1323B-2	Graphite schist	0.42	10.3	

82120		smines	Kaldhammaren		498 815	7639408		BD	ØKS 1435A	Graphite schist	2.32	3.44	3.32
82121		smines	Kaldhammaren		498 815	7639408		BD	ØKS 1435B	Graphite schist	5.92	16.3	17.1
82127		smines	Rota		497 526	7638615		BD	ØKS 1449A	Graphite schist	17.90	2.65	2.7
82142		Frøskeland	Brenna		502 119	7628636		BD	ØKS 1464A	Graphite schist	2.87	8.58	8.77
82185		Skogsøya	Skavls		498 180	7640374		BD	ØKS 14128B	Graphite schist	0.54	4.44	4.43
82187		Skogsøya	Skalvneset		498 263	7640351		BD	ØKS 14129A	Graphite schist	0.08	31.6	29.1
82188		Skogsøya	Skalvneset		498 263	7640351		BD	ØKS 14129B	Graphite schist	0.06	34.9	31.2
82189		Skogsøya	Skalvneset		498 263	7640351		BD	ØKS 14129C	Graphite schist	0.17	27.8	25.2
82200		Haugsneset	Saura		542 110	7670382		BD	AND 1452B	Graphite schist	< 0.02	2.26	1.62
97603		Jørlandsvatnet	Jørlandsvatnet		488 625	7622904		HS	xxxxxxx	Graphite schist	< 0.02	14.2	14.1
92127		Jennestad	i fjæra		512 657	7626511		BD	JEN 1454A	Graphite schist	2.22	3.53	
92132		Jennestad	i fjæra		512 767	7626493		BD	JEN 1460A	Graphite schist	0.15	15.2	
92134		Jennestad	i fjæra		512 765	7626502		BD	JEN 1461A	Graphite schist	0.26	10.9	
92135		Jennestad	i fjæra		512 791	7626512		BD	JEN 1462	Graphite schist	0.46	7.21	
106468		Storå	Storå		511 084	7594428		NC	RAF106468	Graphite schist	5.88	10.5	
92191		Romsetfjorden	Langsstrand		500 639	7633996		BD	BD Øks 1601a	Graphite schist	0.28	17.3	17.2
92192		Romsetfjorden	Langsstrand		500 639	7633996		BD	BD Øks 1601b	Graphite schist	1.12	18.2	18.7
92193		Romsetfjorden	Langsstrand		500 412	7634791		BD	BD Øks 1602a	Graphite schist	0.03	31	30.7
92198		Romsetfjorden	Langsstrand		500 730	7634761		BD	BD Øks 1605	Graphite schist	0.39	3.92	3.98
92200		Romsetfjorden	Langsstrand		500 804	7634942		BD	BD Øks 1607	Graphite schist	0.52	14.7	14.4
99390		Romsetfjorden	Langsstrand		500 454	7634597		BD	BD Øks 1609	Graphite schist	0.06	14.2	14.5

Appendix 3. Selected thin sections pictures

From the collected samples a number of thin sections were made for petrographical examination and description of the graphite ore mineralogy. In addition, using a polarizing microscope and image processing, we made an estimate of the graphite content in these thin sections. The method is described in the main text; here we show the pictures that were used for the modal measurements of the graphite content, this picture collection also illustrates the mineralogical variation and complexity of the graphite ore. The Results are listed in Table 11 in the main text. Black areas are graphite.

Localities and samples numbers

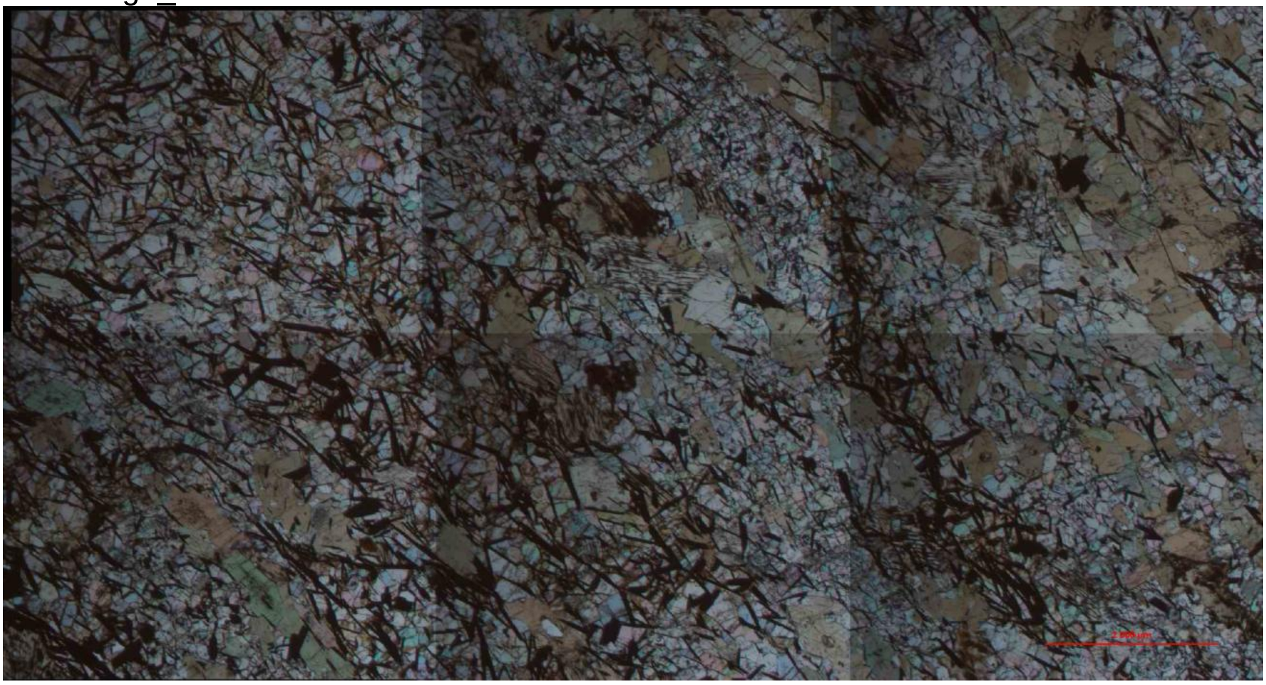
Frøskeland Hg31b_14

Modal graphite content: 27.80%

Haugsneset Hg18_12

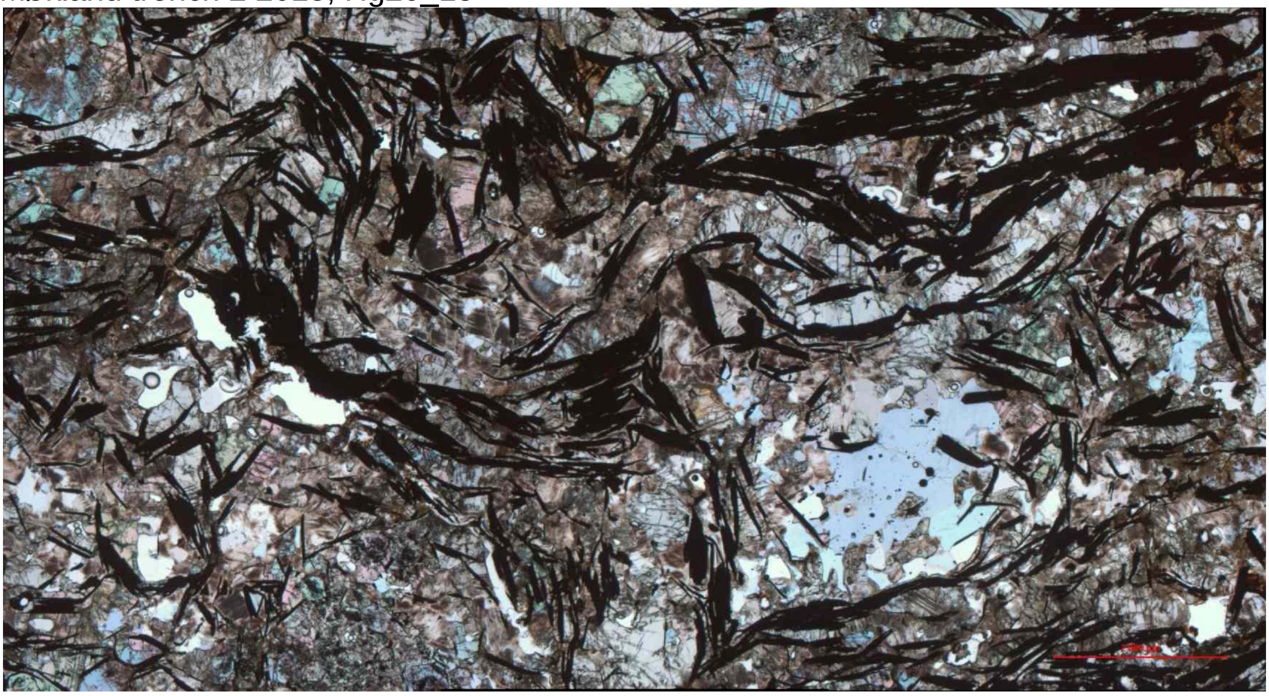
Modal graphite content: 15.92%

Koven Hg9_15



Modal graphite content: 17.10%

Møkland trench 2 2015, Hg20_15

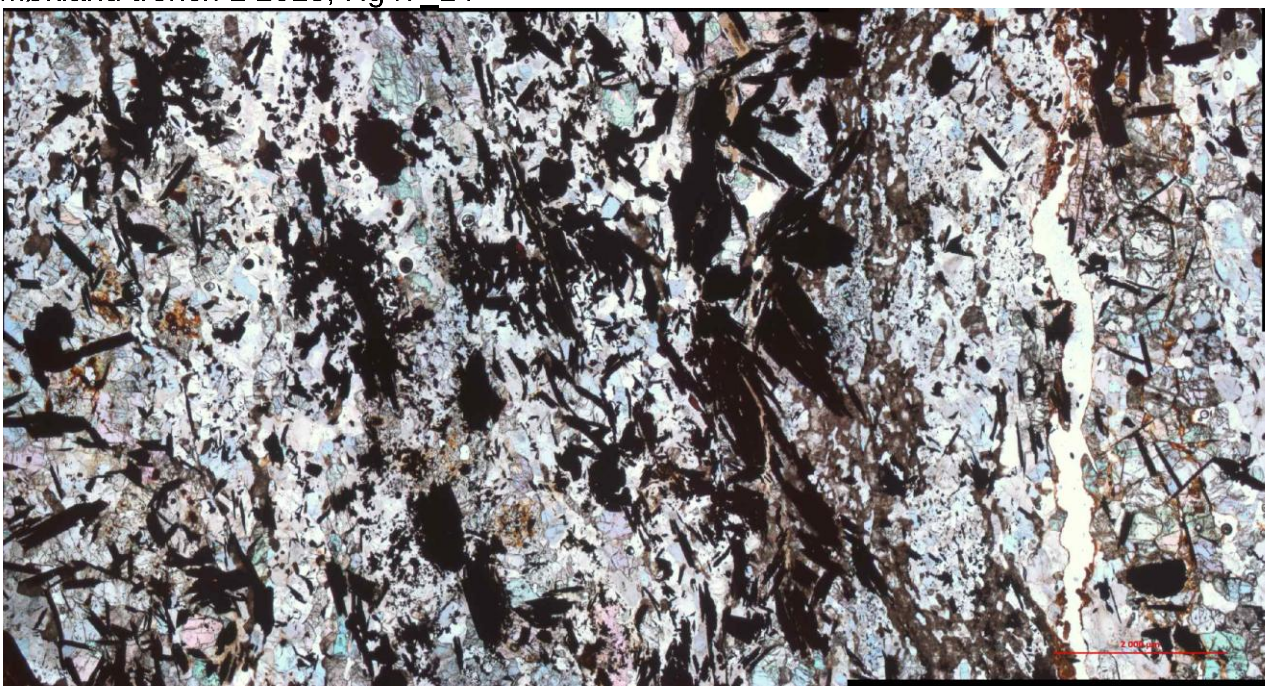


Modal graphite content: 22.33%

Møkland trench 1 2015, Hg11_15

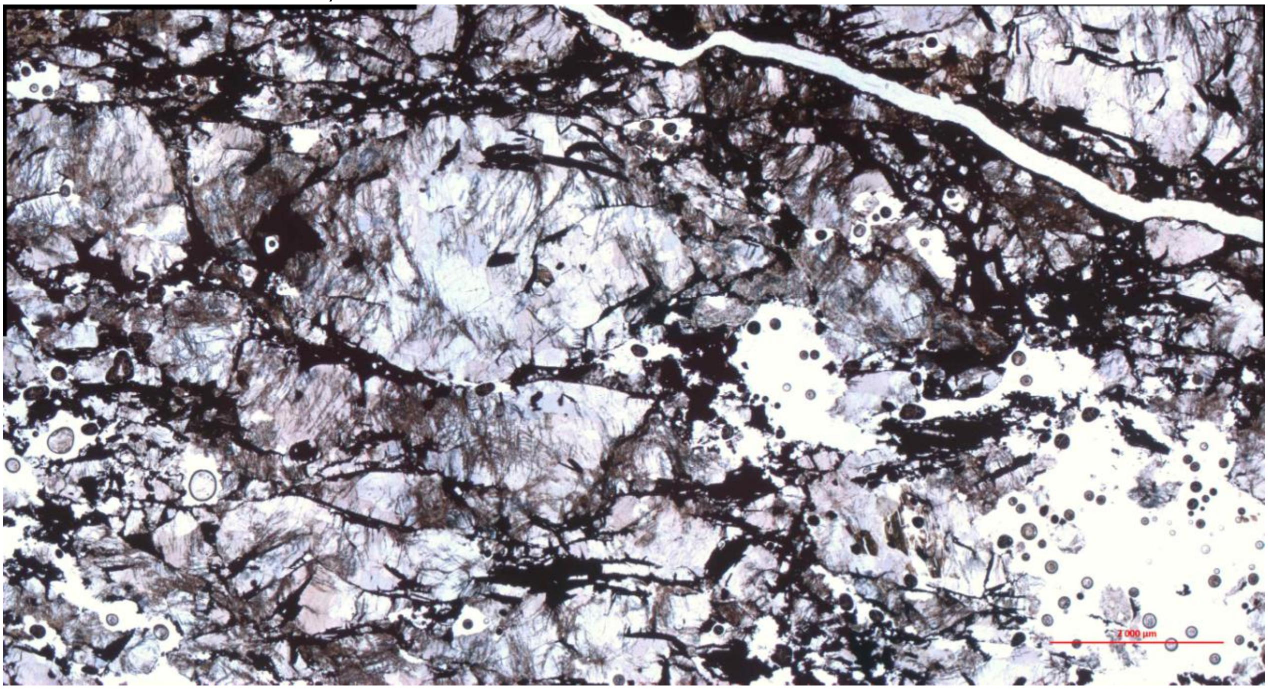
Modal graphite content: 24.47%

Møkland trench 1 2015, Hg47_14



Modal graphite content: 29.41%

Møkland trench 1 2016, Jk1

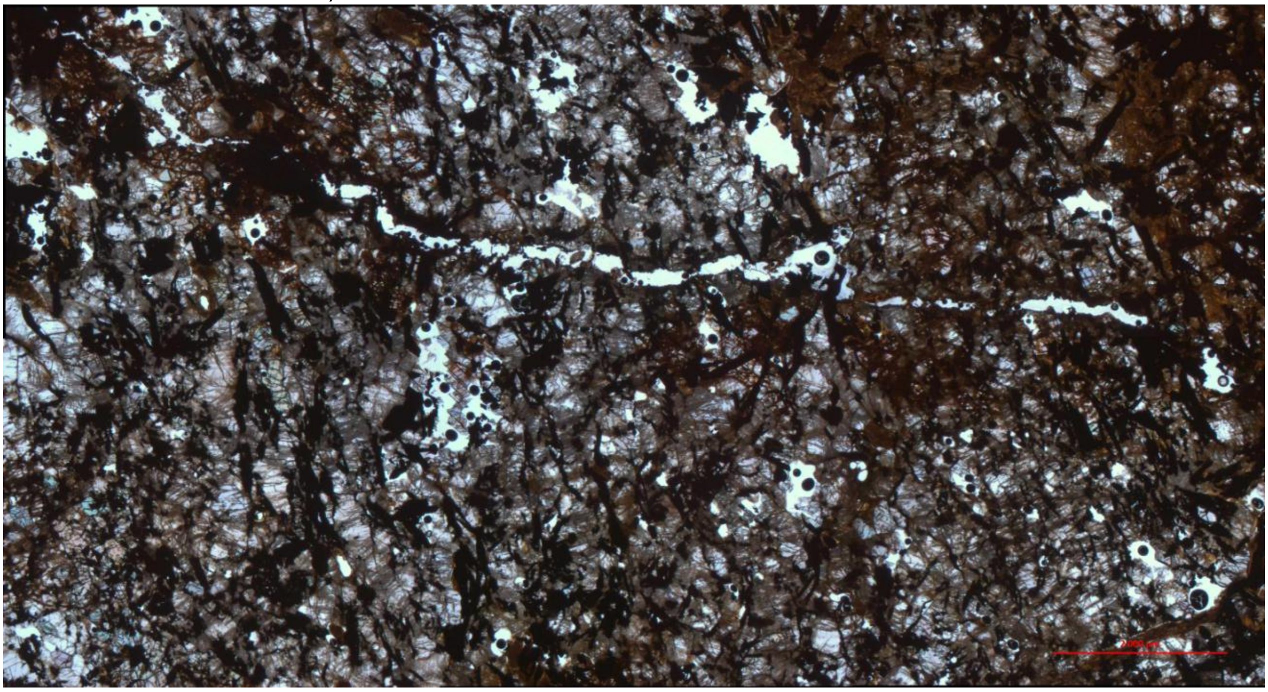


Modal graphite content: 17.20%

Møkland trench 1 2016, JK7

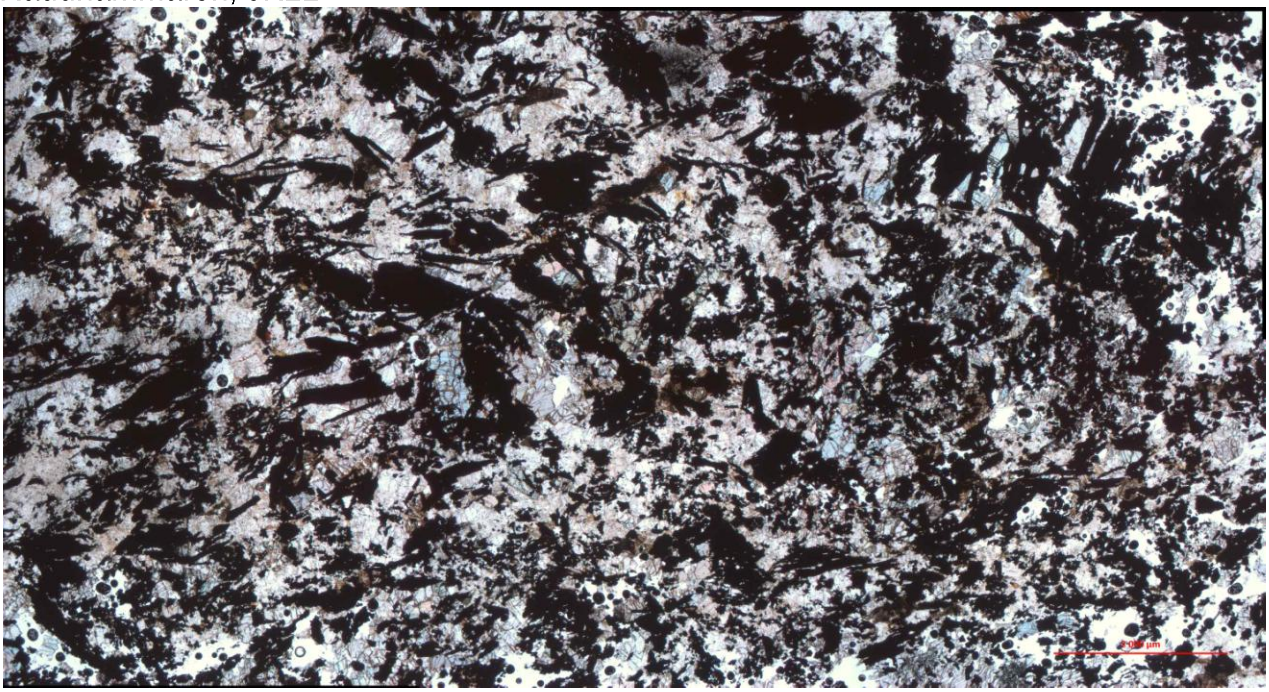
Modal graphite content: 15.34%

Møkland trench 3 2016, JK5



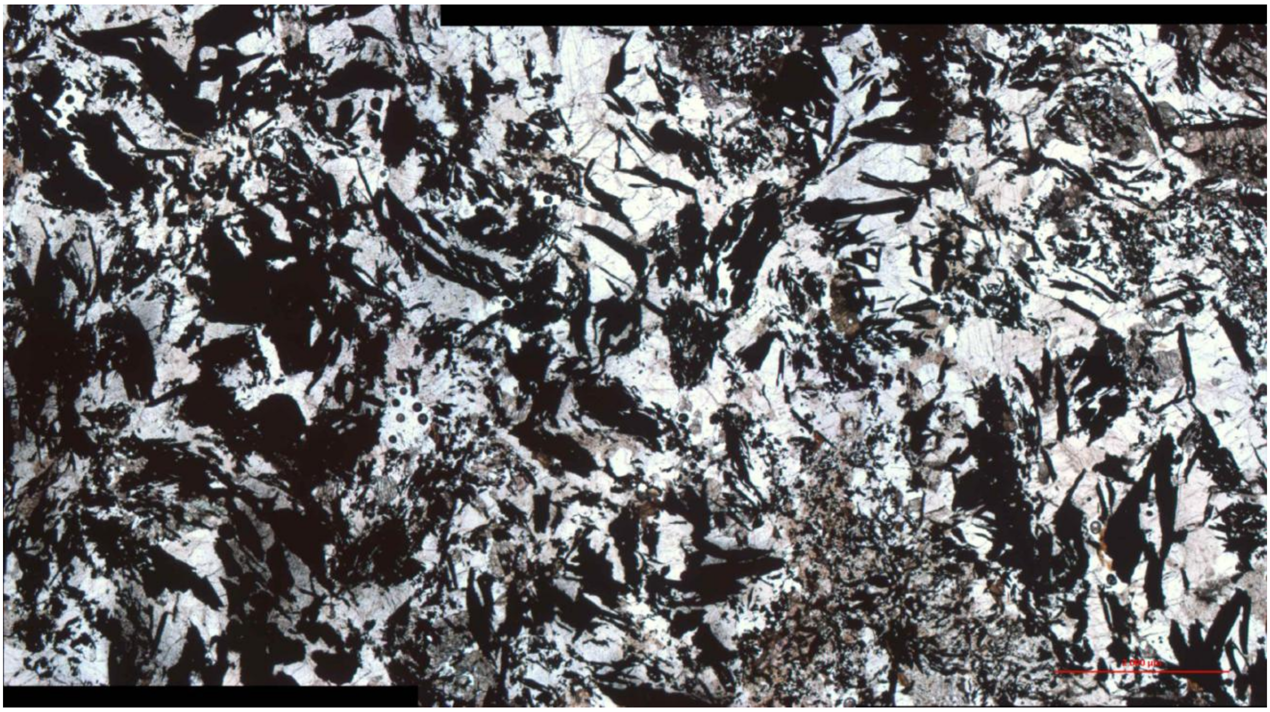
Modal graphite content: 16.3%

Raudhammaren, JK11



Modal graphite content: 18.29%

Raudhammaren JK12

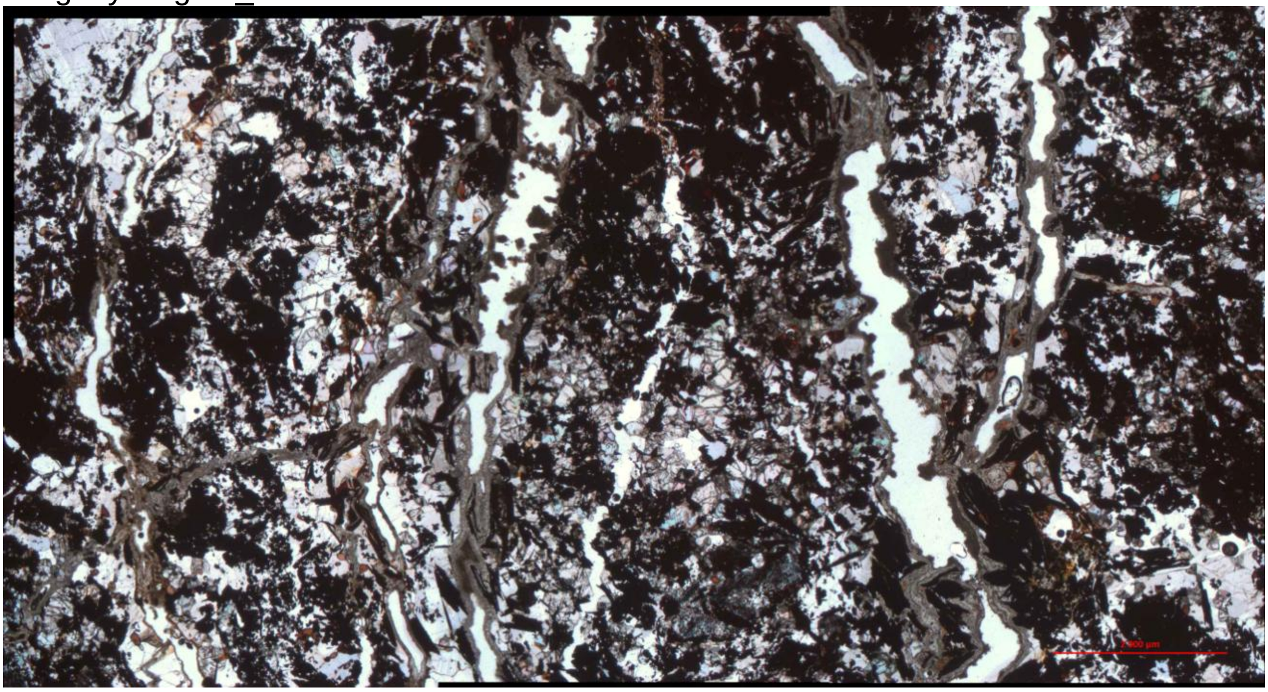


Modal graphite content: 18.61%

Raudhammaren JK9

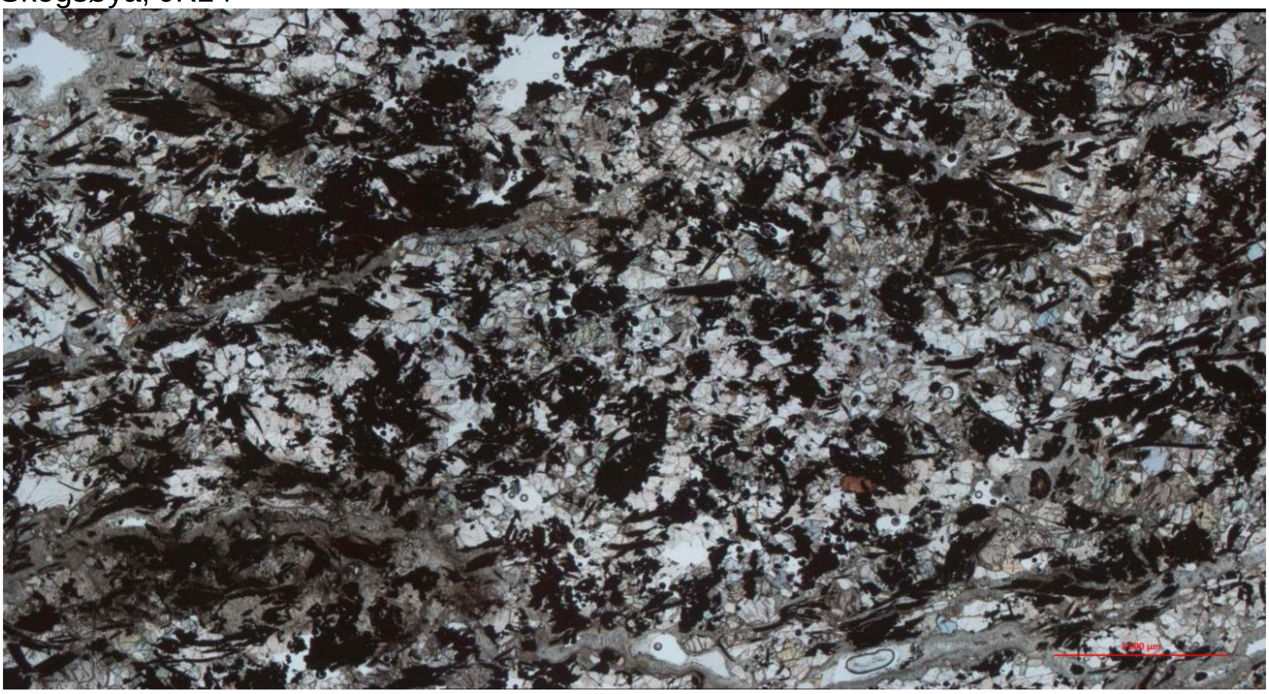
Modal graphite content: 23.13%

Skogsøya Hg 33_14



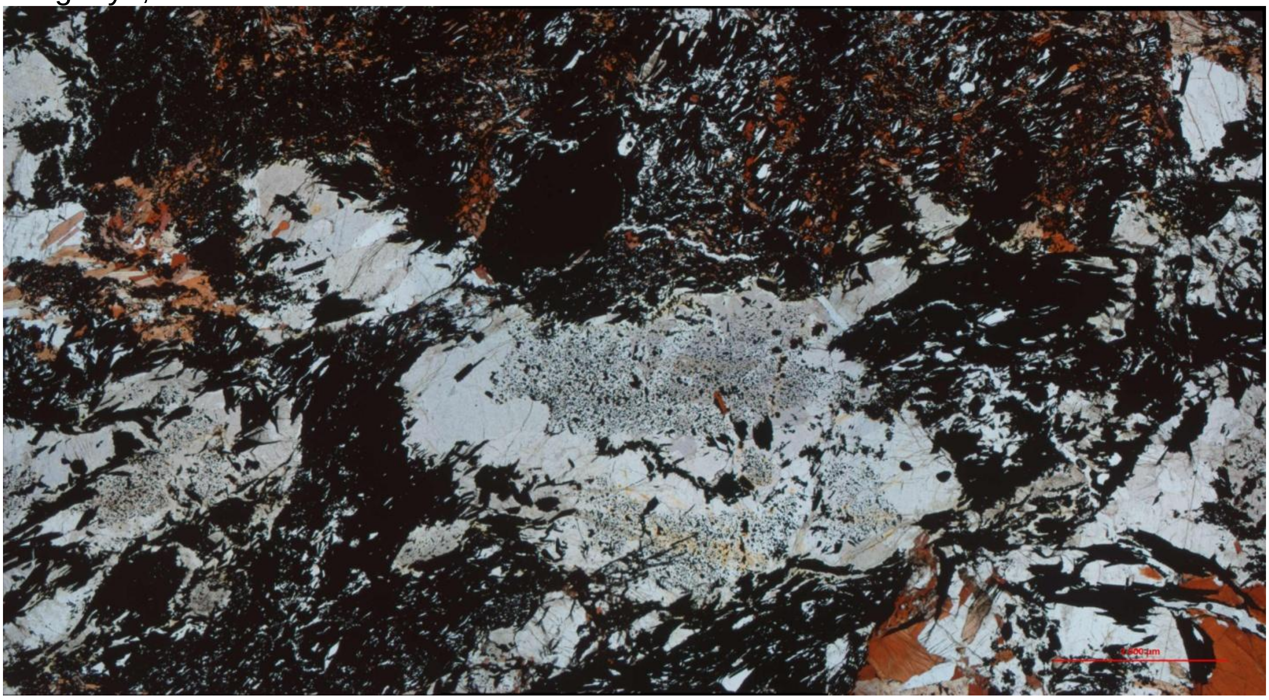
Modal graphite content: 25.92%

Skogsøya, JK14



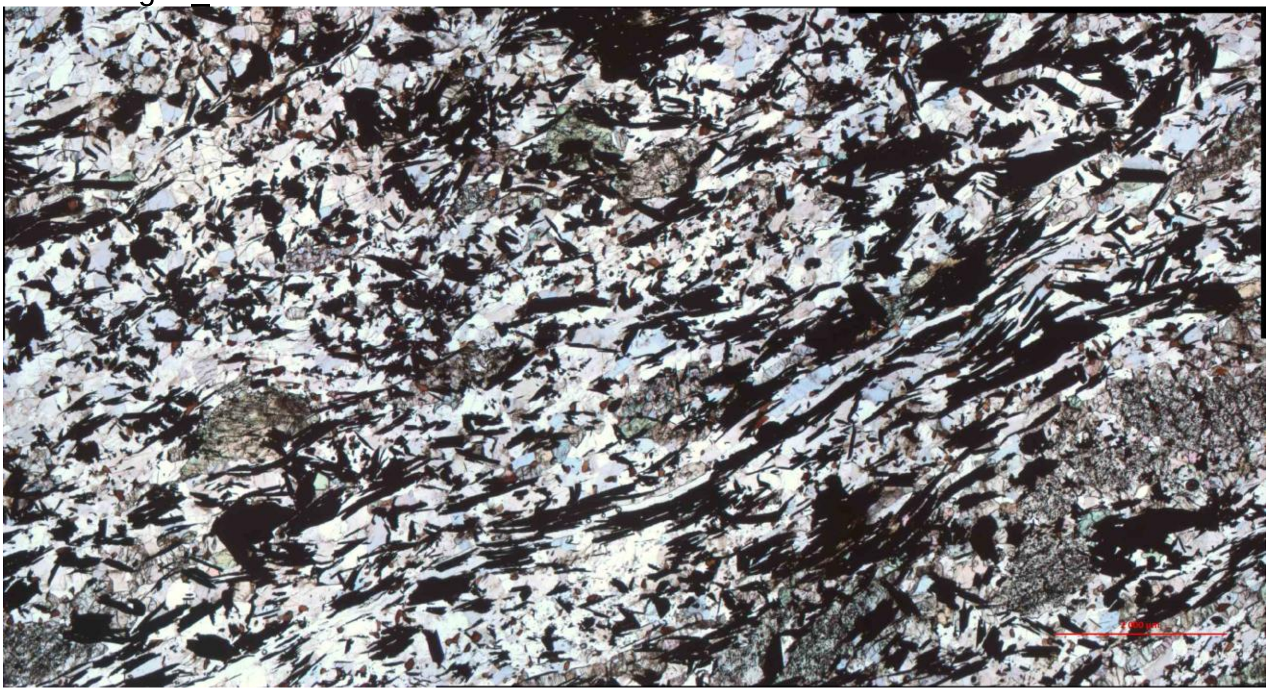
Modal graphite content: 29.96%

Skogsøya, JK15



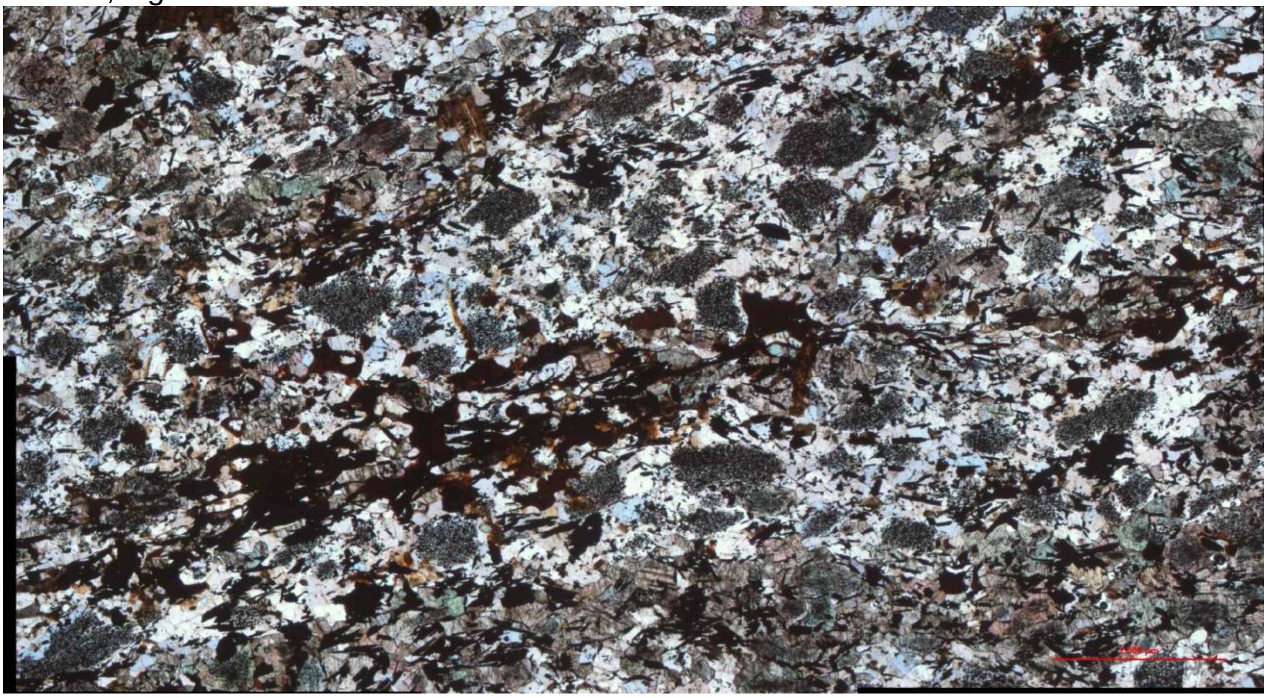
Modal graphite content: 18.37%

Smines Hg40_14



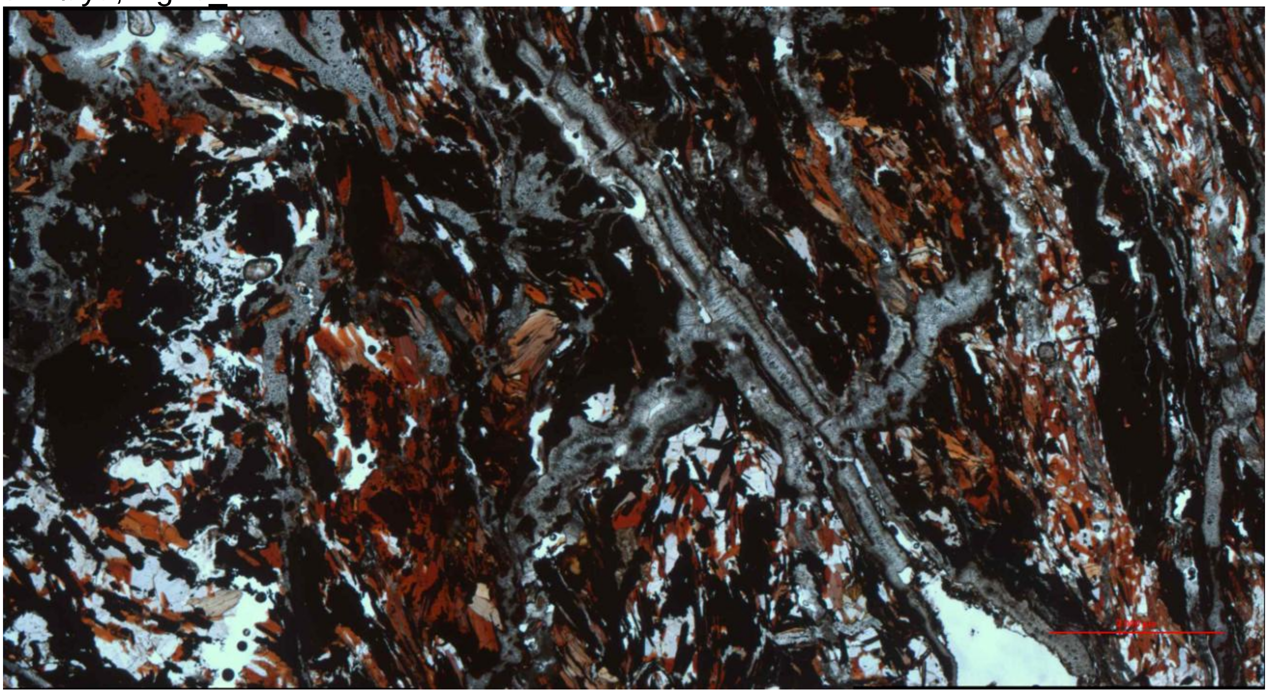
Modal graphite content: 32.37%

Smines, Hg7-15



Modal graphite content: 24.32%

Svinøya, Hg28_14



Modal graphite content: 15.86%

GEOLOGICAL
SURVEY OF
NORWAY
- NGU -

Geological Survey of Norway
PO Box 6315, Sluppen
N-7491 Trondheim, Norway

Visitor address
Leiv Eirikssons vei 39
7040 Trondheim

Tel (+ 47) 73 90 40 00
E-mail ngu@ngu.no
Web www.ngu.no/en-gb/