



GEOLOGICAL
SURVEY OF
NORWAY

- NGU -



Graphite in Fennoscandia

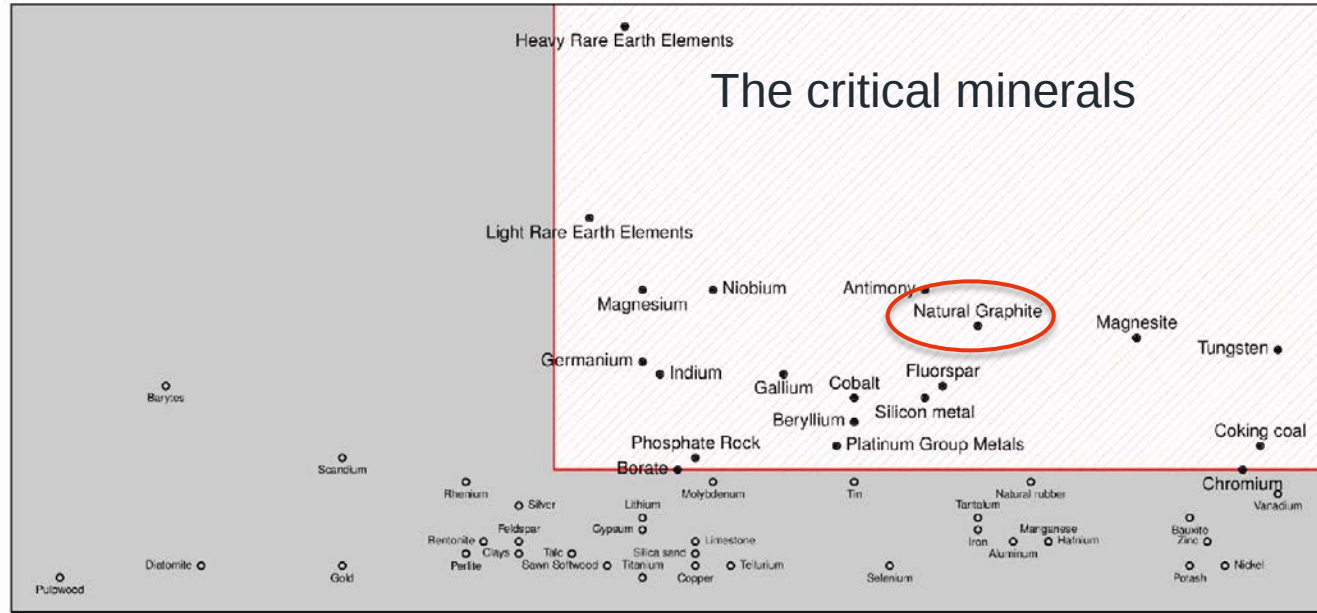
- **Håvard Gautneb, Geological Survey of Norway**
- **Contributors:**
 - Timo Ahtola GTK, Finland
 - Olav Eklund, Åbo Akademi University, Finland
 - Edward Lynch, SGU, Sweden



Nordic Mining Day PDAC 2016

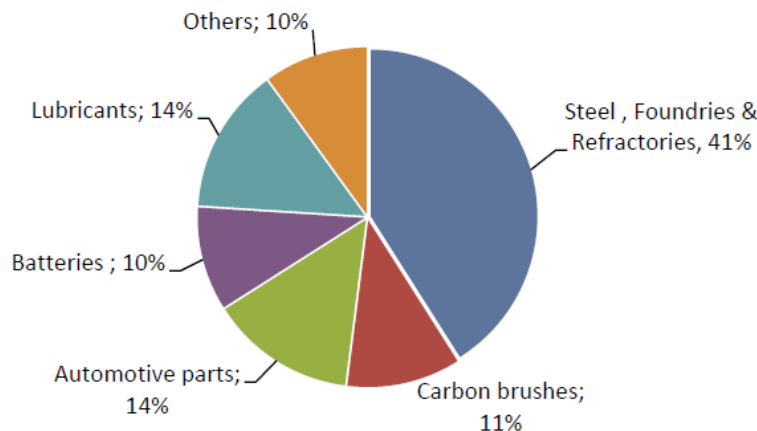
Why graphite

Economic importance



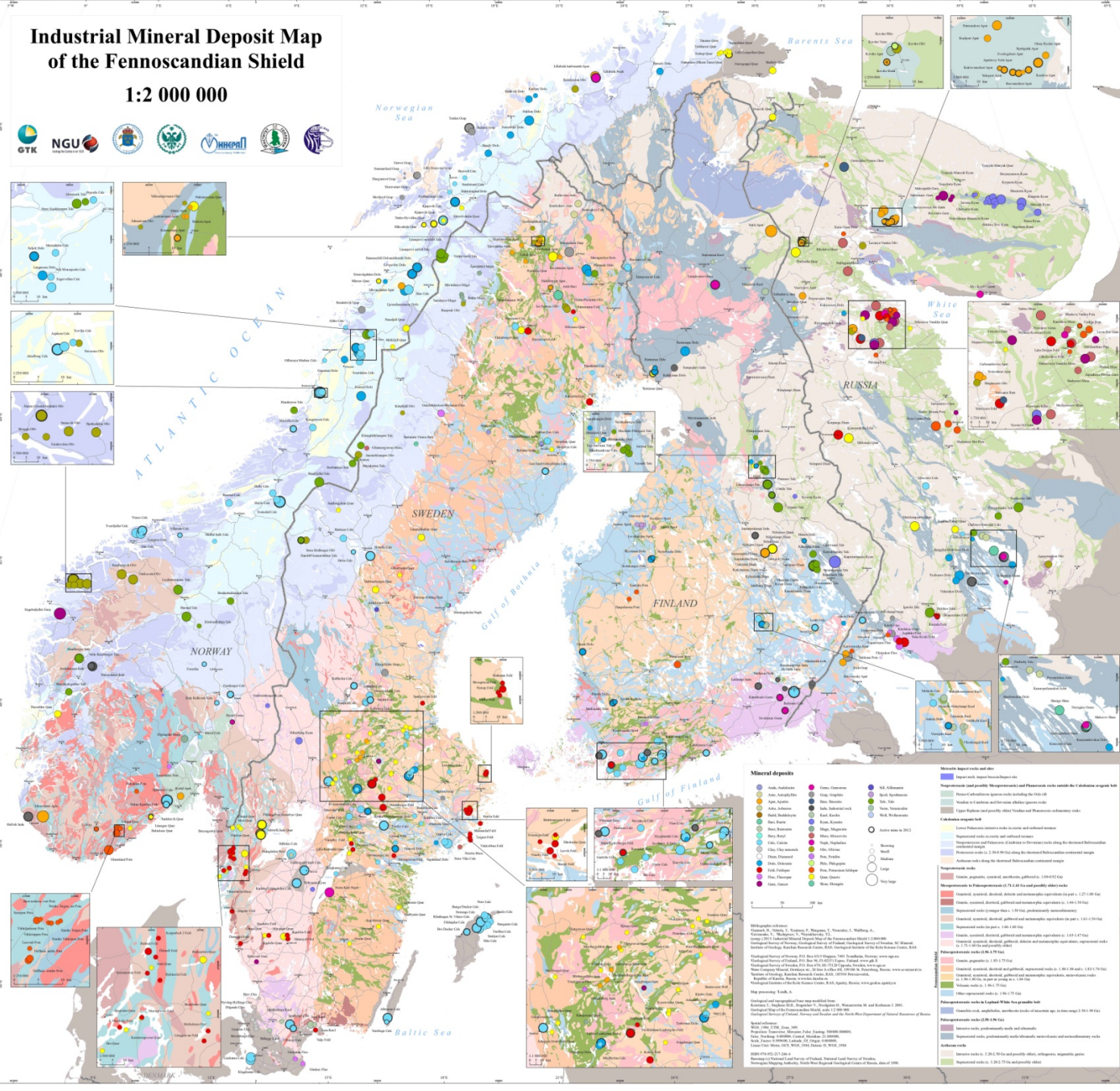
Supply risk

Graphite is one of EU's "critical minerals" meaning that it is of large economical importance and at the same time has a supply risk since world production is dominated by few producing countries



Graphite will have an important role in green technology, batteries electrical cars energy storage etc. and will be one raw material for production of graphene (mono layer graphite)

1:2 000 000



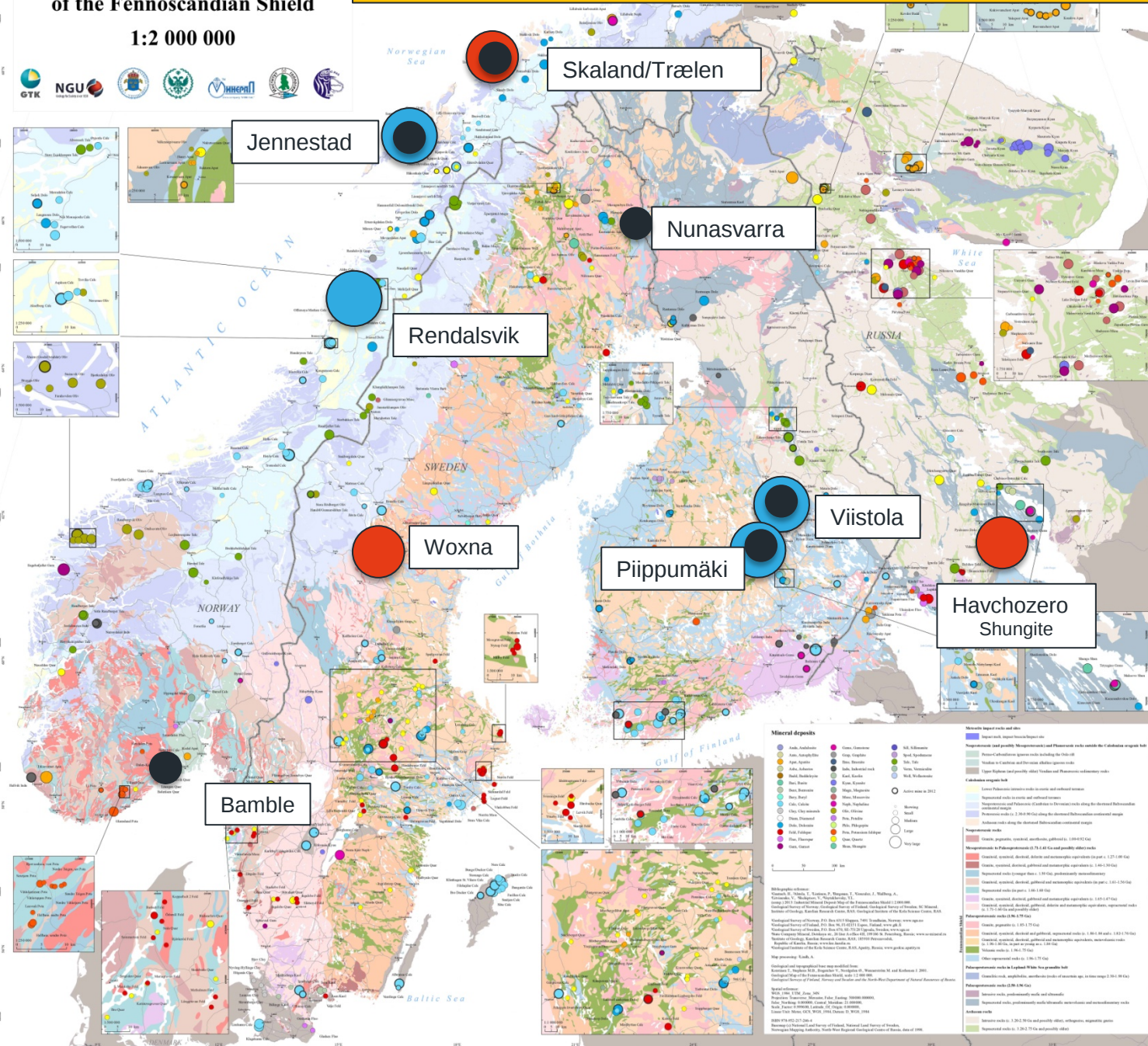
Industrial Mineral Deposit Map of the Fennoscandian Shield

1:2 000 000

GRAPHITE: Past and current producers & active exploration

- Active mine
- Past producer/prospect
- Active exploration

The Fennoscandian graphite and Russian shungite occurrences are all ~2.0-2.5 billion years old (Proterozoic)



Flake graphite in Finland

- ⬤ Graphite quarries from 1760s to 1947
- Flake graphite from GTK field observations
- ▲ Flake graphite from GTK drill holes

Digital bedrock map of Finland 5M

Caledonian tectonic units

● Schists, gneisses or intrusions of variable origin

Paleozoic

■ Alkali rock pipe (Iivara) and carbonatite (Sokki)
■ Sandstone and shale, Cambrian

Neoproterozoic

■ Sandstone and shale, Vendian

Mesoproterozoic

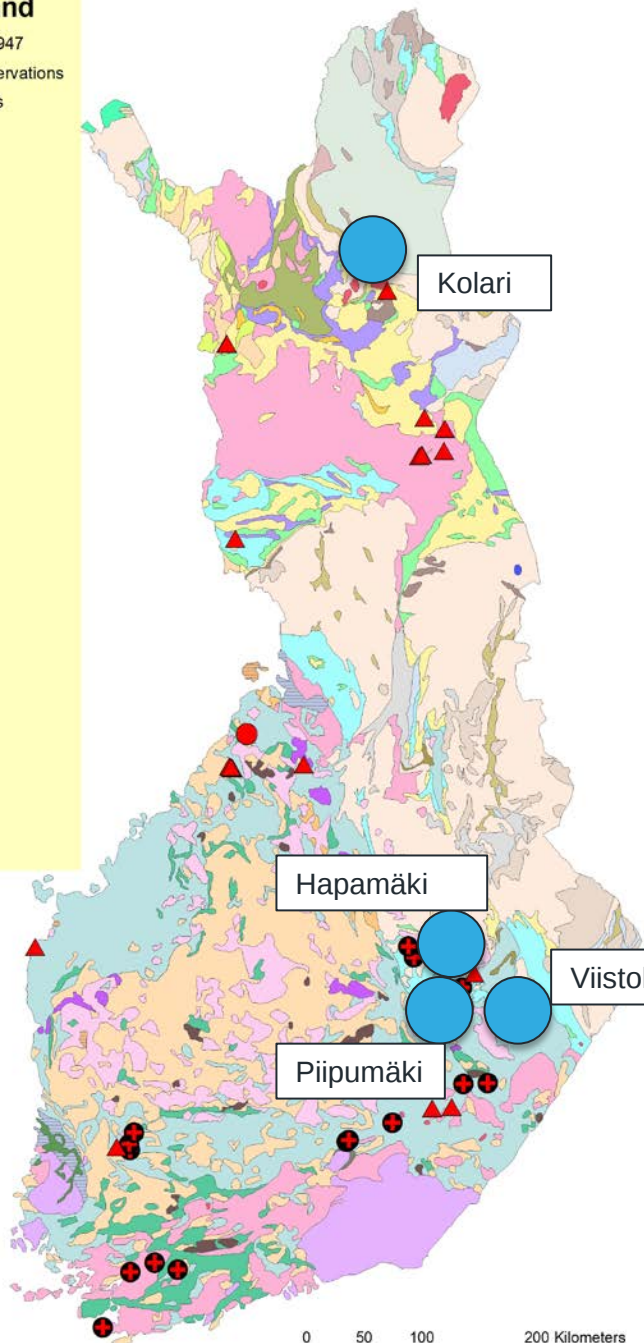
■ Diorite sills, Jotnian
■ Sandstone and shale, Jotnian
■ Rapakivi granite
■ Gabbro-anorthosite
■ Diorite dyke swarms, Subjotnian

Paleoproterozoic

■ Quartzite and conglomerate, molasse of Lapland
■ Postorogenic granitoids 1.81 - 1.77 Ga
■ Late orogenic granites 1.85 - 1.82 Ga
■ Granite and granodiorite 1.86 - 1.86 Ga
■ Pyroxene granite and monzonite 1.885 - 1.87 Ga
■ Granodiorite 1.89 Ga
■ Gabbro-diorite 1.89 - 1.87 Ga
■ Tonalite 1.92 - 1.91 Ga
■ Mica schist and migmatite
■ Mica schist
■ Metavolcanic rocks 1.92 - 1.88 Ga
■ Serpentine and other rocks of opiolite c. 1.96 Ga
■ Garnet gneiss and diorite: Lapland granulite belt
■ Anorthosite
■ Foliated gabbro and granodiorite 1.95 - 1.93 Ga
■ Gneissic granite and hornblende gneiss
■ Quartzite and conglomerate
■ Metavolcanic rock and mica schist, the Kibila allochthon
■ Calc-silicate rock, black schist, basic volcanic intercalates
■ Quartzite with intercalates c. 2.3-2.0 Ga
■ Layered intrusions 2.44 Ga
■ Mafic, intermediate and felsic metavolcanic rocks 2.5 - 2.0 Ga

Archean

■ Latest Archean granitoids
■ Metavolcanic rocks of the greenstone association
■ Metasediments of the greenstone association
■ Biotite + hornblende gneisses and migmatites
■ Tonalite-trondhjemite gneisses and migmatites



Finland:

About 30 graphite deposits have been exploited during the period 1760 to 1947. 20 deposits are located within the present borders of Finland. The total output of these mines is about 14,000 tons.

Graphite is a common mineral in the schist belts of Finland. The potential for new deposits is regarded as good in areas with carbonaceous gneisses with high metamorphic grade.

Some deposits currently of special interest:

- **Viistola,**
Grade 28.3 %Cg/4.2 Mt Indicated
- **Piipumäki,**
Historical graphite mining site with grade 5-10% Cg
- **Hapamäki**
Historical mining of graphite, grades up to 46% Cg found
- **Kolari**
8.9% Cg, Drilled by GTK in 1978
Reference: various GTK reports

Current graphite investigations in Finland

FENNO FLAKE Project 2015-2019:

- 1076000 euro from Academy of Finland
- Exploration
- Mineralogy
- Geophysics
- Technology

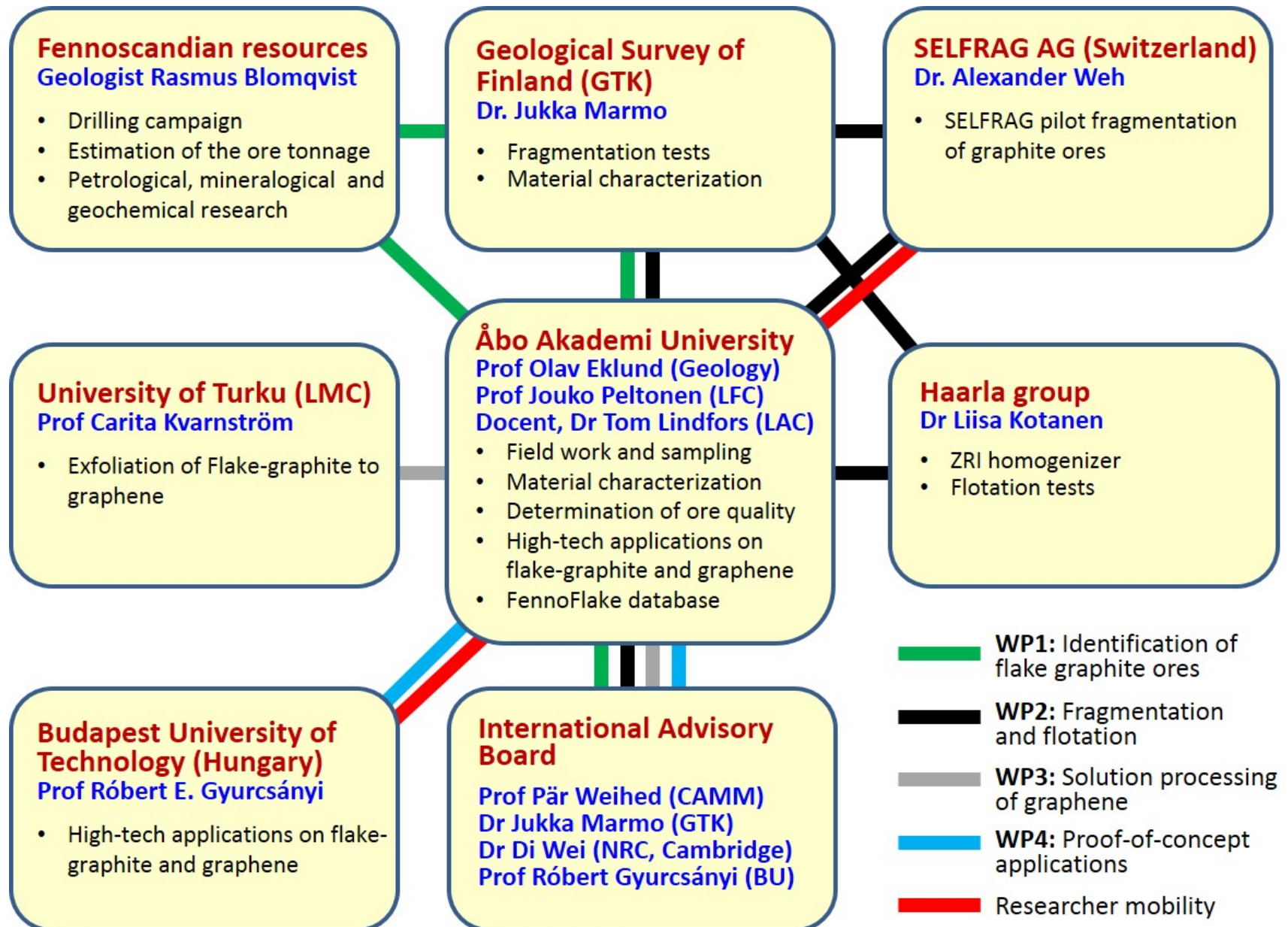
Project leader: Olav Eklund, Åbo Akademi University

Industrial partner: Beowulf Mining, London

GTK activity:

- Mapping
- Geophysics
- Re-logging and analysis of drillcore of known graphite prospects and showings

FENNO FLAKE ACTIVITIES IN DETAIL



Sweden:

54 known occurrences

Almost all of Svecokarelian age 2.0-2.4 Ga

The majority of these in the Norbotten craton

Geological setting: Metamorphic volcano-sedimentary sequences.

Both flake and amorphous graphite types.

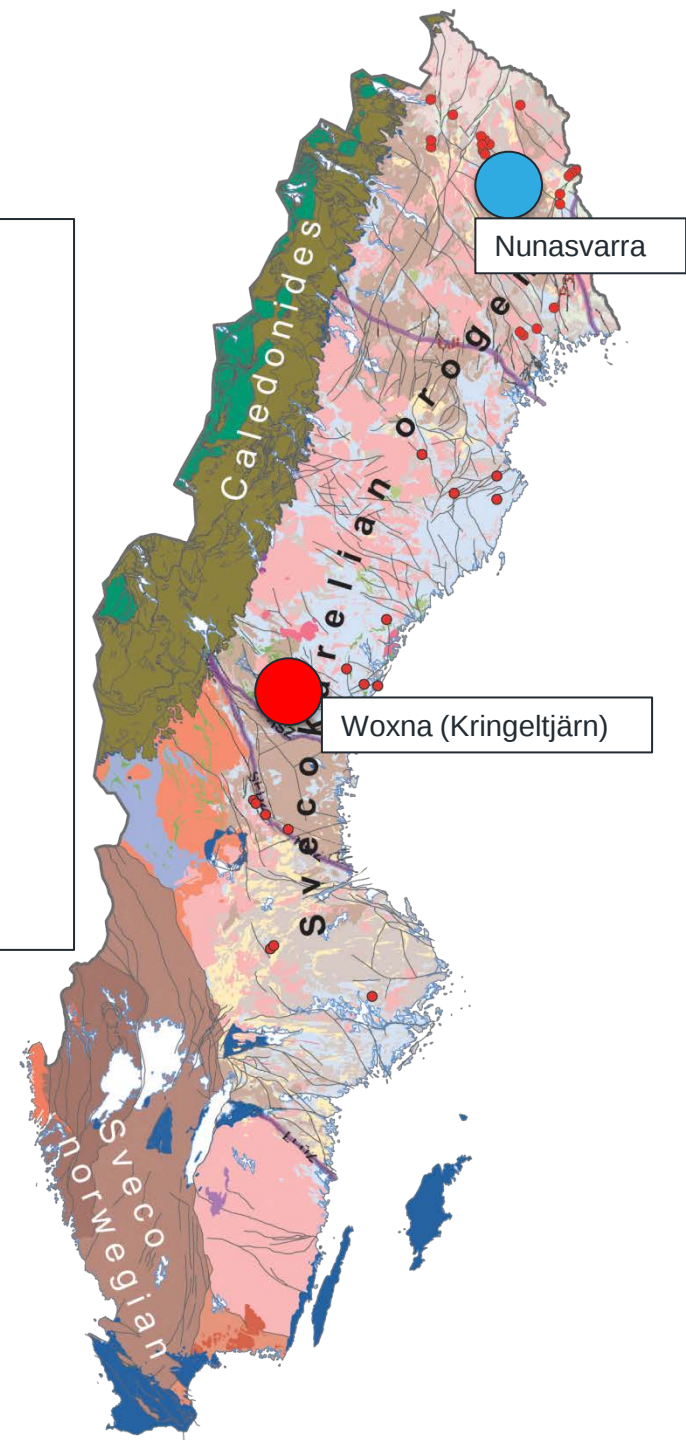
Few detailed studies.

- **Woxna graphite mine, central Sweden,**
9.3% Cg / 7.7 Mt proven and indicated, 4 ore bodies

www.flindersresources.com

- **Nunasvarra: northern Sweden close to Kiruna**
24% Cg, 7.7 Mt proven and indicated, flake and amorphous.

www.talgaresources.com



Geology of Norway and graphite provinces

Lofoten - Vesterålen

Senja

Skaland

Jennestad

Rendalsvik

Holandsfjord

Bamble

Norway:
75 registered
occurrences/showings
2 former and 1 active
producer

- Rendalsvik mine
- Jennestad mine
- Skaland mine (active)

Geological map of Norway

LEGEND

- Igneous rocks of the Oslo province (Permian-Carboniferous)
- Sedimentary rocks of the Oslo province (Cambrian-Silurian)
- Sedimentary rocks (Devonian)
- Thrust nappes of Precambrian age
- Metamorphic and igneous rocks
- Sandstone and schists
- Basement rocks within the Caledonides
- Basement rocks outside the Caledonides

Caledonian
nappes

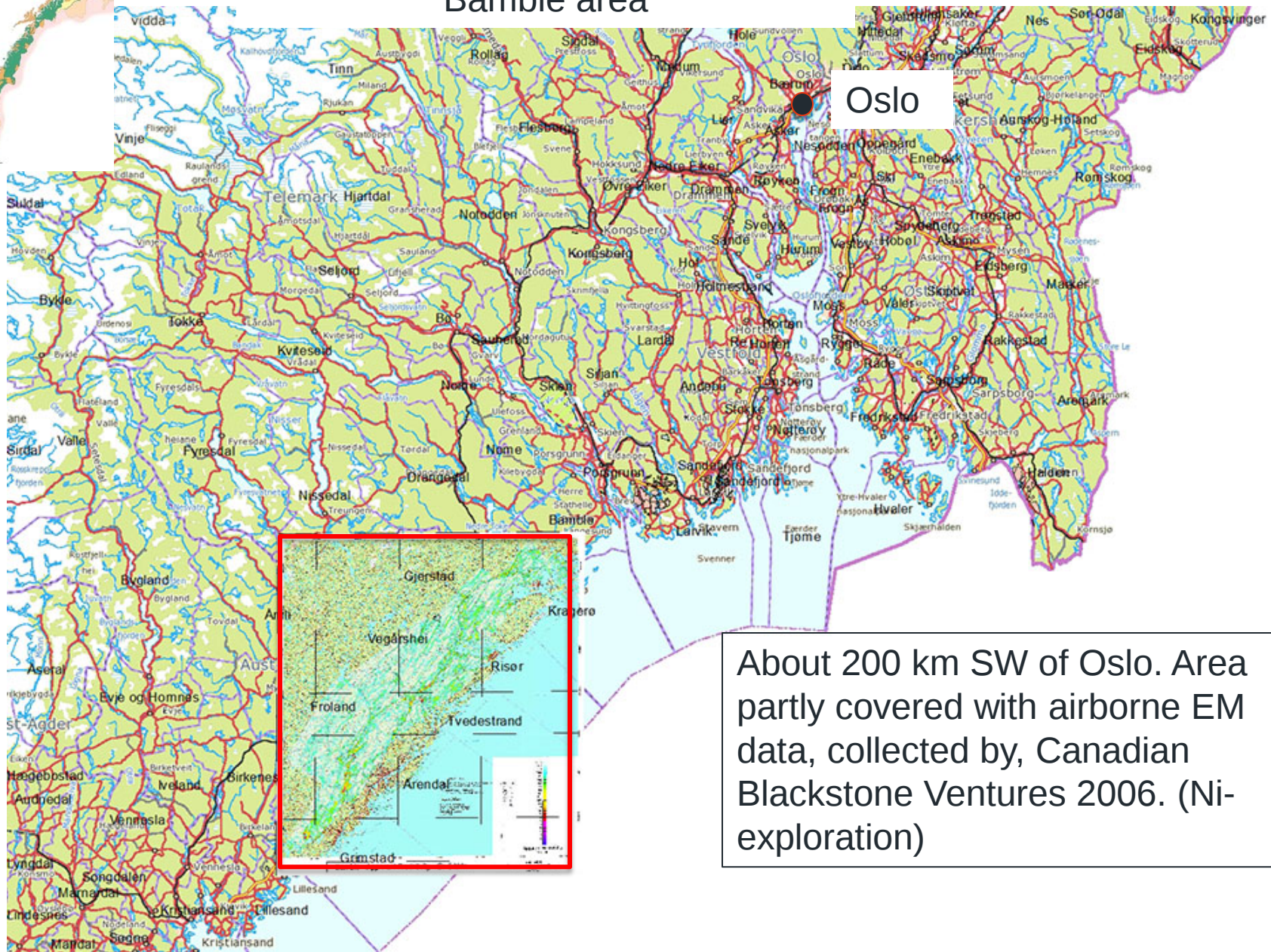
100 km



GEOLOGICAL SURVEY OF NORWAY

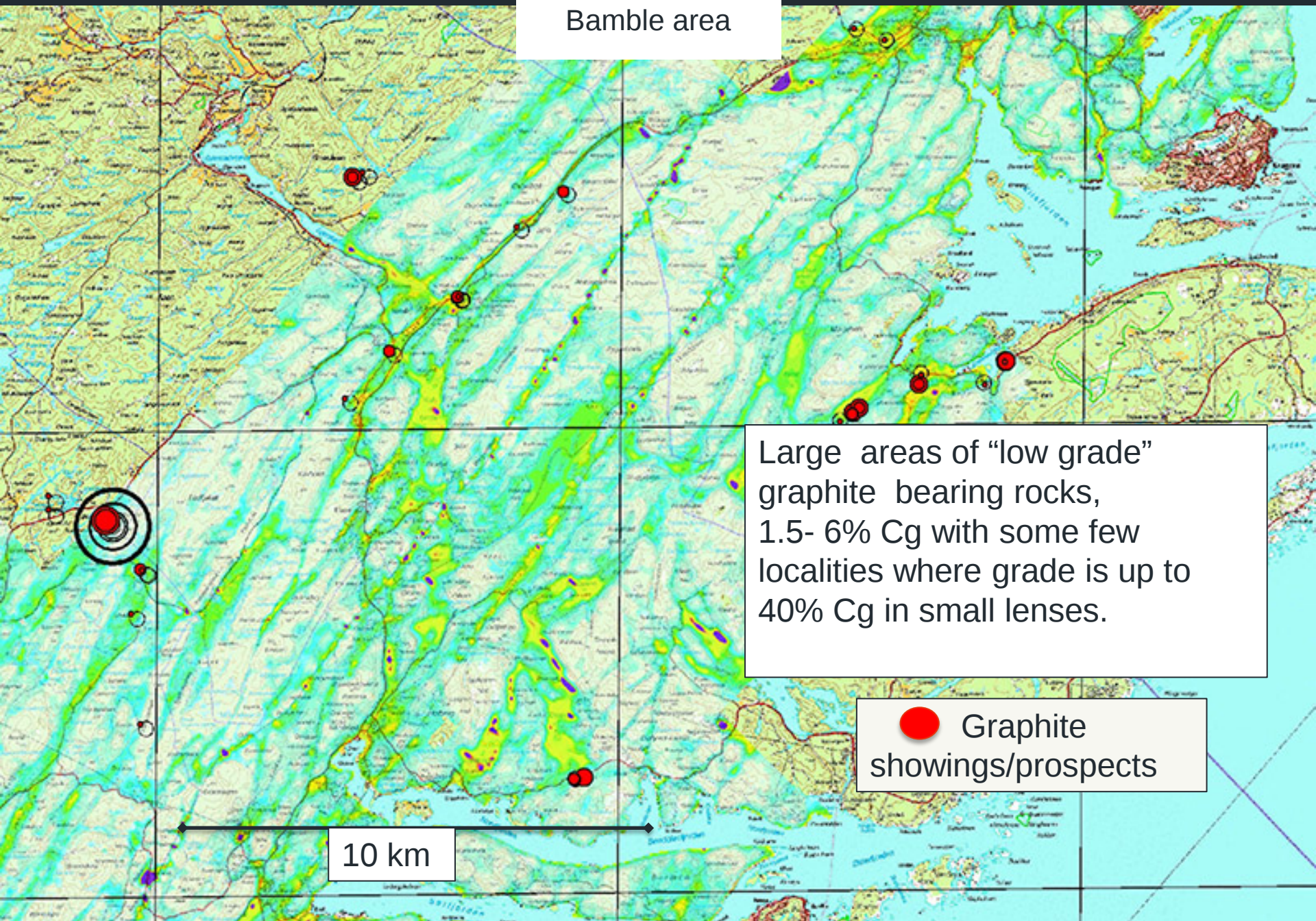
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Bamble area



About 200 km SW of Oslo. Area partly covered with airborne EM data, collected by, Canadian Blackstone Ventures 2006. (Ni-exploration)

Bamble area



Large areas of “low grade” graphite bearing rocks, 1.5- 6% Cg with some few localities where grade is up to 40% Cg in small lenses.

● Graphite showings/prospects

10 km

Holandsfjord area



Nord-Værnes
prospect

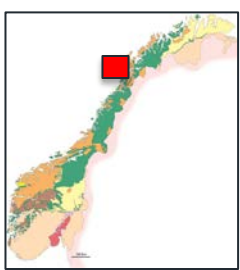
Rendalsvik mine
(abandoned 1948)

13% Cg
Orebody drilled (1982)
300m, length 30m width
Depth 100m
(Open at depth)

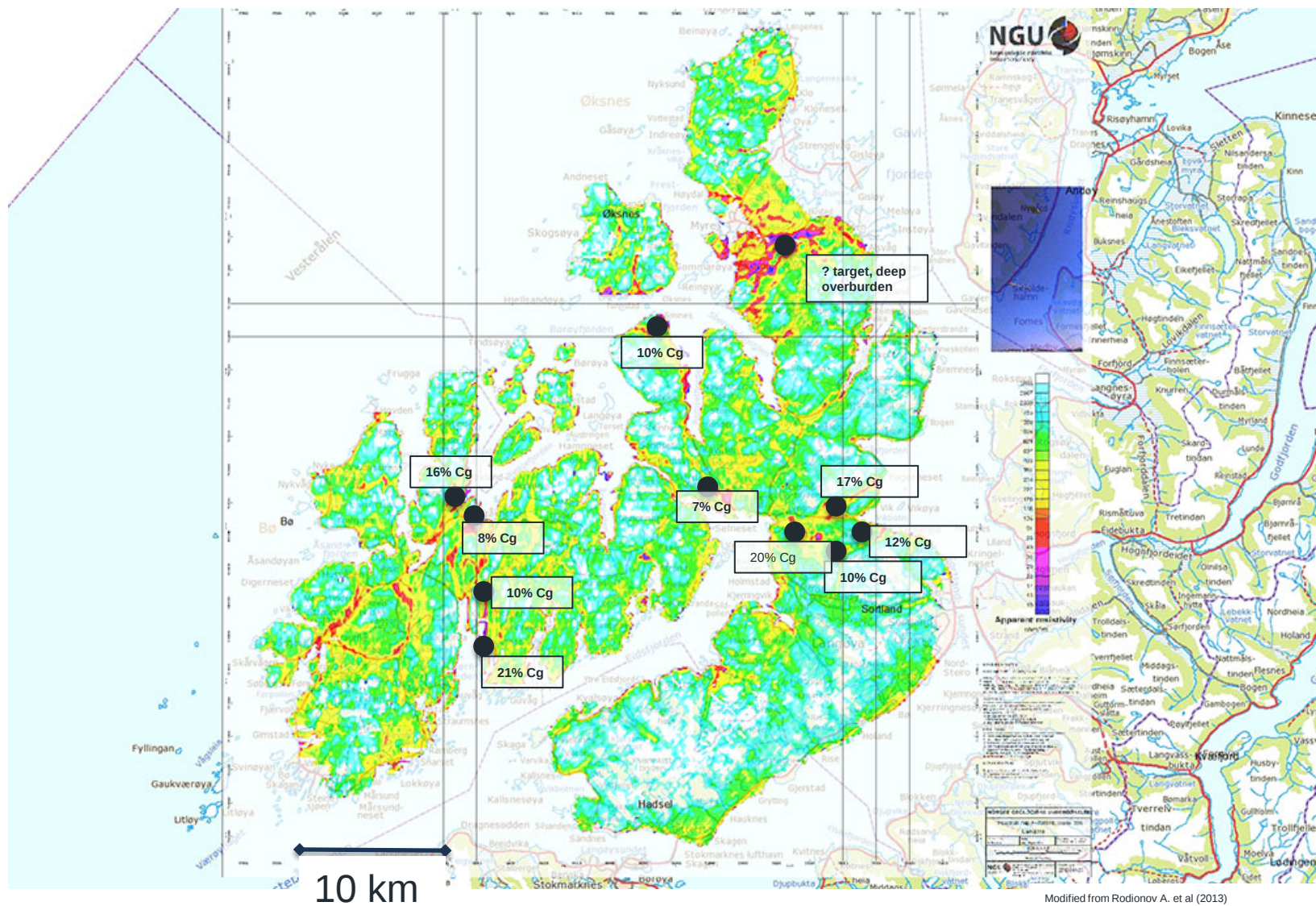
5% Cg 500m length

5 km

Modified from Rodionov A. et al (2013)
NGU report 2013.043

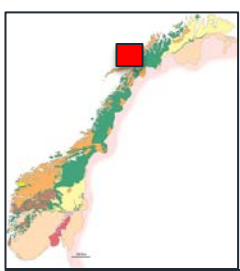


Lofoten- Vesterålen Islands



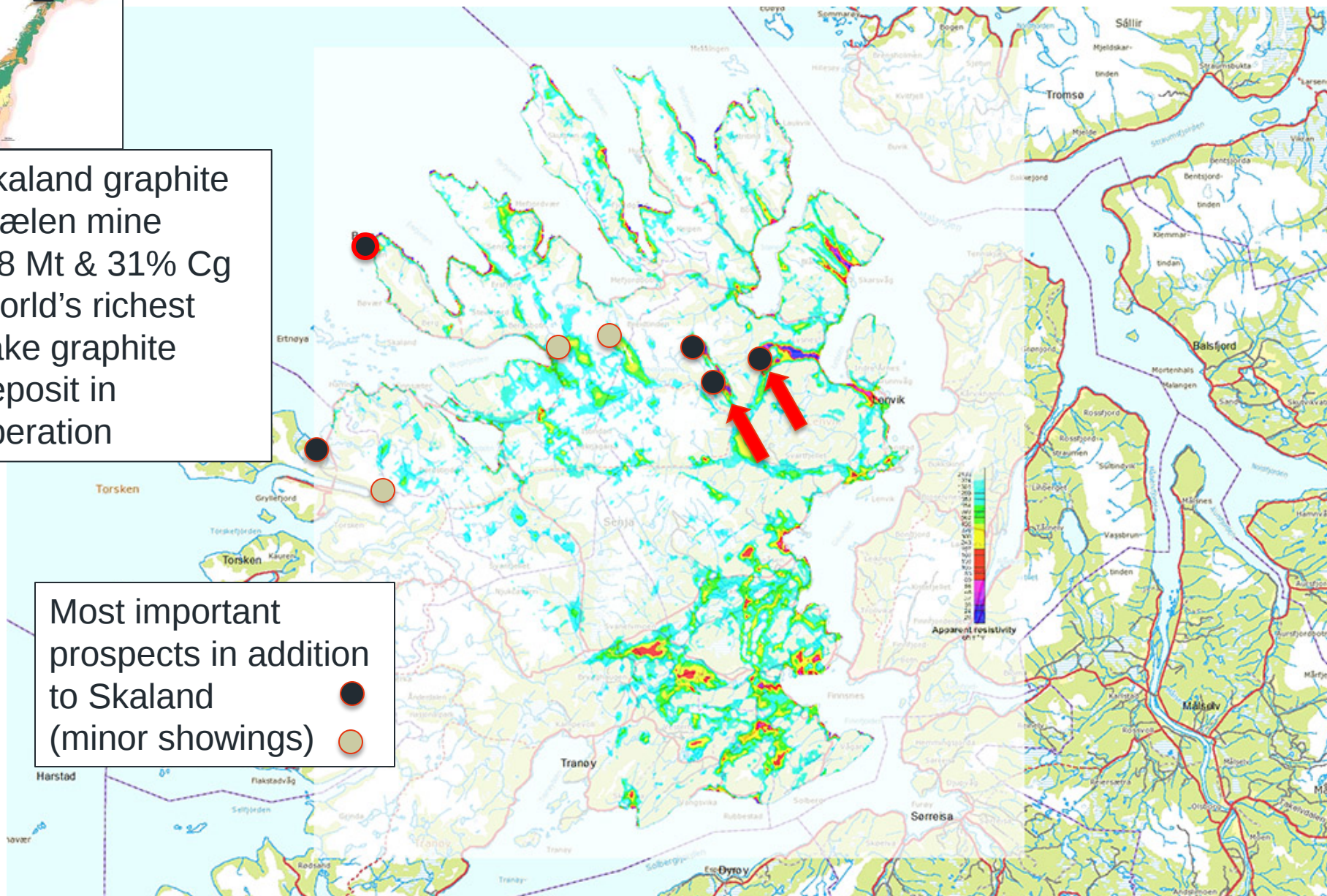
Modified from Rodionov A. et al (2013)
NGU report 2013.044

Island of Senja

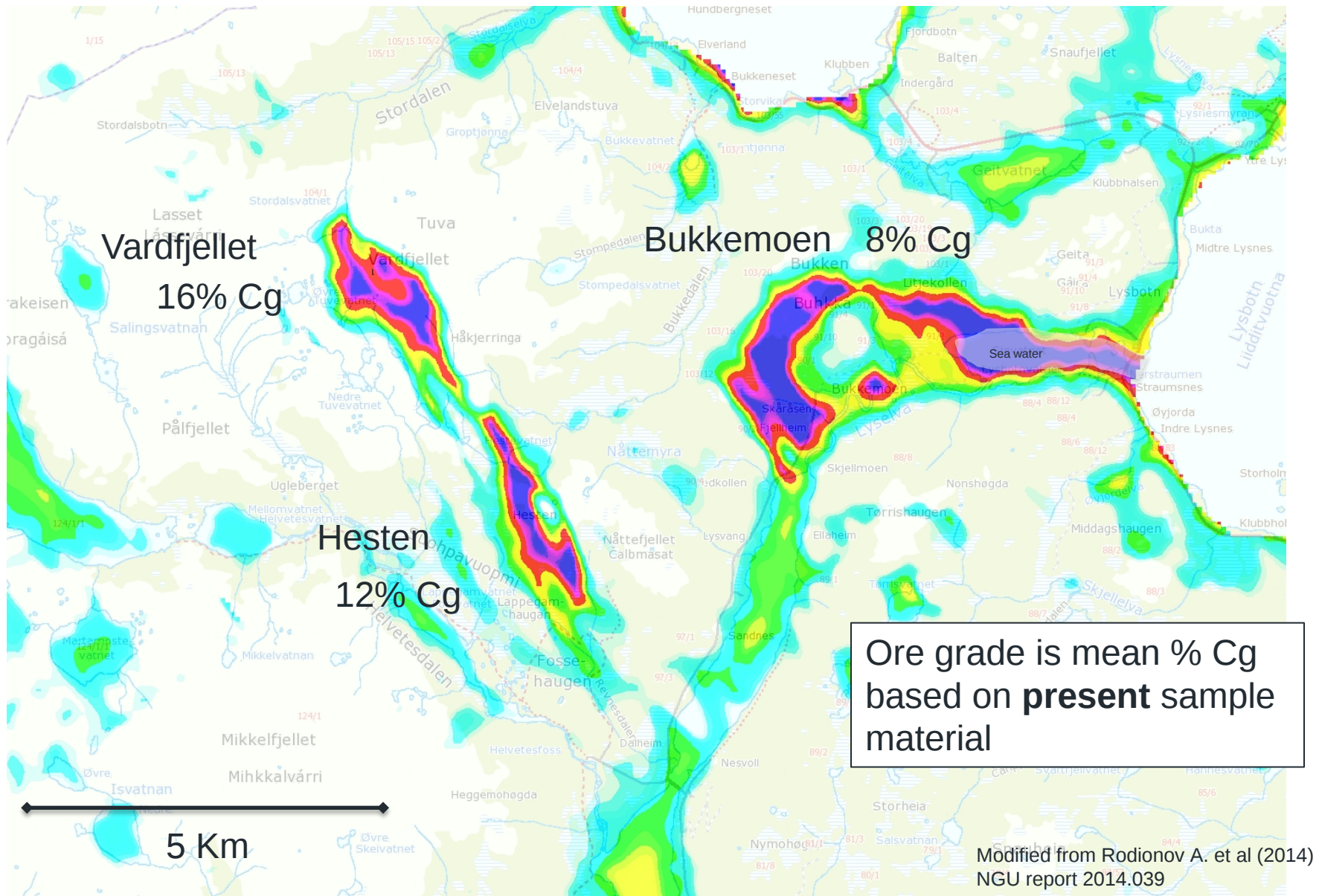


Skaland graphite
Trælen mine
1.8 Mt & 31% Cg
World's richest
flake graphite
deposit in
operation

Most important
prospects in addition
to Skaland
(minor showings)



Vardfjellet – Hesten- Bukkemoen prospects



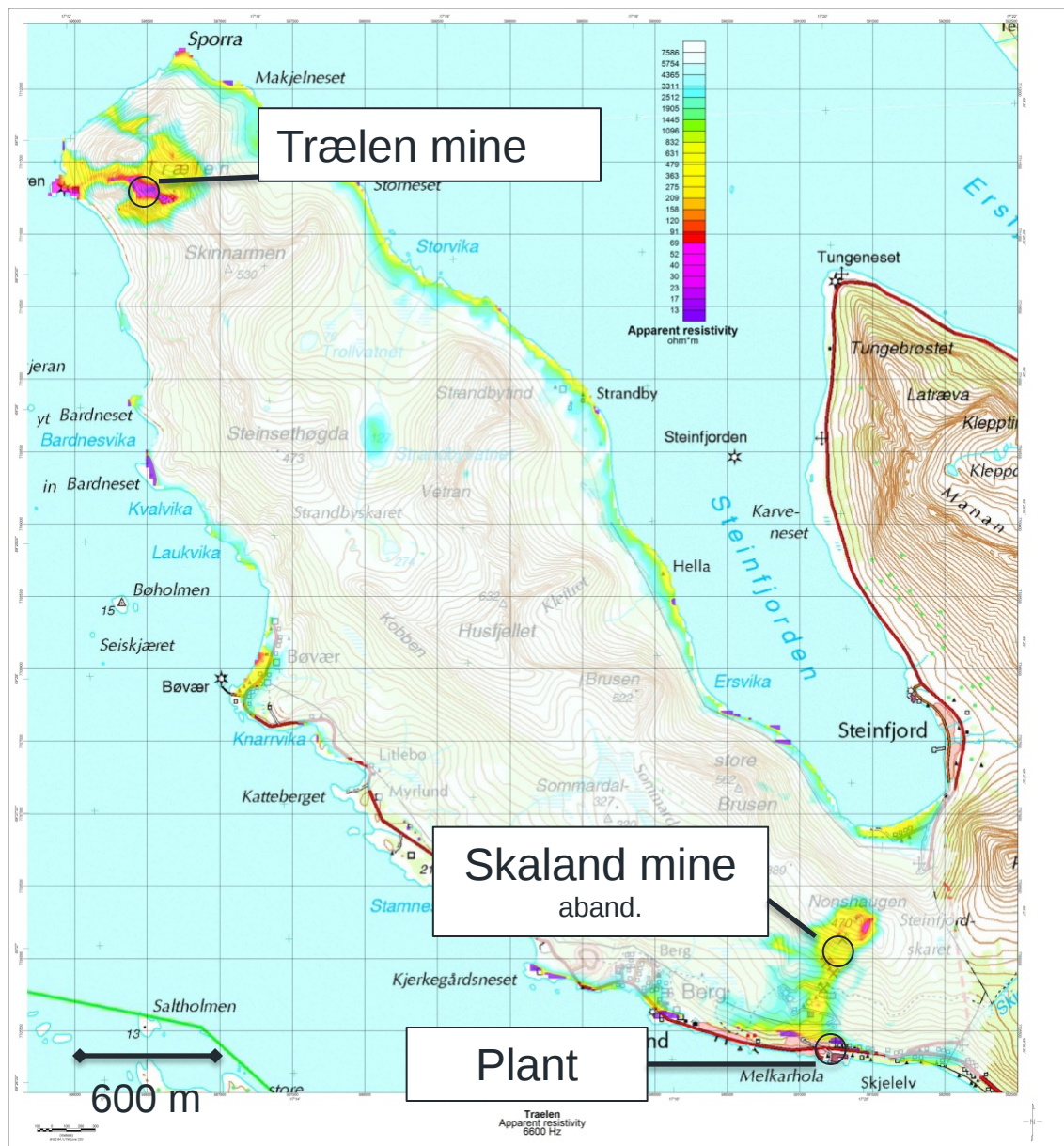
“Graphite scenery” abandoned mines & showings



The graphite ore is located under
thin cover using Geonics EM 31

Skaland graphite, operations

EM helicopter survey
of the Skaland- Trælen
area





Underground mining (overhead stoping)

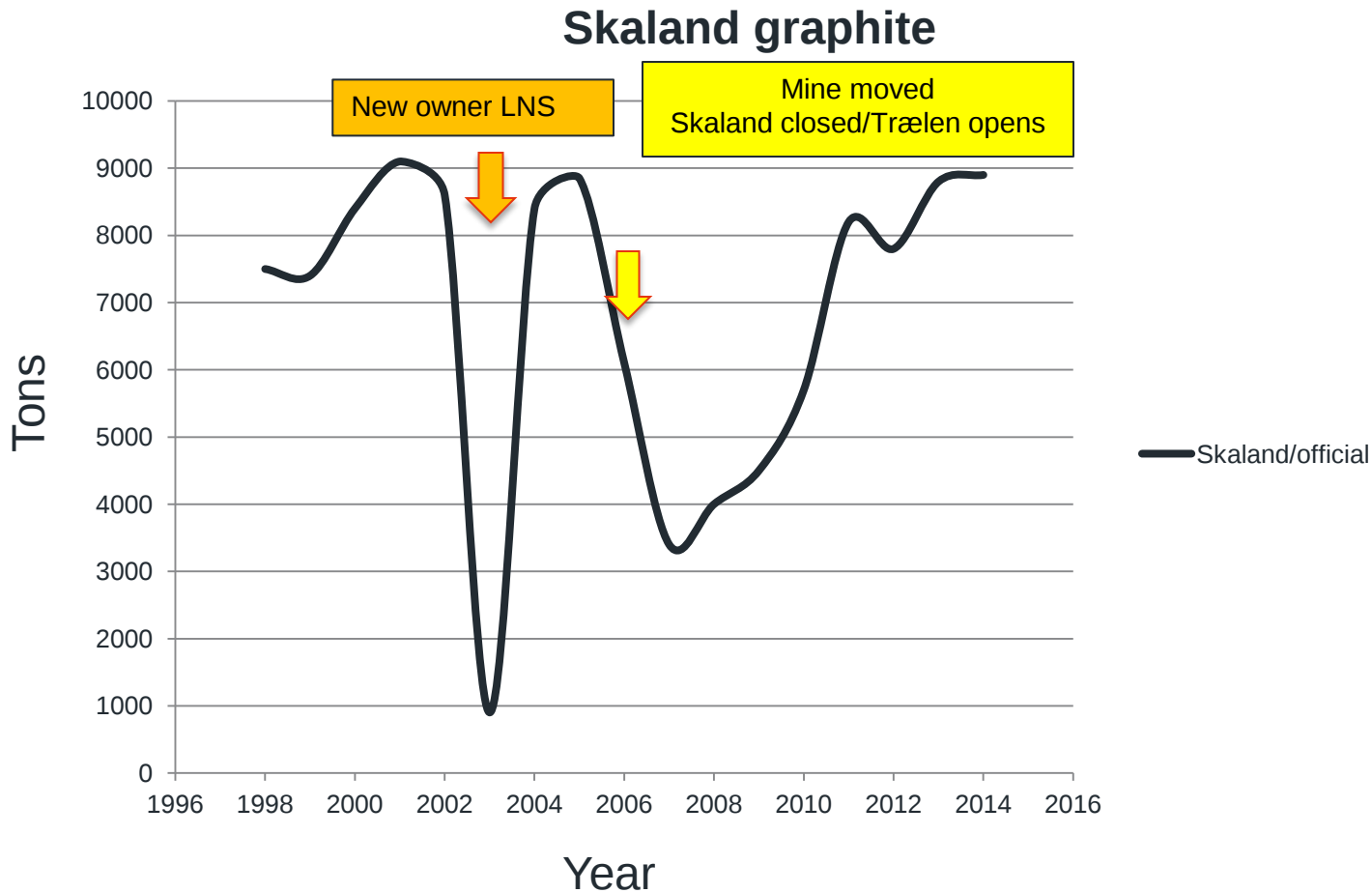


Flotation



Big bags/shipping

Norwegian graphite production



For more details check Norwegian mining statistics at www.dirmin.no



Thank you for your attention