GEOLOGICAL SURVEY OF ESTONIA

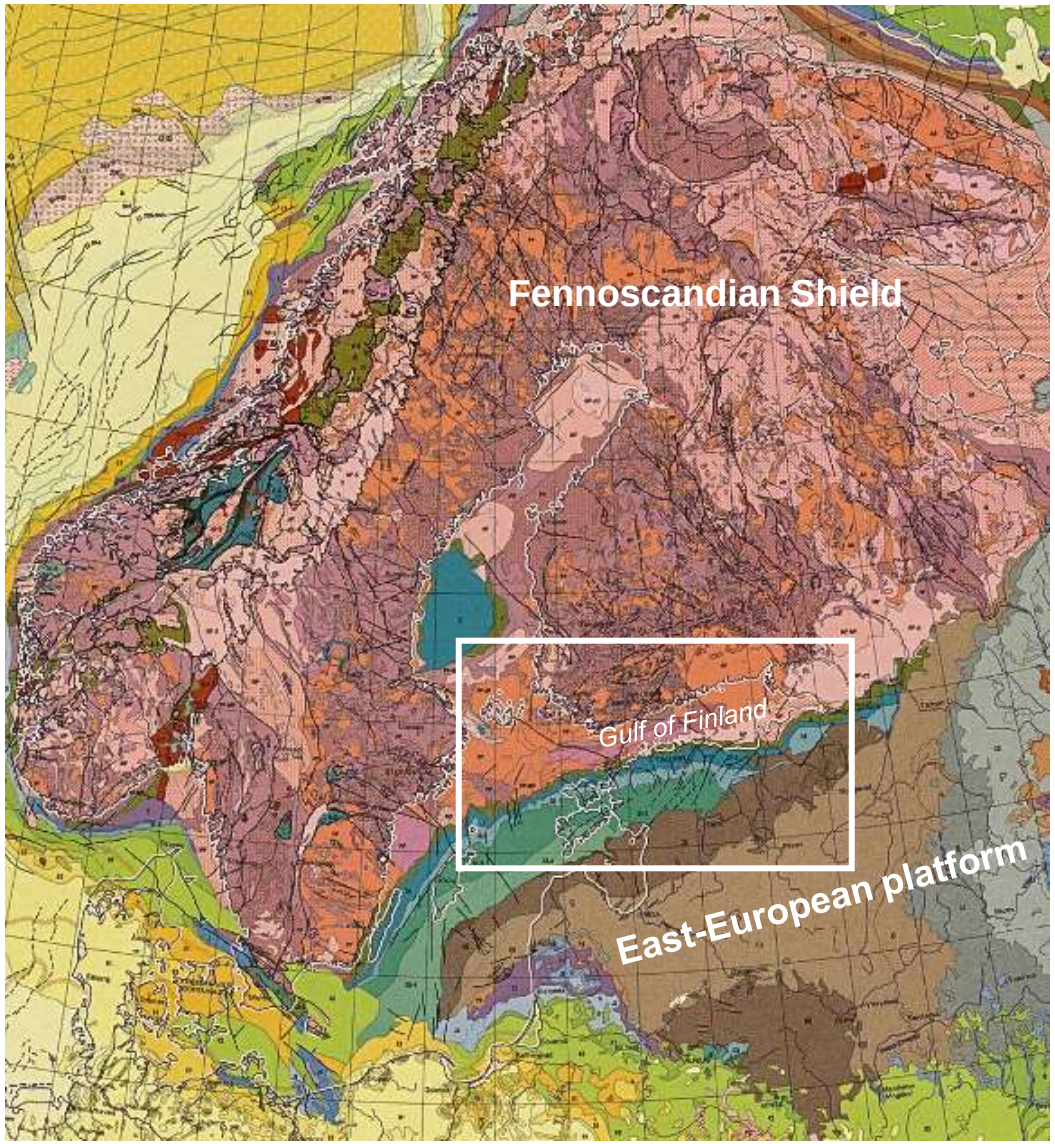
Distribution of the Fe-Mn concretions on the Estonian seafloor

Sten Suuroja, Aivo Lepland and Martin Liira
Geological Survey of Estonia

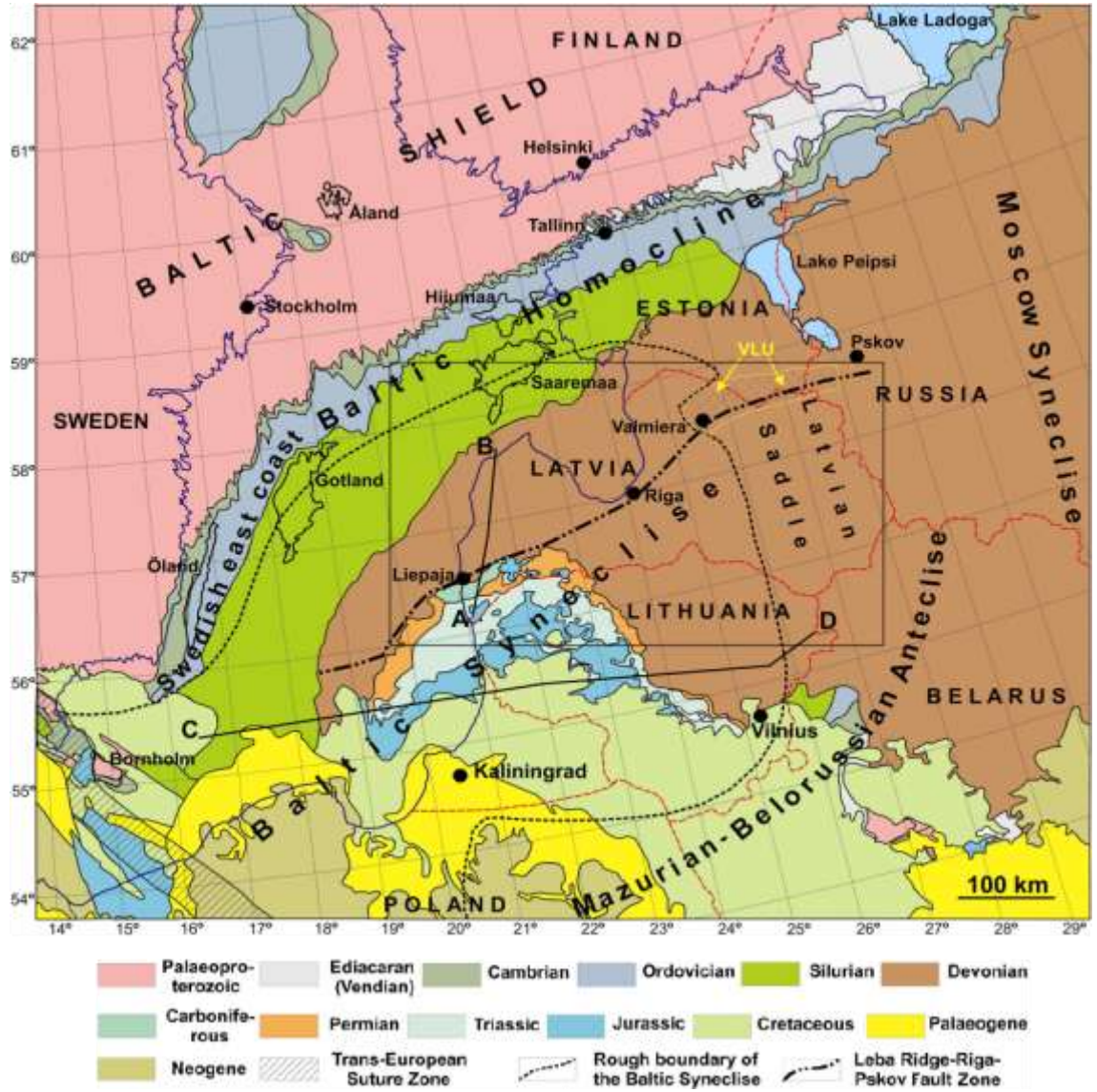
22.04.2022; Conference "Geologic And Economic Potentials Of Mineral Resources On Both Side Of The Gulf"

Geology

Source: IGME5000

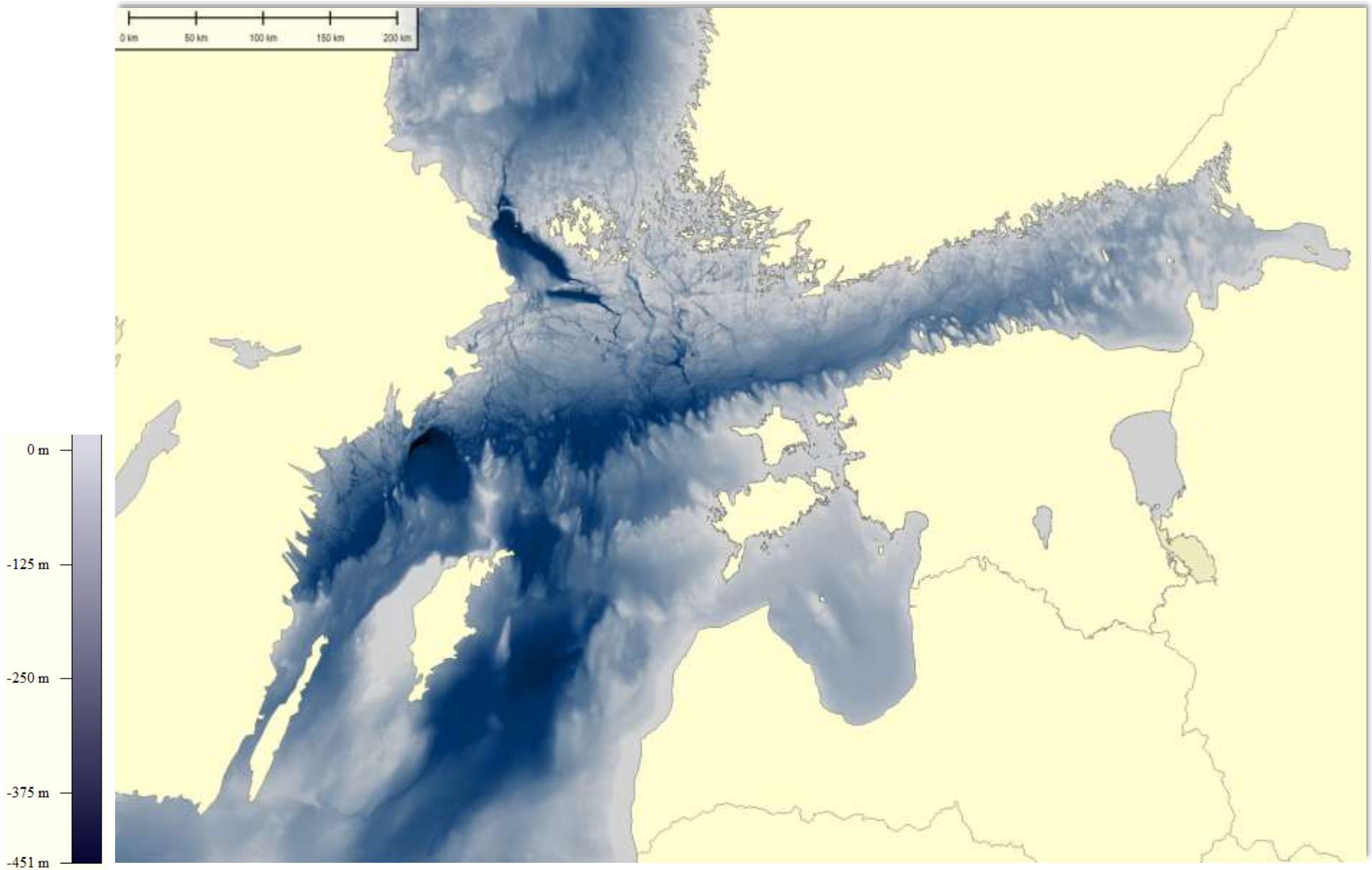


Tuuling, 2019

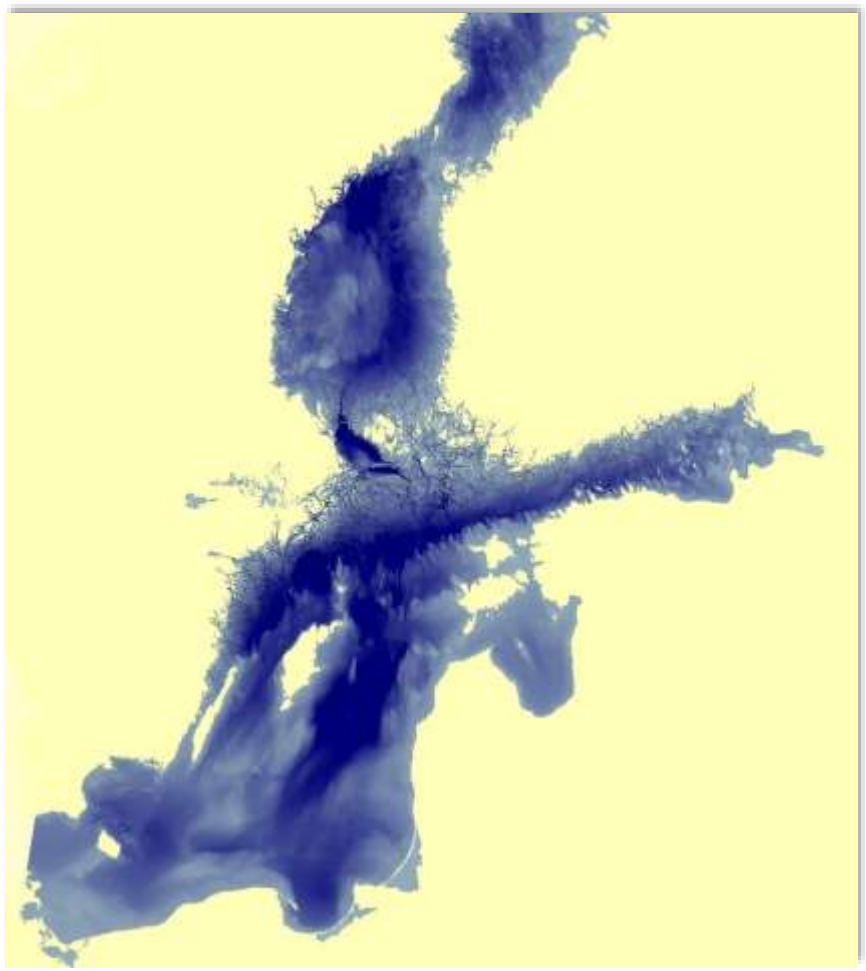


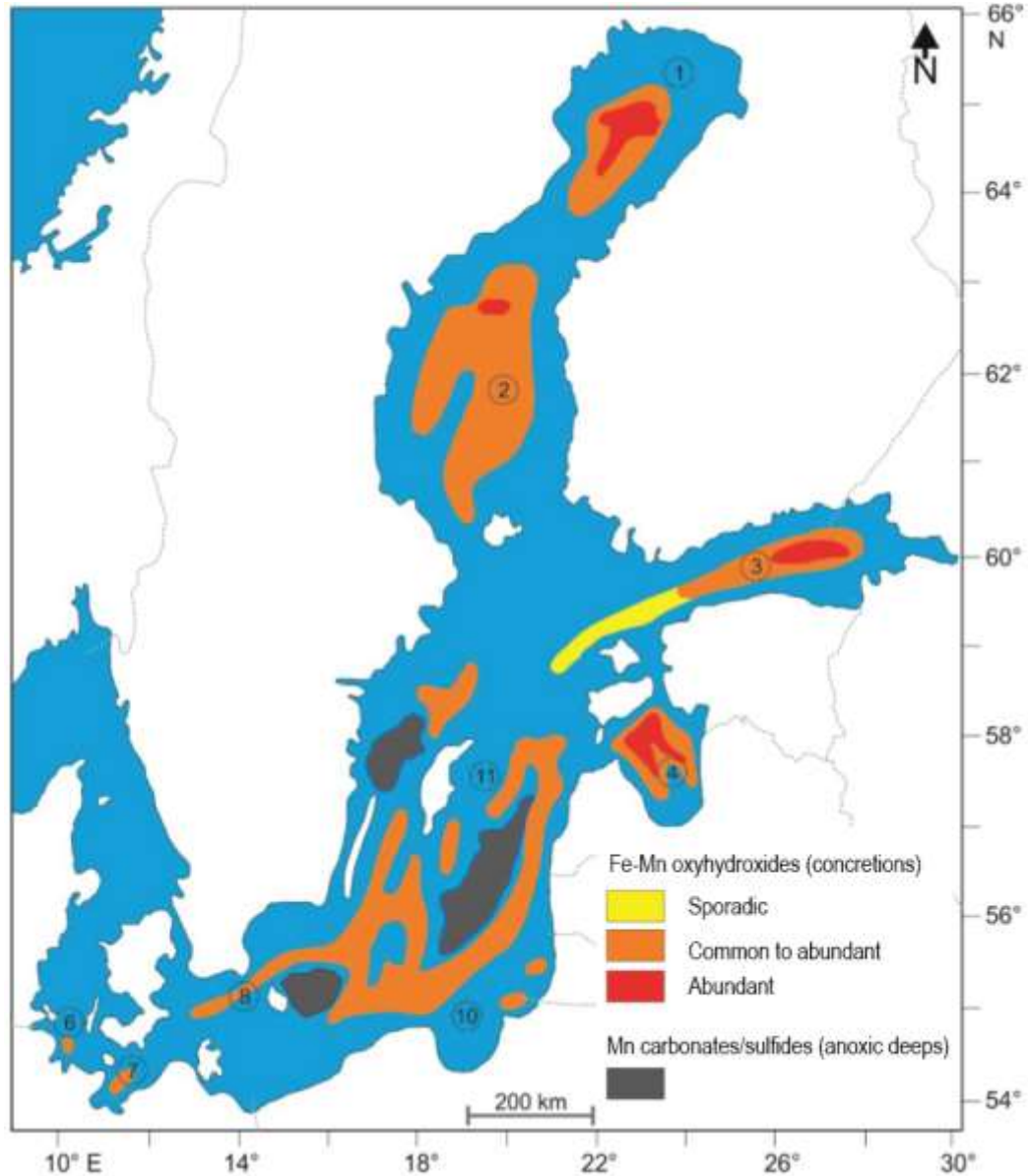
Seafloor relief of Baltic Sea

Data source: www.emodnet-bathymetry.eu



Distribution of authigenic Mn precipitates on the seafloor and in bottom sediments of the Baltic Sea





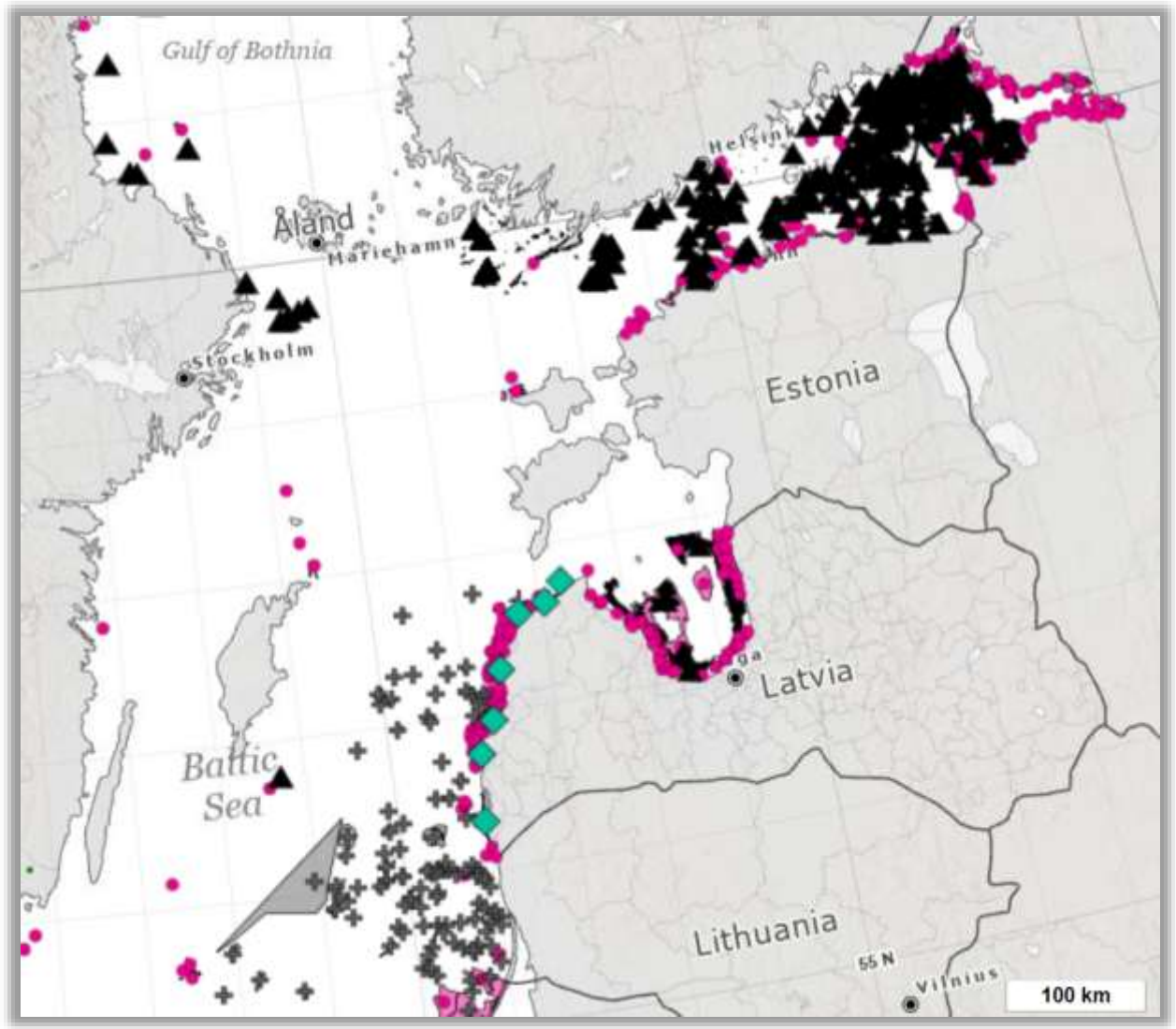
Modified by A. Lepland
after Glasby et al. 1997 & Wasiljeff 2015

EMODnet-Geology – providing harmonised information on marine geology in Europe.

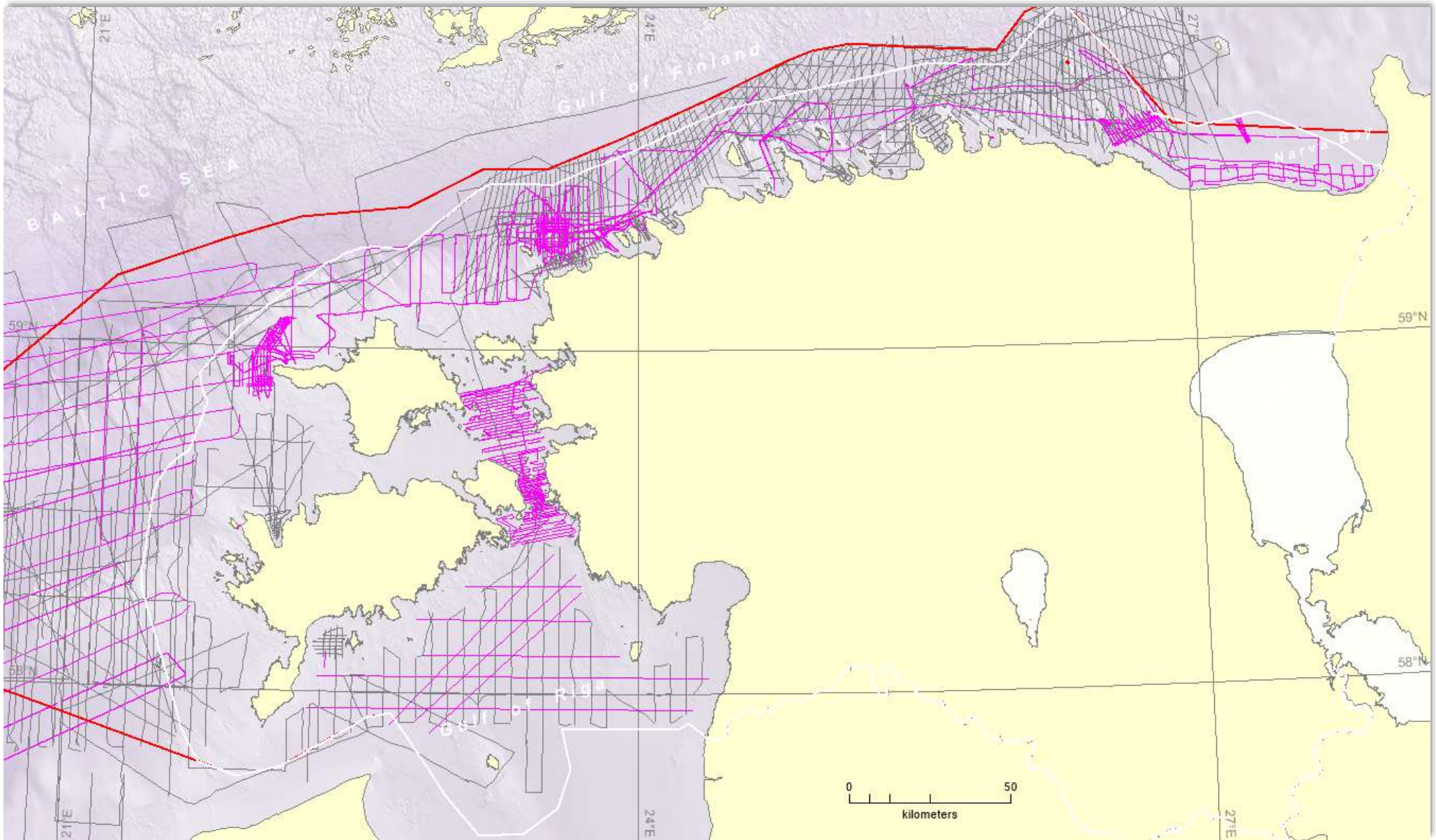
EMODnet GEOLOGY
Discover Europe's seabed geology

Marine minerals

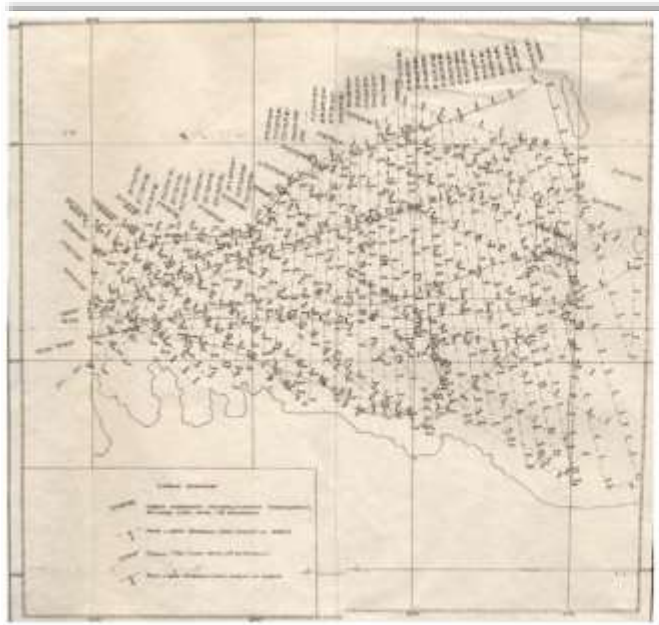
- Aggregate
- Cobalt rich ferromangase crust
- Evaporite
- Gas hydrates
- Hydrocarbon
- Metal rich sediments
- Phosphorites
- Placers
- Polymetallic nodules
- Polymetallic sulphides
- Rock, pegmatite and vein hosted mineralisation
- Sapropel

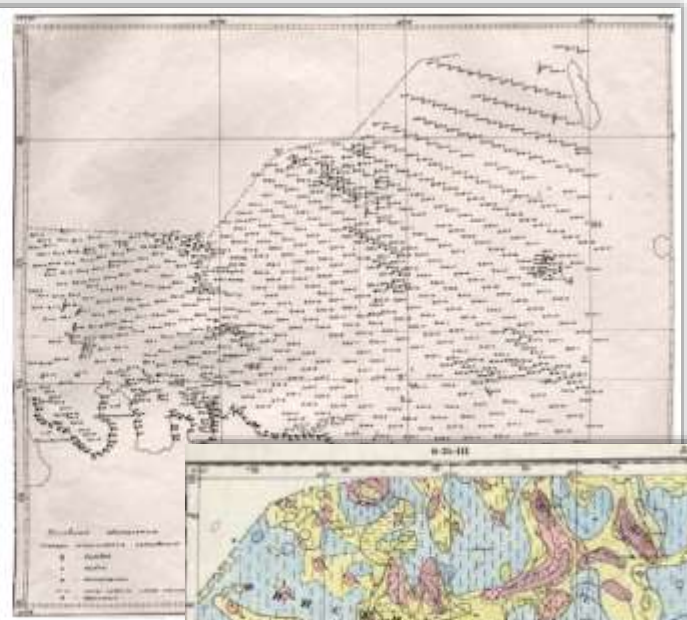


Geological mapping (seismo-acoustic profiling)



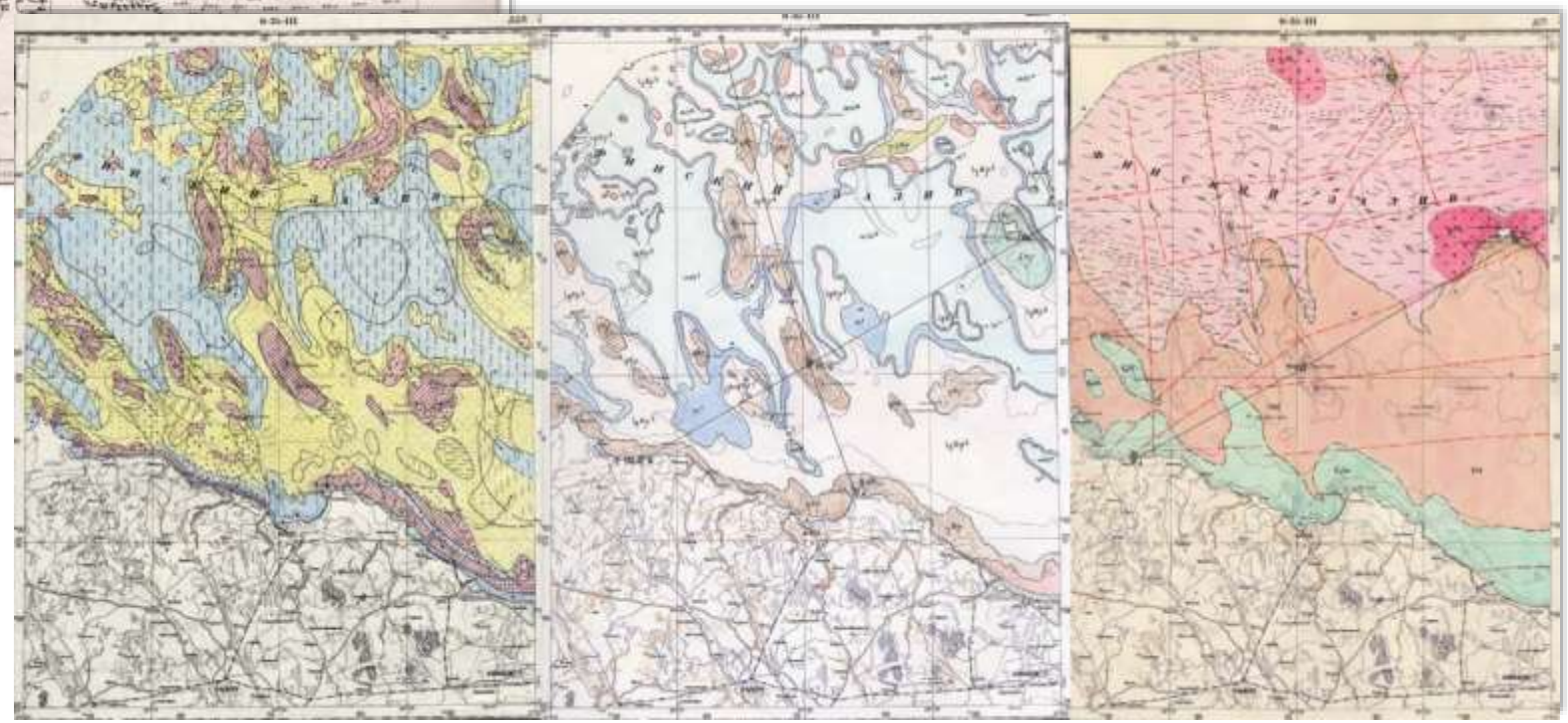
Geological mapping of Gulf of Finland in scale 1:200 000



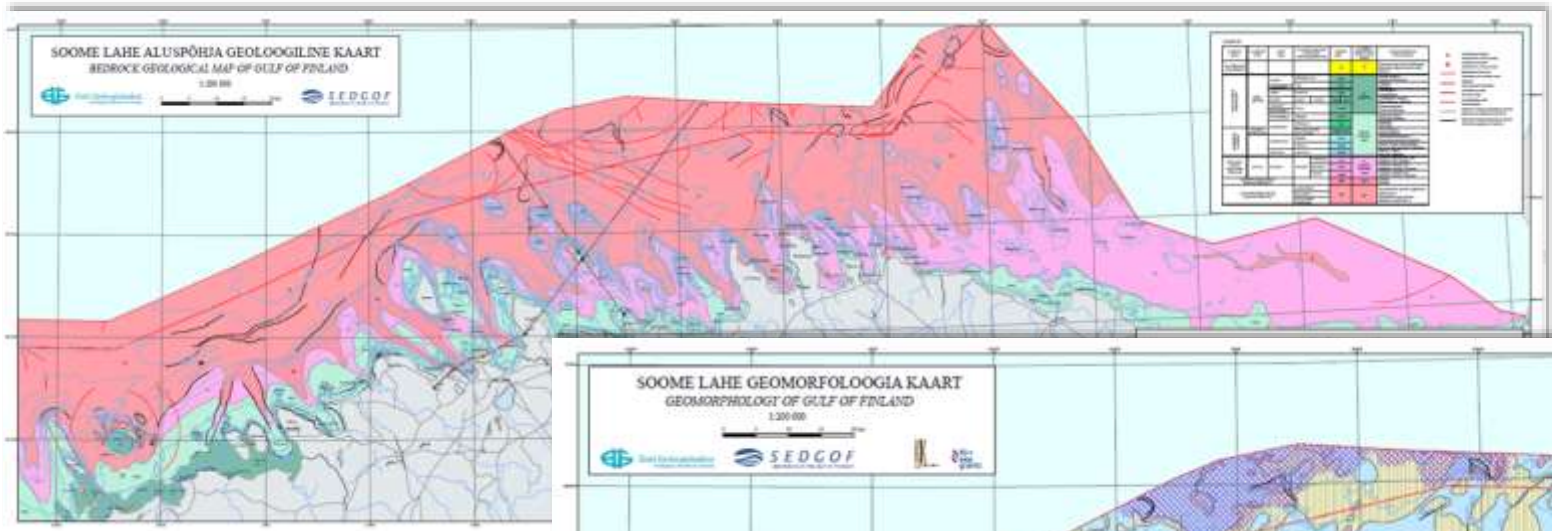






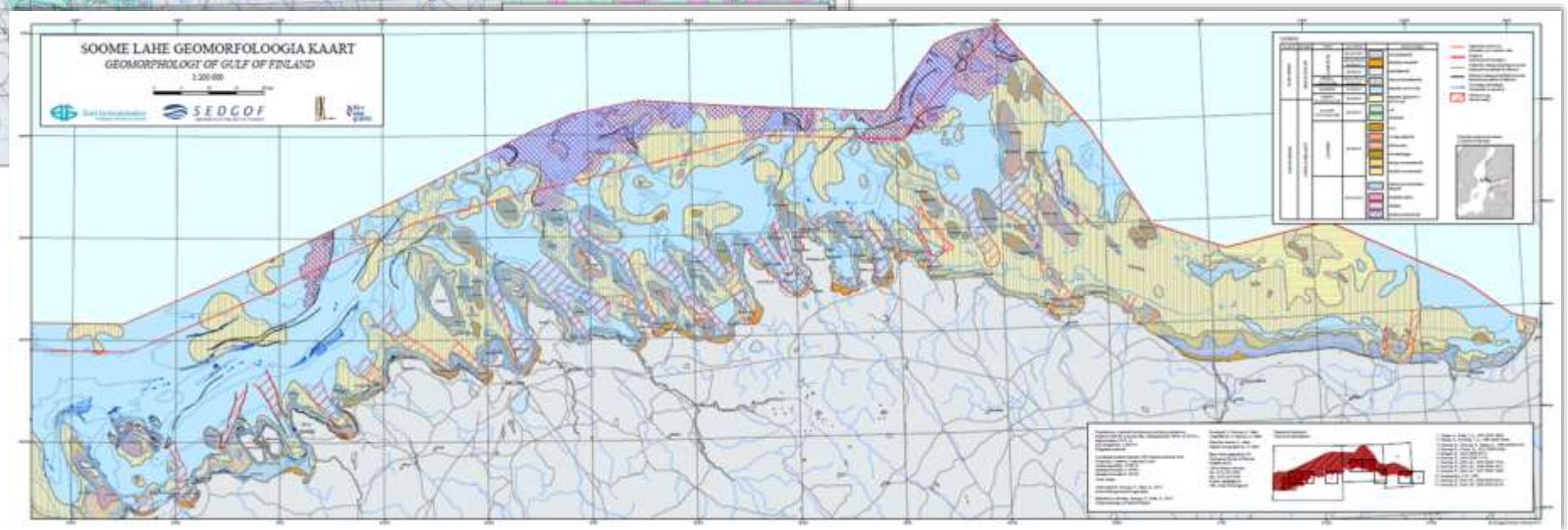


The assessment for the MSFD principles
by using the case of seabed exploitation and sedimentation in the Gulf of Finland



Bedrock geological map

Geomorphology



SEDGOF
Sediments of the Gulf of Finland

Eesti Geoloogiakeskus
Geological Survey of Estonia

TALLINNA TEHNIKAÜLIKOOL
GEOLOOGIA INSTITUUT

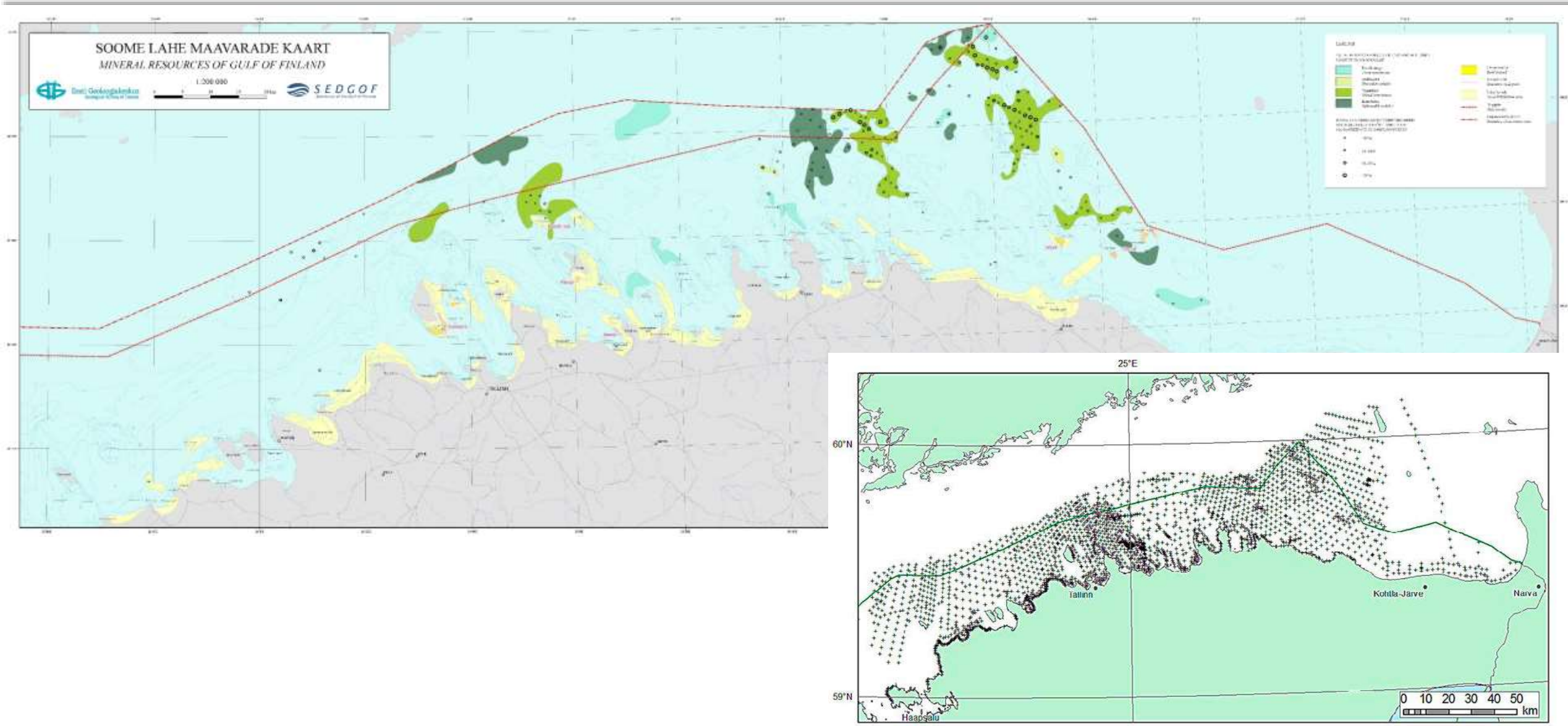
TLÜ ÖKOLOOGIA KESKUS

MSI

GEOLOGICAL SURVEY OF NORWAY

eea grants

Map of mineral resources



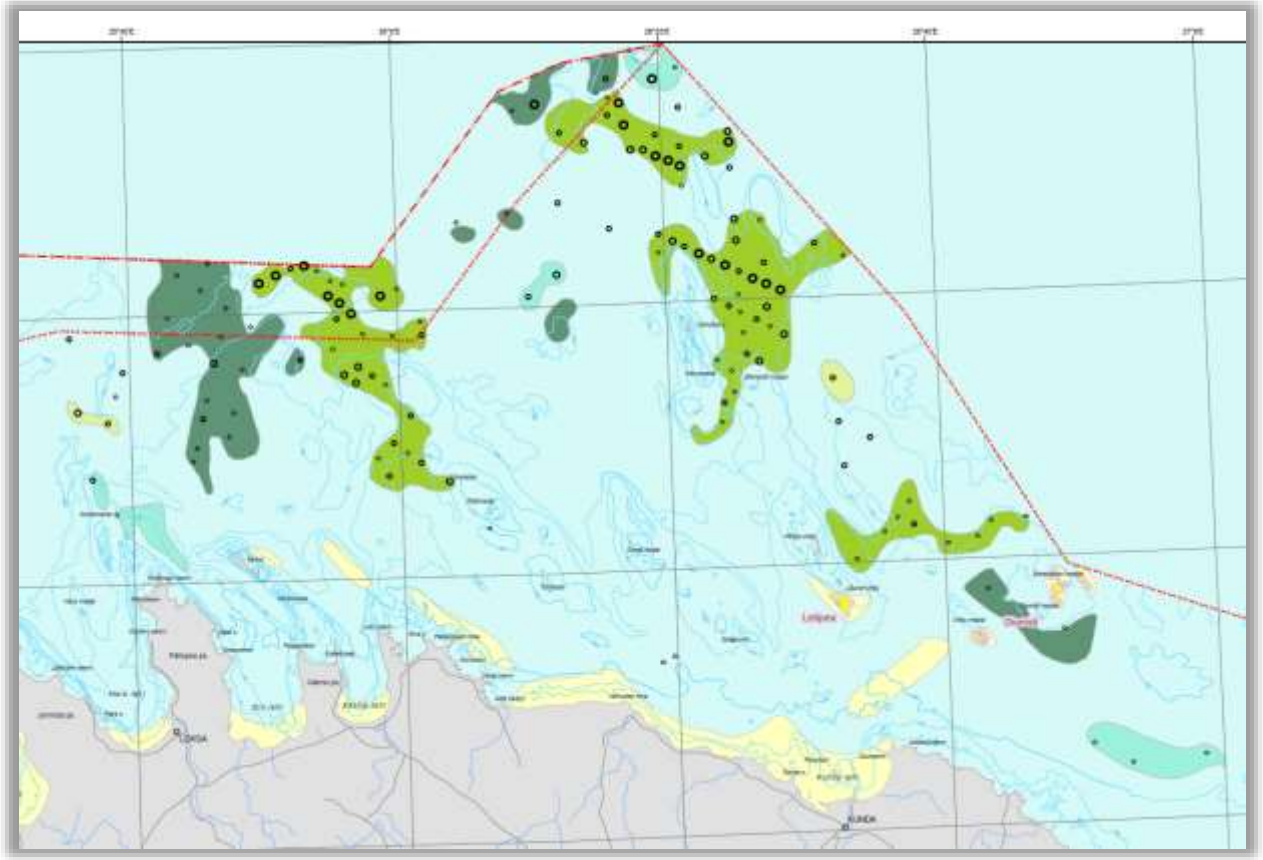
Fe-Mn nodule distribution in Gulf of Finland

Morphological types of Fe-Mn nodules

- Crust concretions
- Discoidal nodules
- Spheroidal nodules
- Mixed types of concretions

Fe-Mn presence in sampling sites

- <10%
- 10–25%
- 25–50%
- >50%







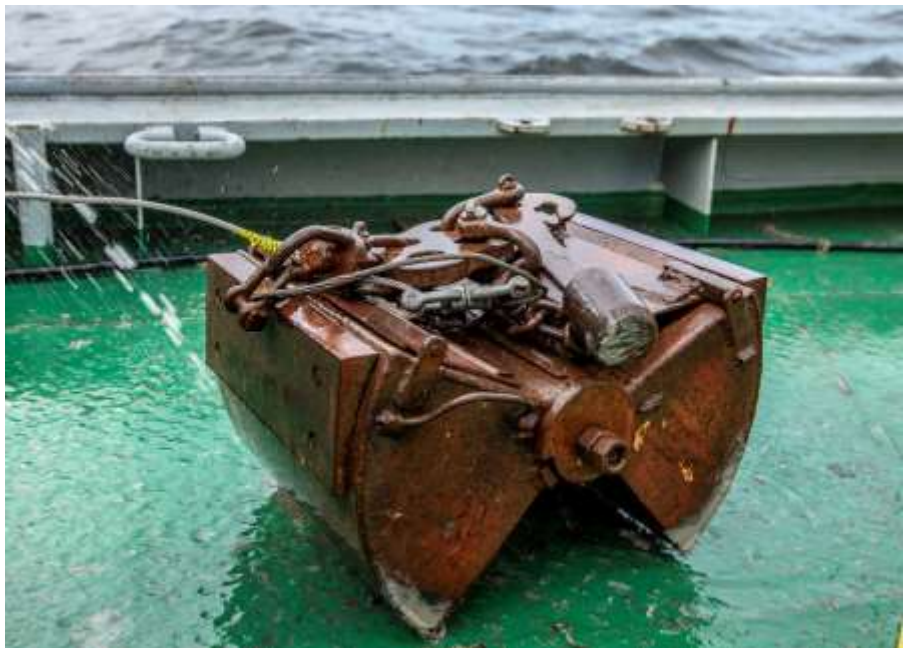


Grab samplers





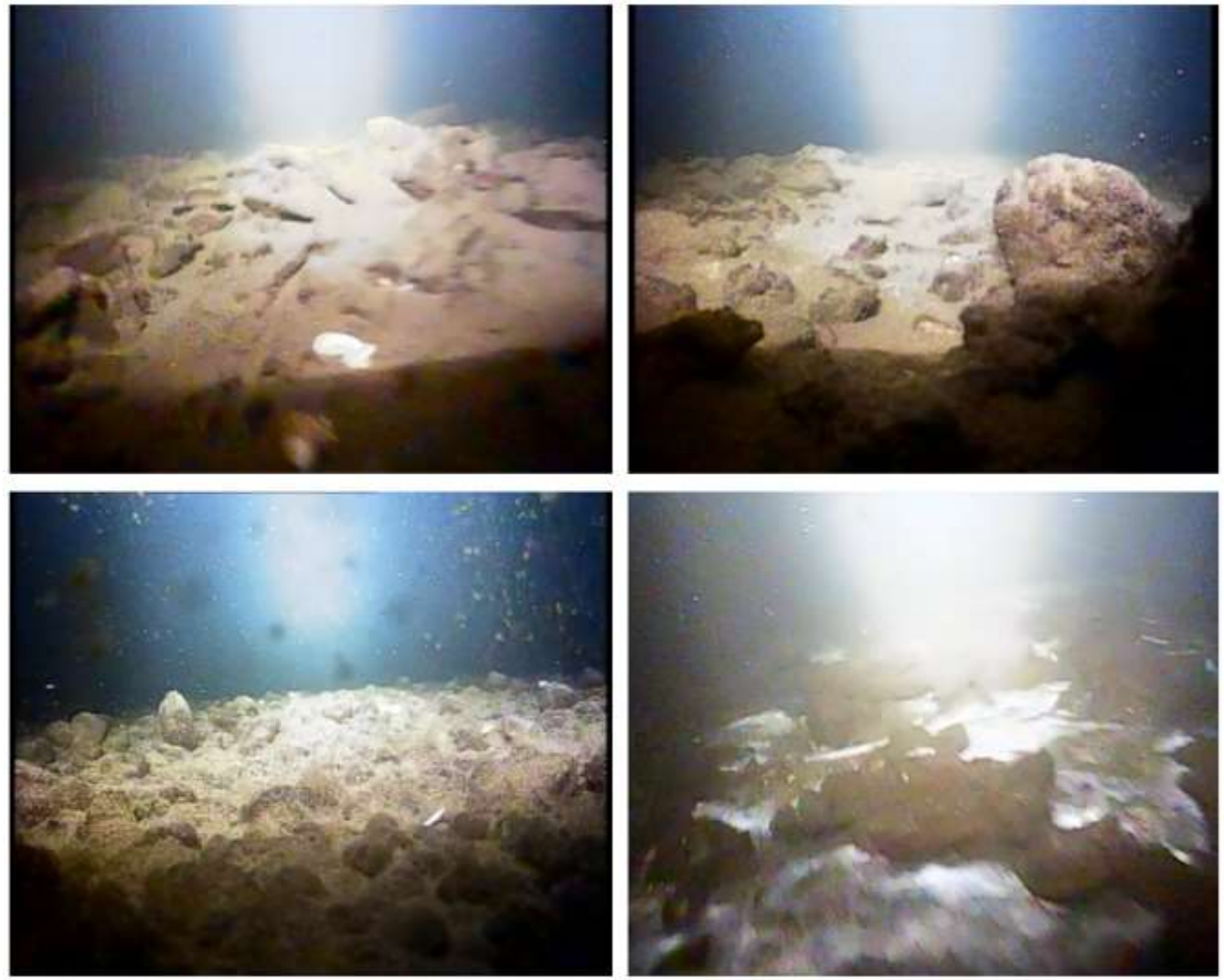
Van-Veen





’Oceanology’

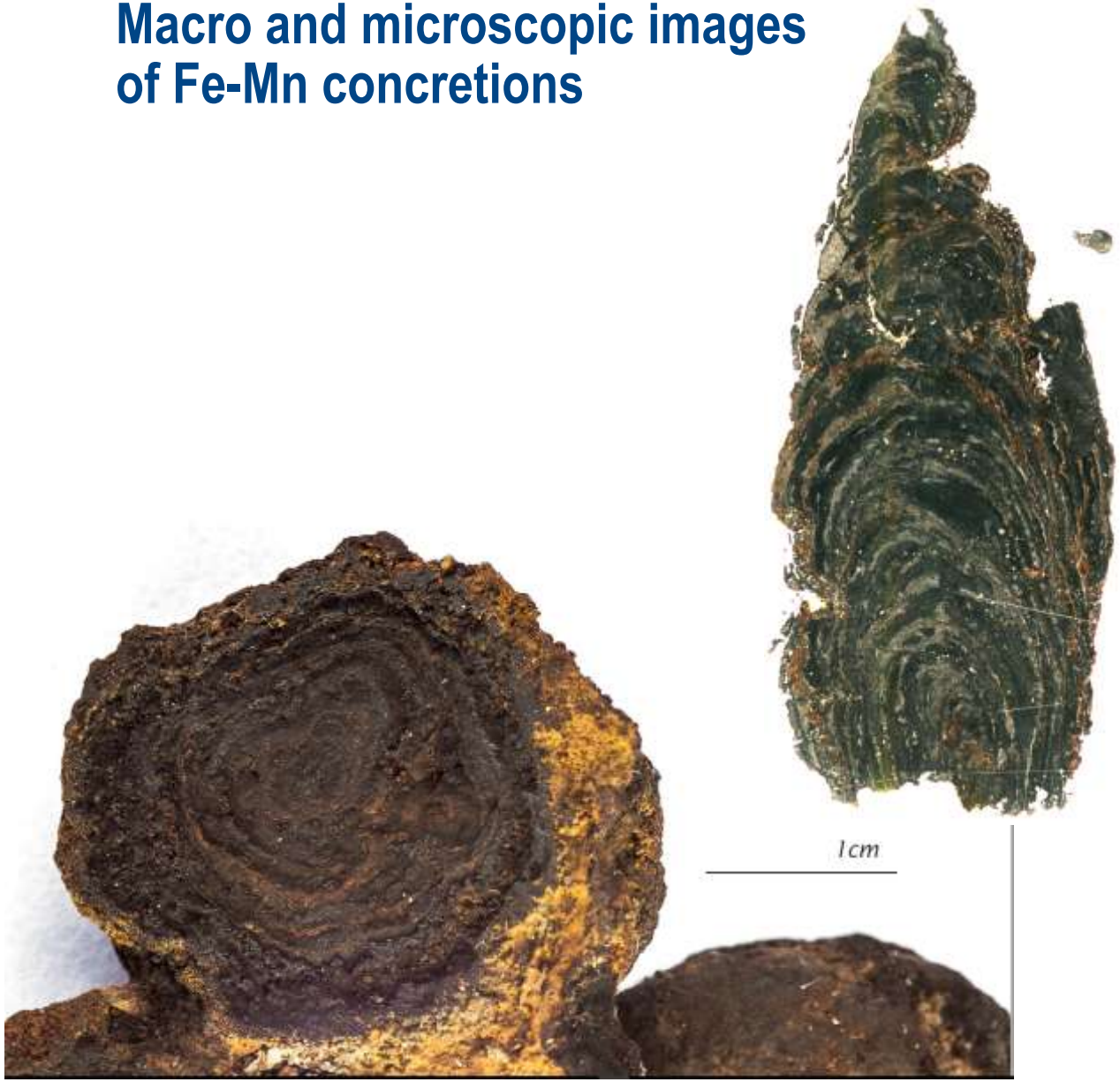
Seabed video observations



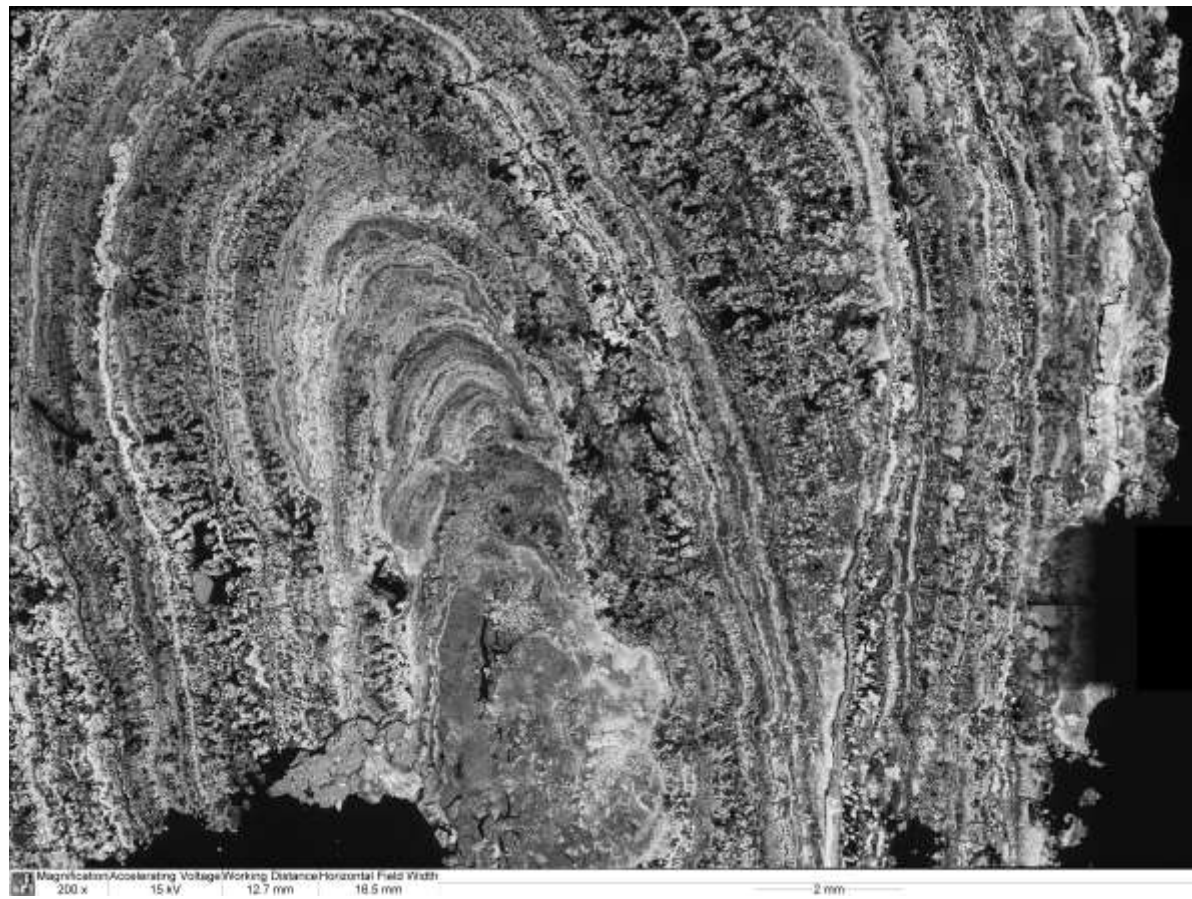
FeMn-concretions and white microbial mats on the seafloor



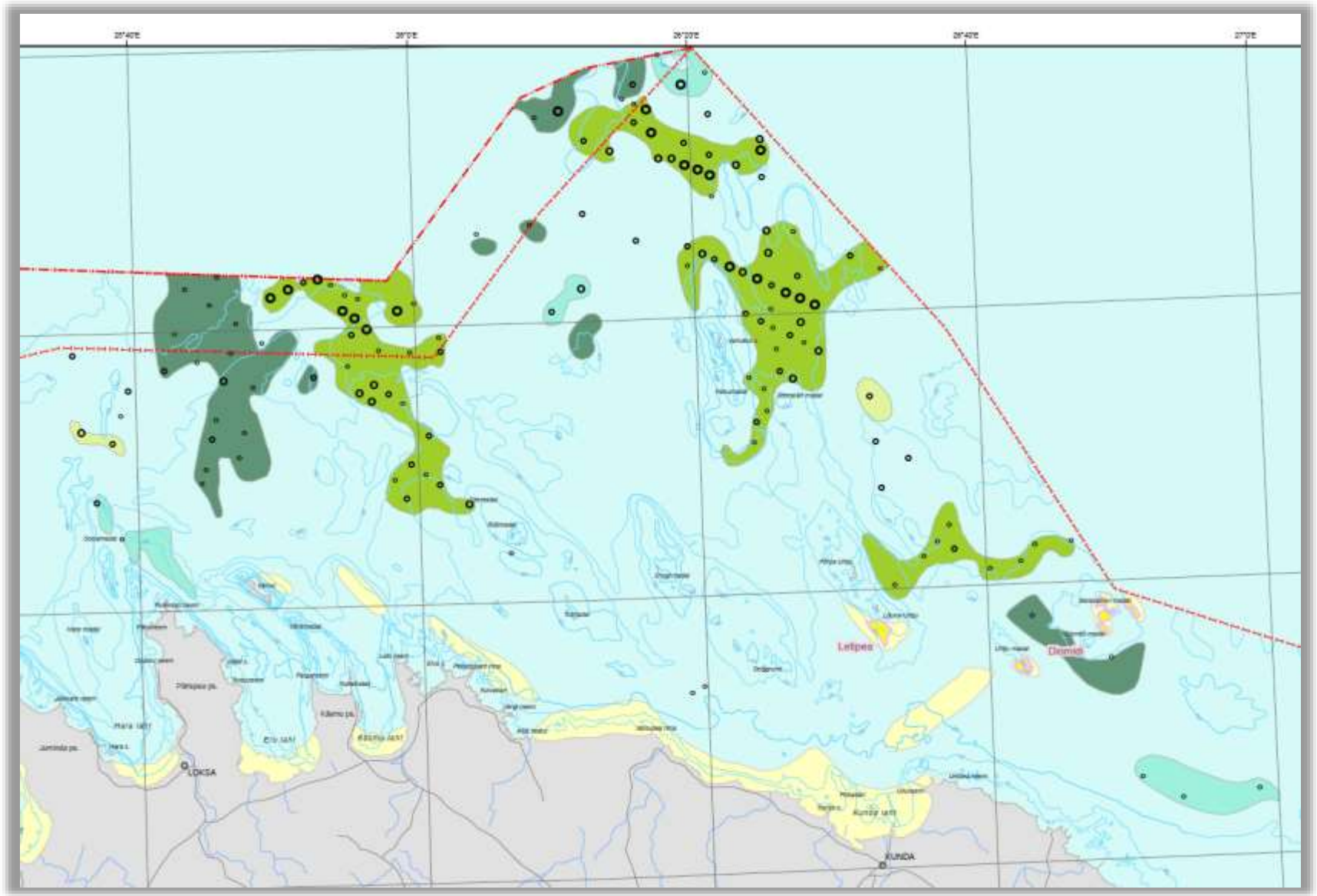
Macro and microscopic images of Fe-Mn concretions



Photos: A. Lepland

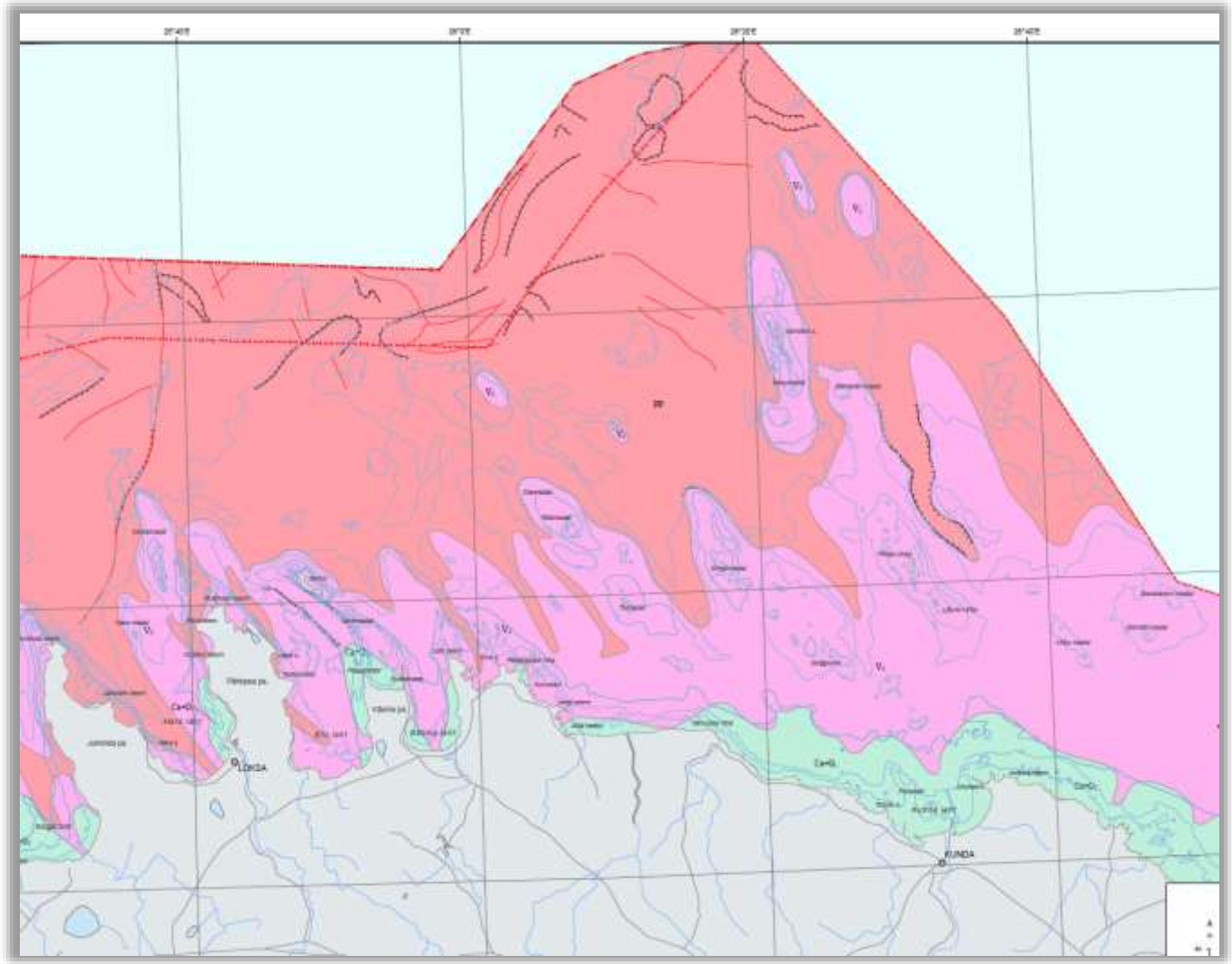


Distribution of Fe-Mn concretions in Gulf of Finland

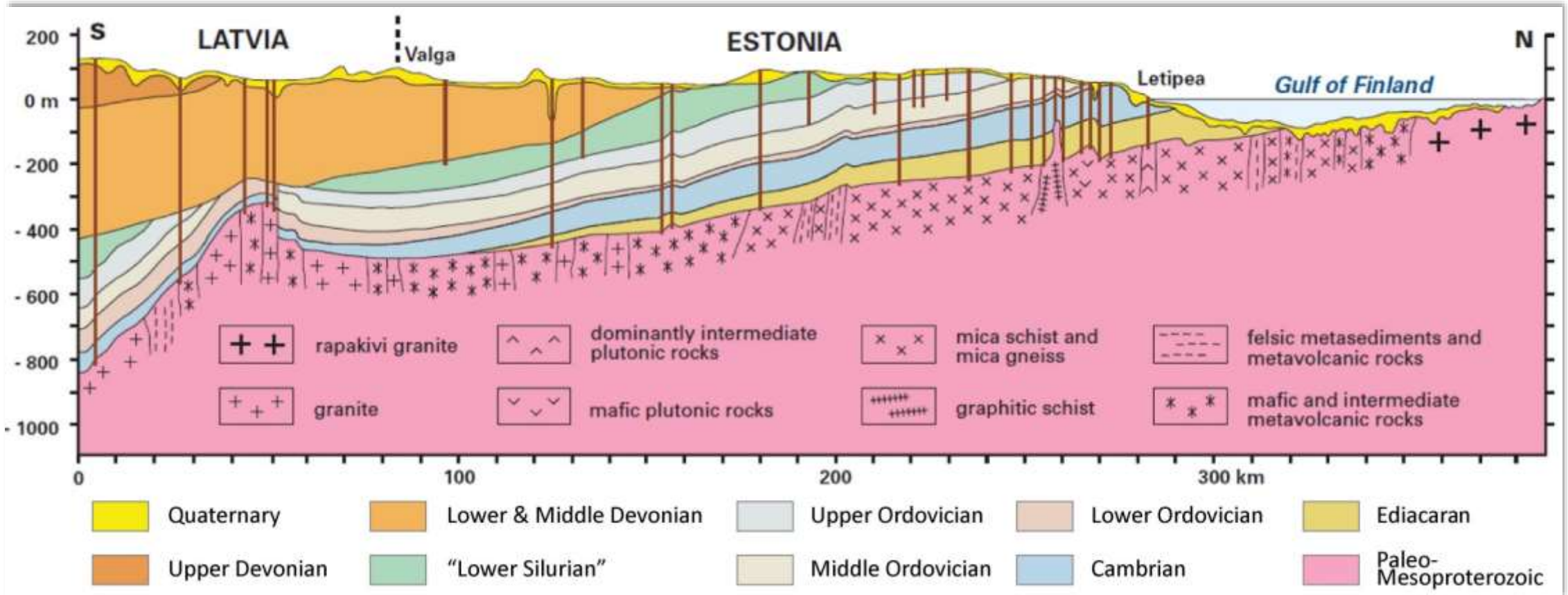


Bedrock geological map

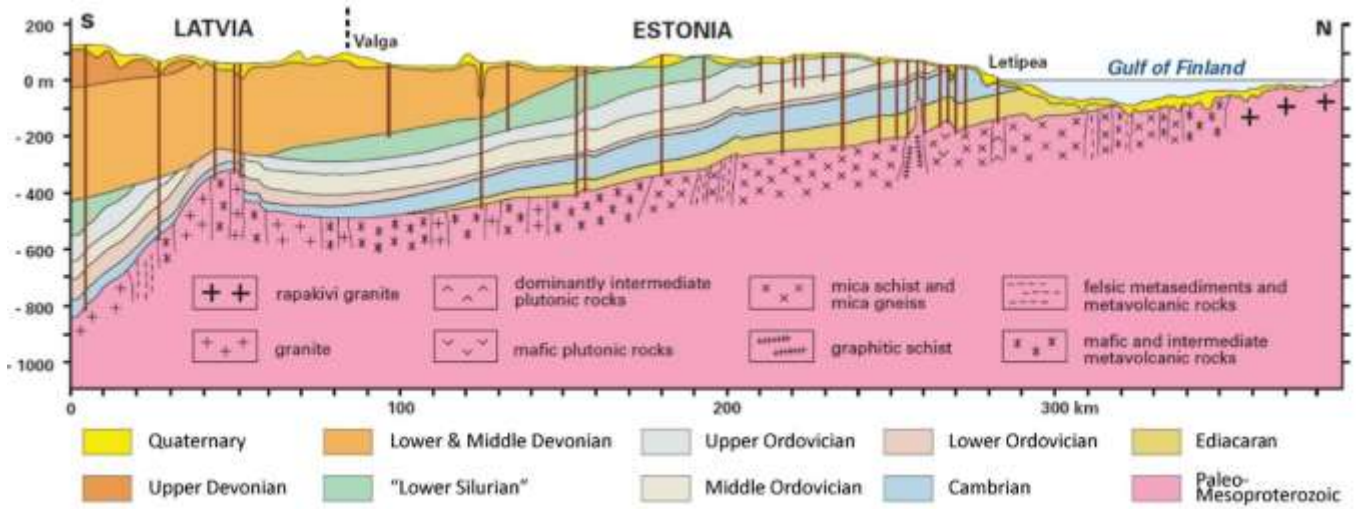
System	Outcrop on sea bottom	Rock description
QUATERNARY	Q	Quaternary deposits (only on cross-sections)
ORDOVICIAN	O_2 limestone	Argillaceous limestone
		Limestone
		Ooid-limestone
		Sandy limestone, limestone
		Glauconite limestone
	$Ca+O_1$ sandstone, clay	Glauconite sandstone
		Alum shale
CAMBRIAN		Obolus sandstone
		Fine-grained quartzose sandstone
		Blue clay with interbeds of sandstone
		Blue clay, sandstone
EDIACARAN	V_2 sandstone siltstone, clay	Sandstone, silty claystone
		Sandstone, siltstone, claystone
		Sandstone, siltstone, claystone
MESO-PROTEROZOIC	MP	Rapakivi
PALEO-PROTEROZOIC	PP	Metamorphic rocks: gneisses, migmatite, amphibolite etc

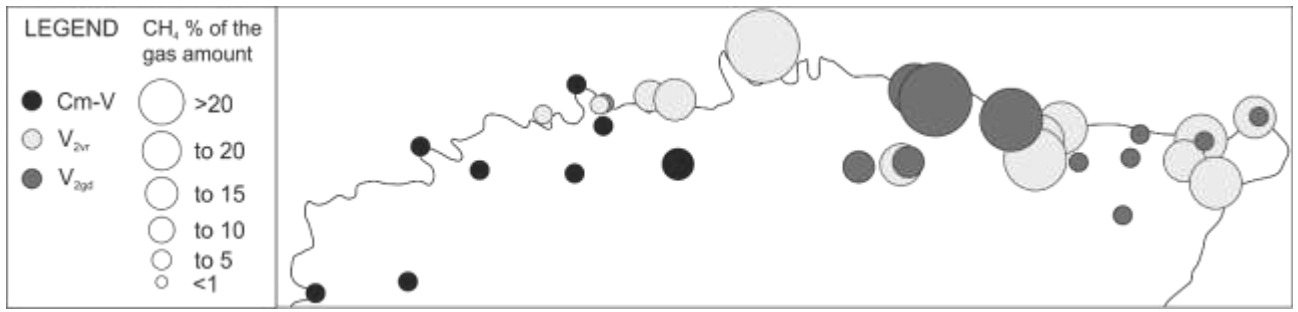


Geological cross-section



Geological cross-section



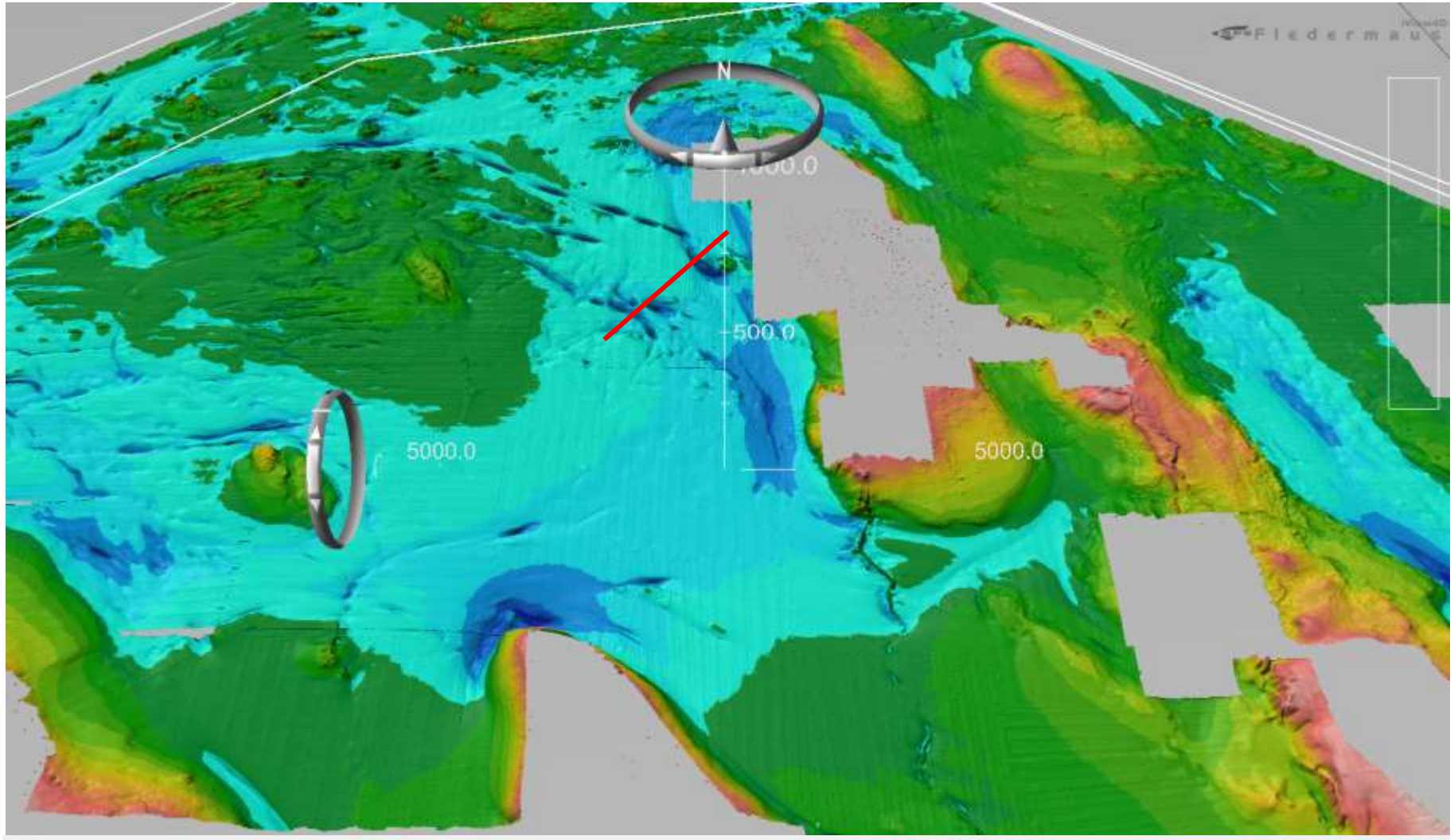


- **Could the source of reducing fluids and dissolved Mn be in underlying sediments and rocks?**
- **Possibly; Cambrian-Ediacaran aquifer is known to be relatively high in methane**

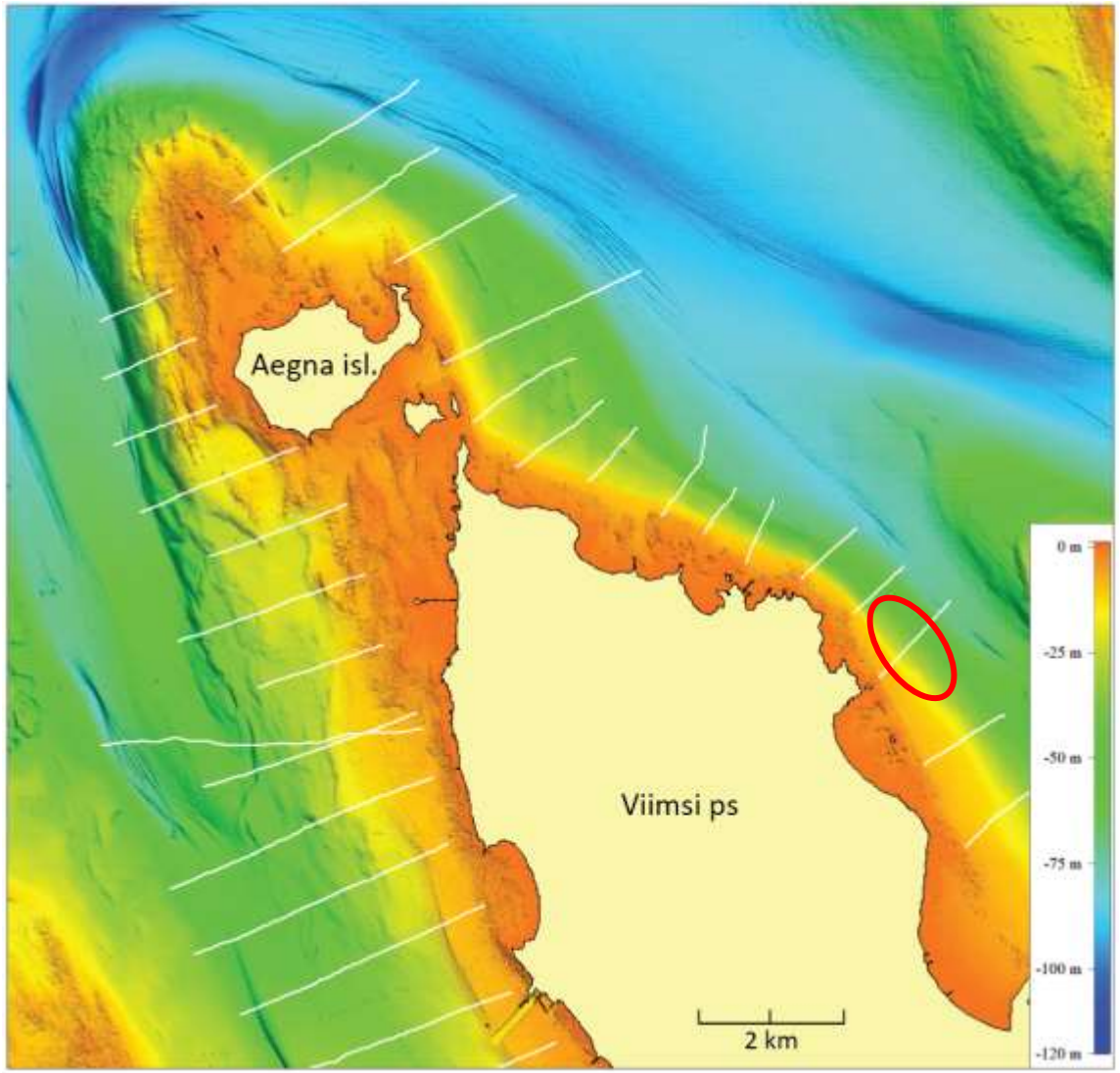
Raidla et al 2019 (modified)

3D Seabed relief image – indications of groundwater seepage

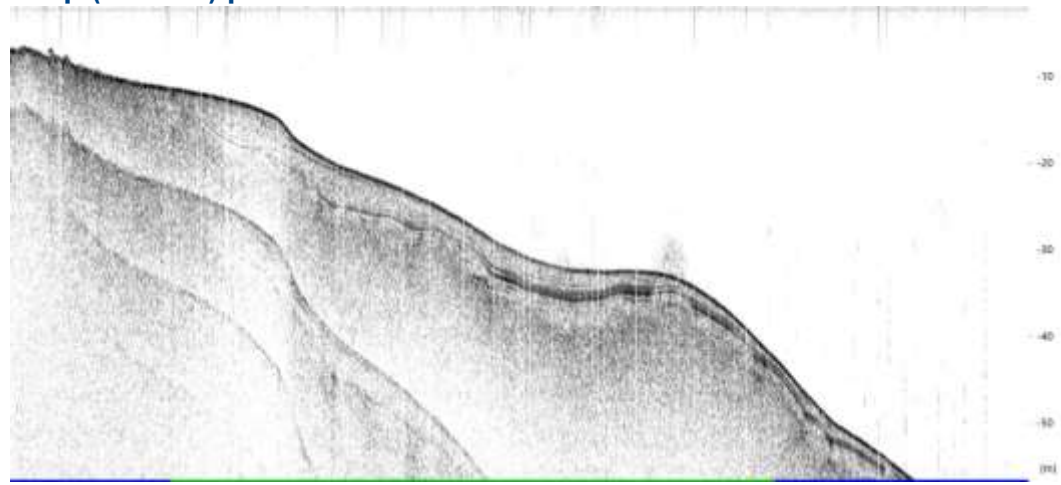
Data source: Transportation Administration, Department of Hydrography



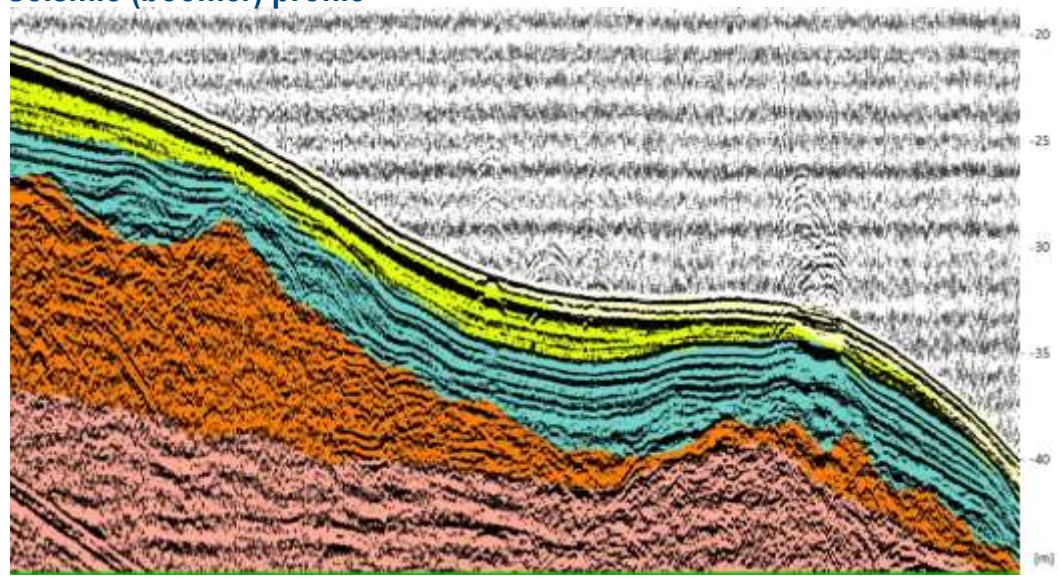
Possible groundwater outflow on seabed at Viimsi ps



Chirp (3-9 kHz) profile

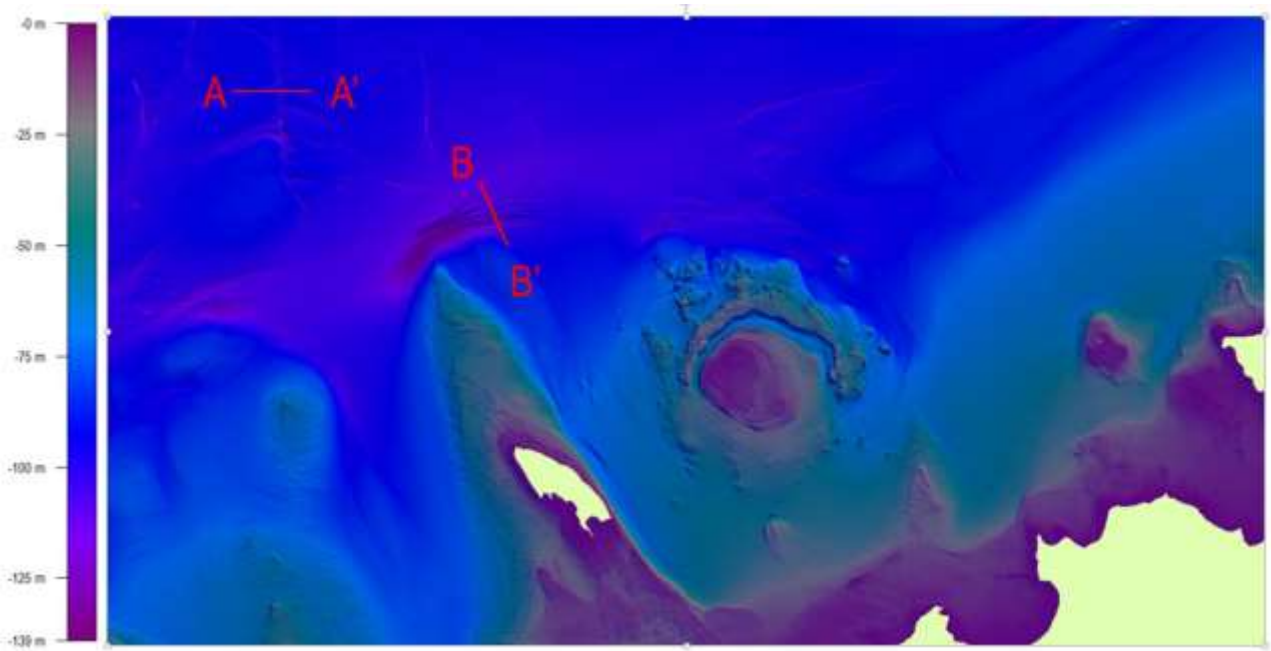


Seismic (boomer) profile



Litorina/Limnea sea - fine sand
Ancylus lake - silt, clay
Baltic Ice Lake - varved clays
Glacial - till
Bedrock - sandstone, clay

Possible groundwater outflow at entrance of Gulf of Finland



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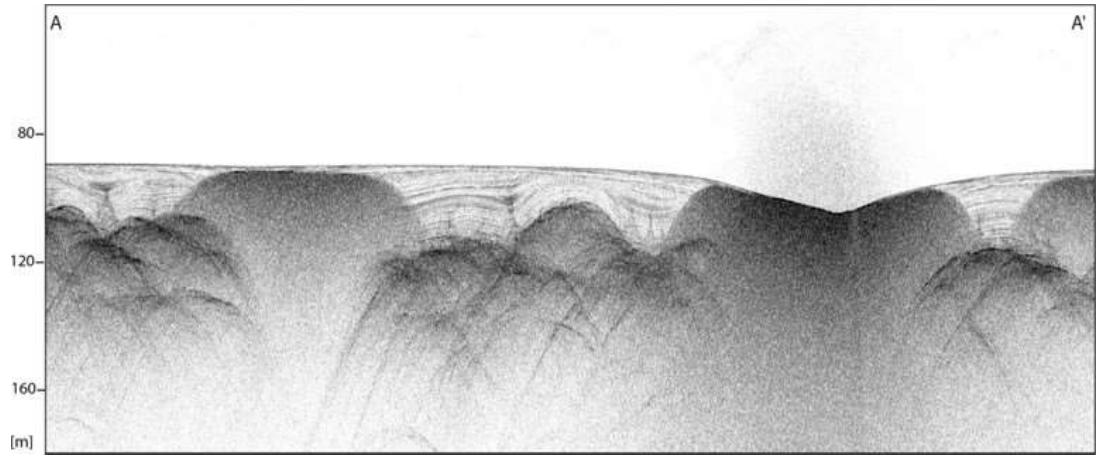
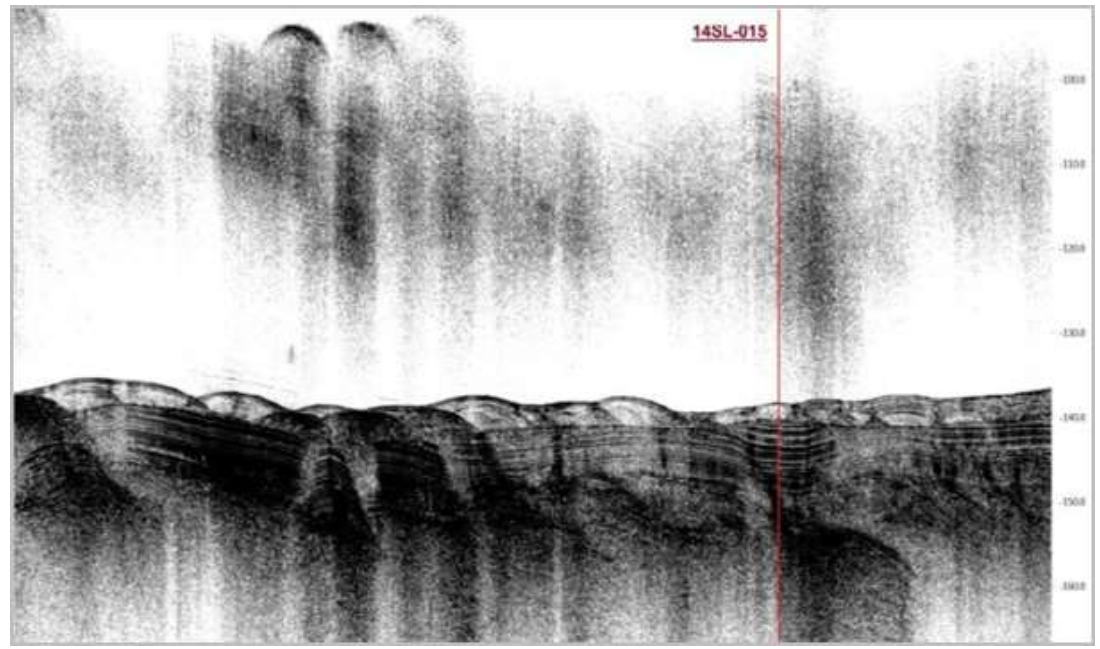




Map of Quaternary sediments

HOLOCENE

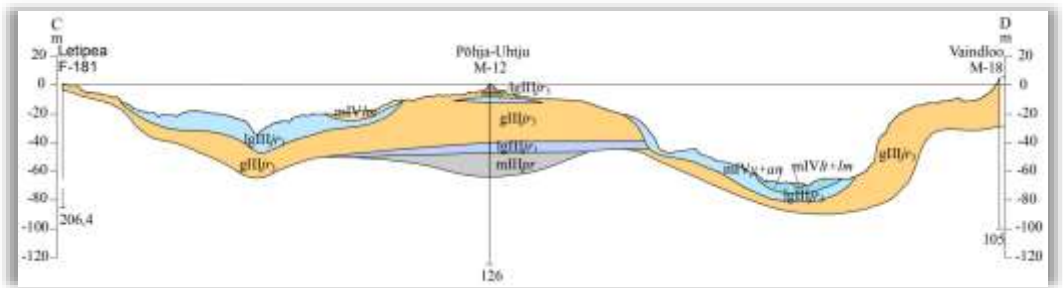
- mIV*lm* — Limnea Sea deposits. Gravel, sand, silt.
- mIV*lt+lm* — Littorina and Limnea Sea deposits. Mud.
- mIV*y+an* — Yoldian sea and Ancylus Lake deposits. Clay, silt.

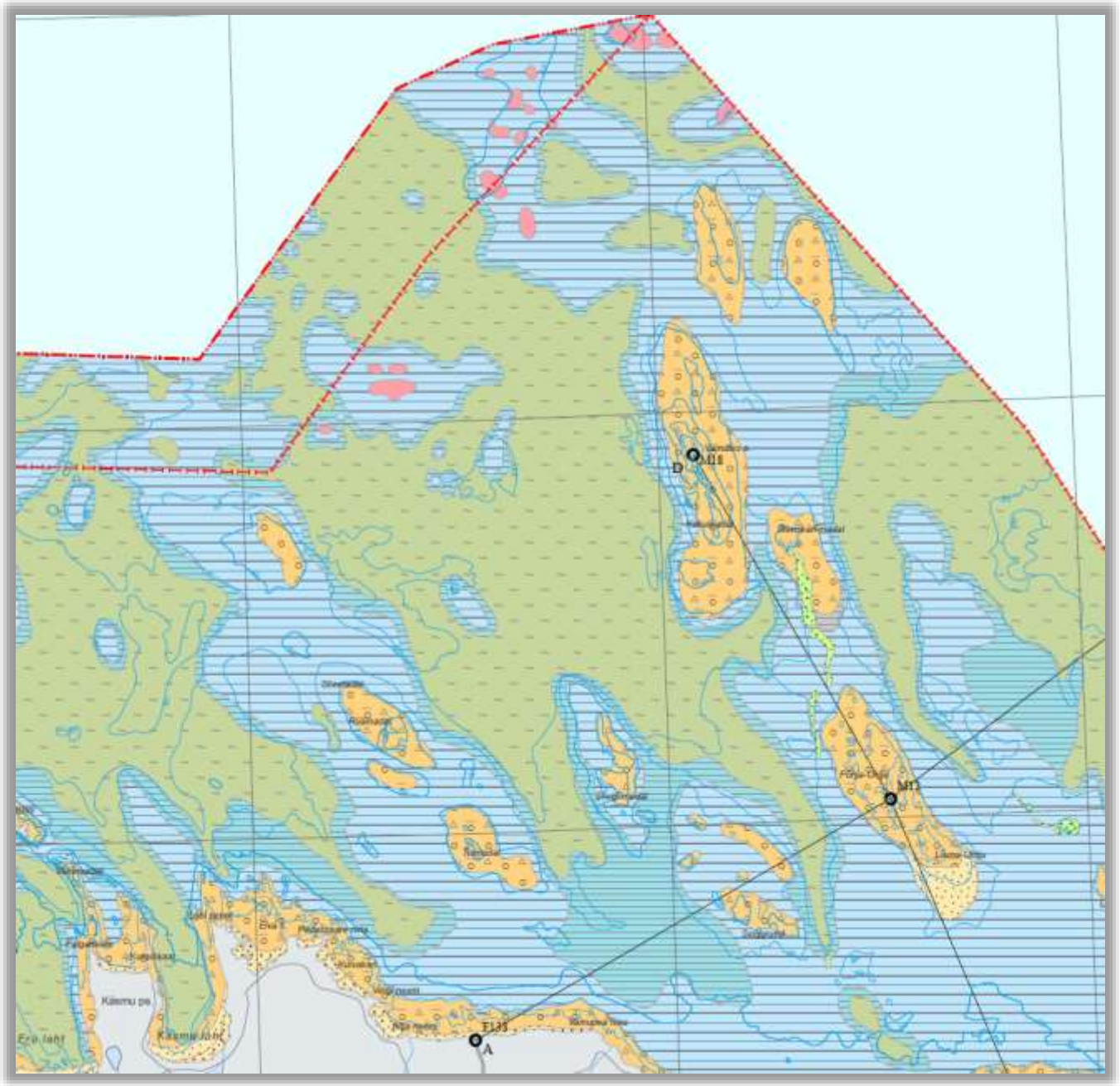
UPPER PLEISTOCENE

- lgIII/r_3 — Glaciolacustrine deposits. Varved clay, silt, sand.
- fIII/r_3 — Glaciofluvial deposits. Sand, gravel.
- gIII/r_3 — Glacier deposits. Till/diamicton.
- lgIII/r_1 — Glaciolacustrine deposits. Silt, silty clay
- mIII*pr* — Deposits of the Prangli subformation
- Bedrock

LITHOLOGIC TYPES

- Gravel, sand
- Sand of different grain size
- Fine sand
- Silt
- Clay
- Varved clay
- Mud
- Till/diamicton





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- lgIIIjr_1 — *Glaciolacustrine deposits. Silt, silty clay (on cross-sections).*
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- *Clay*
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- *Mud*
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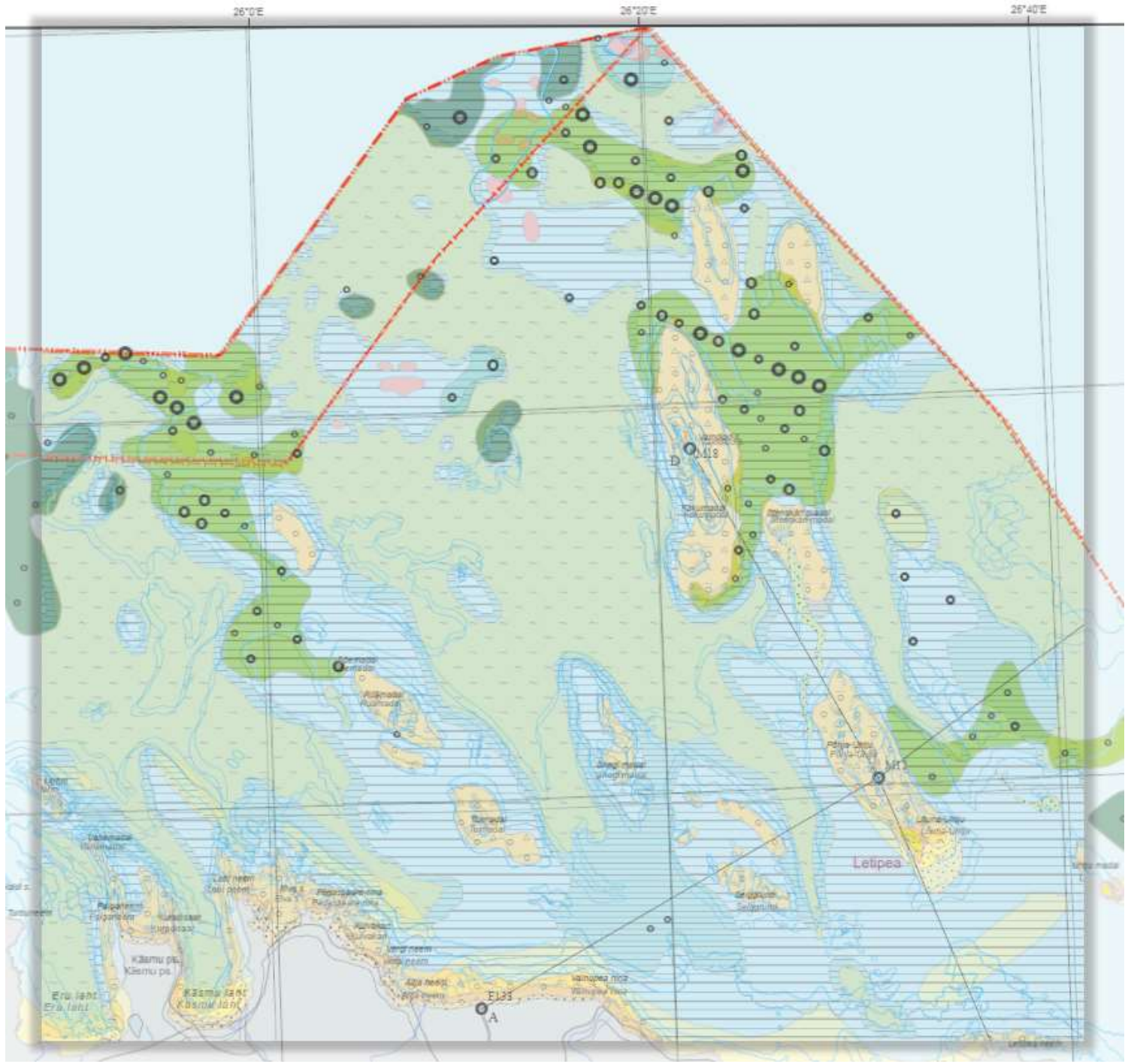
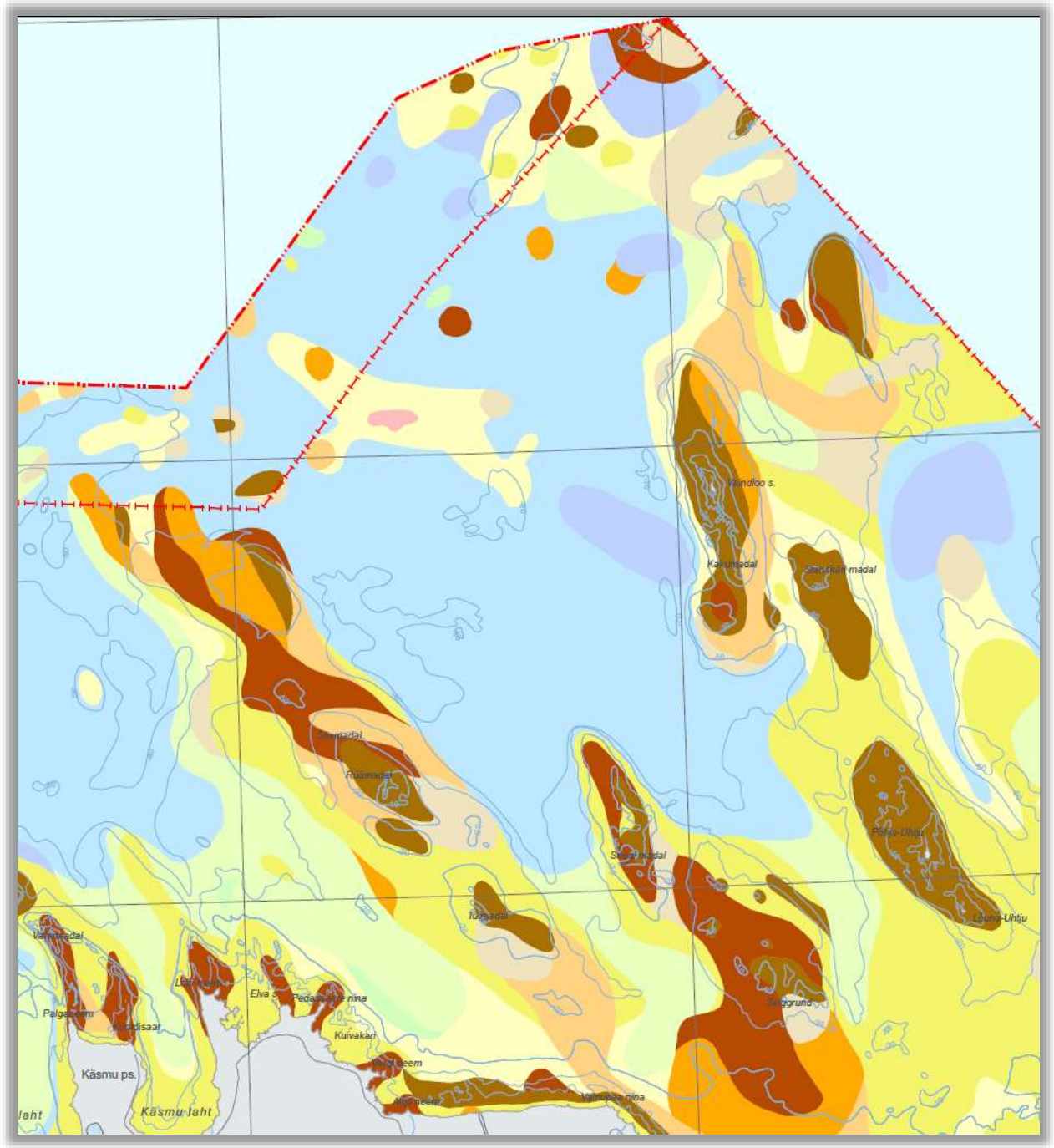


Map of Bottom sediments

- Clay
- Pelite
- Pelite with aleurite and/or sand
- Aleurite
- Aleurite with pelite and/or sand
- Sand with aleurite and/or pelite
- Sand
- Sand with gravel
- Gravel
- Gravel with pebbles
- Mixed sediment
- Till/diamicton
- Bedrock



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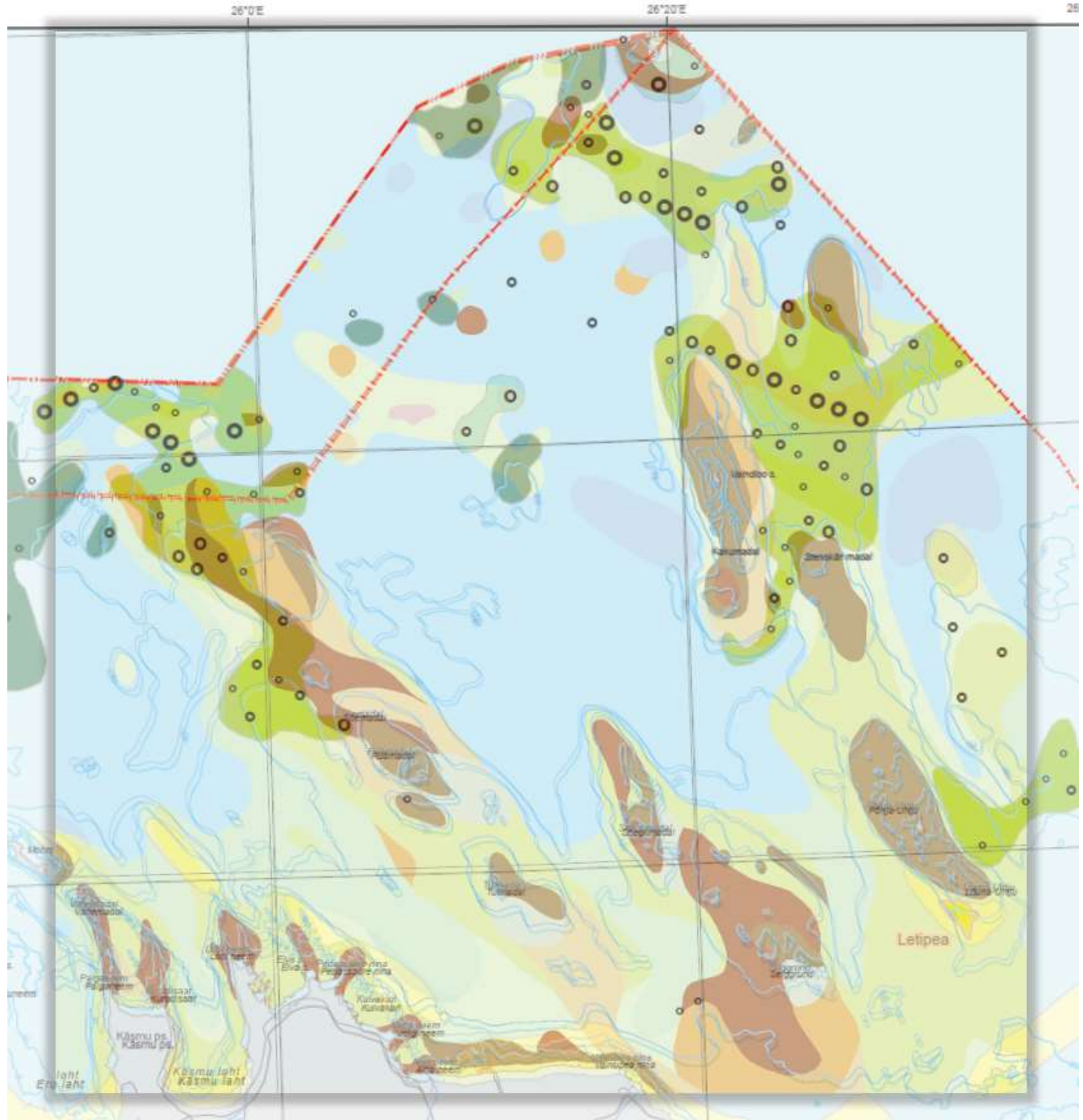
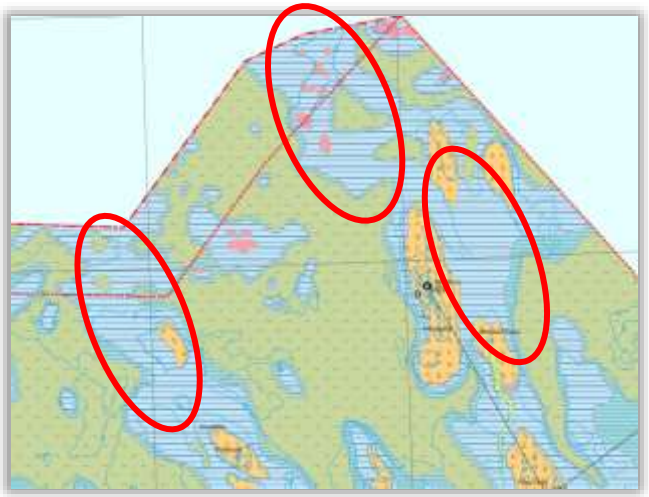
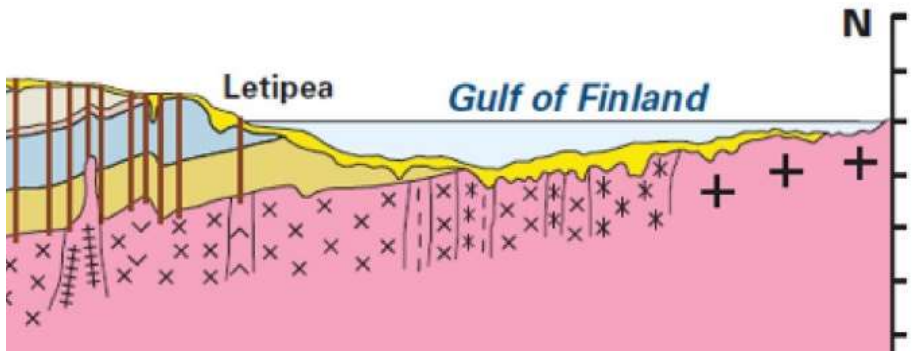


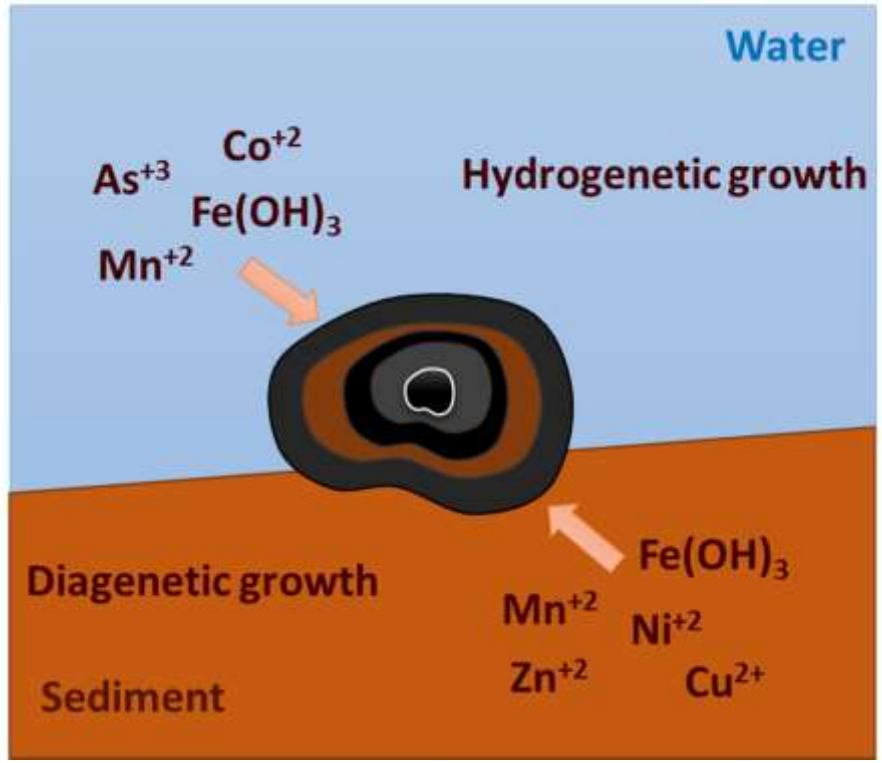


Geologic associations of FeMn-concretions in Gulf of Finland

- Occur within exposure areas of late glacial clays with no modern sedimentation
- Association with microbial mats of sulfide oxidizing bacteria (such mats are typical for methane seepage and anaerobic oxidation of methane)
- Underlied by Ediacaran-Cambrian sedimentary rock formations
- Is the Mn and fluid source in the water column or in underlying sediments/rocks/aquifers?

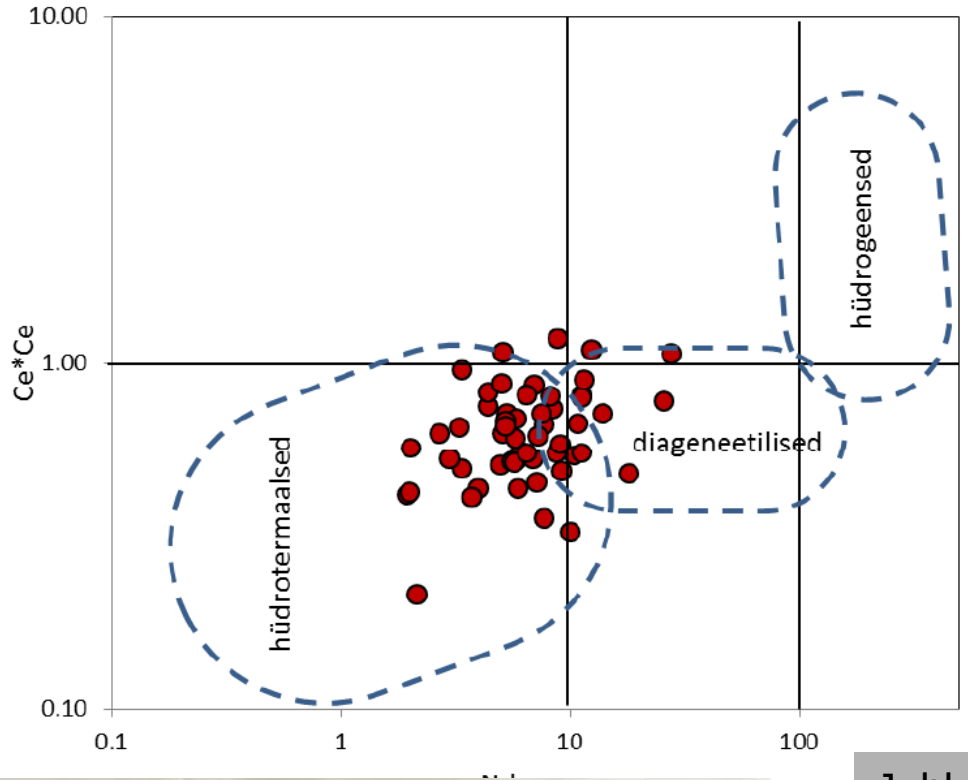


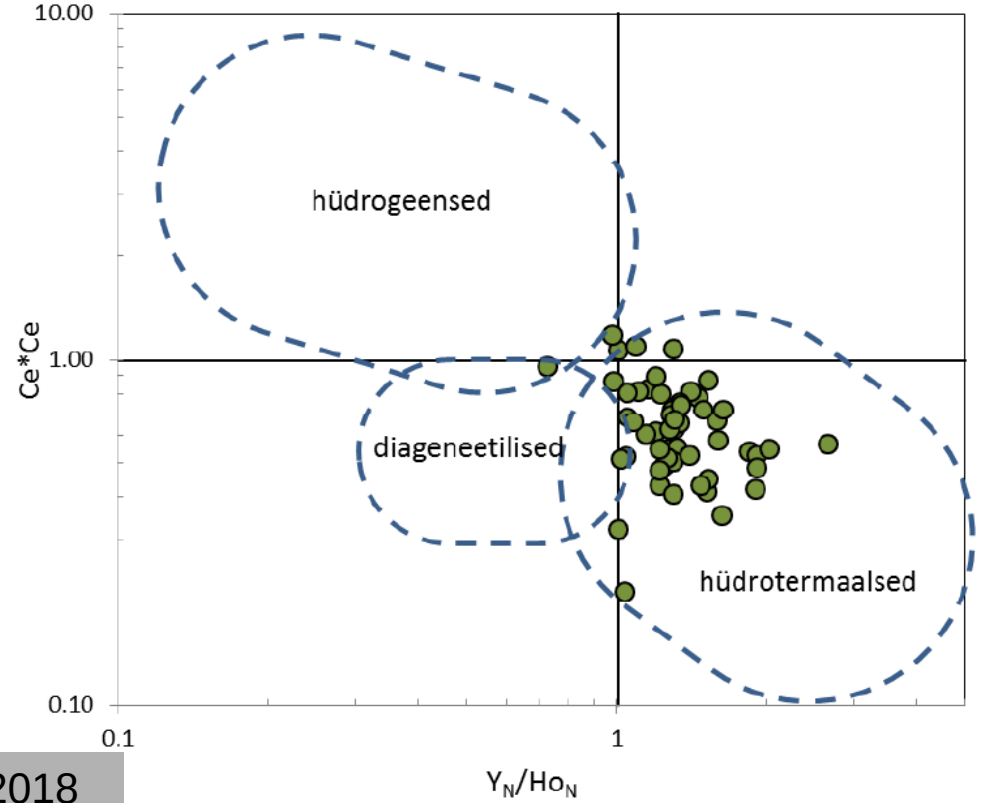




Torro et al 2020

Geologic associations of FeMn-concretions in Gulf of Finland



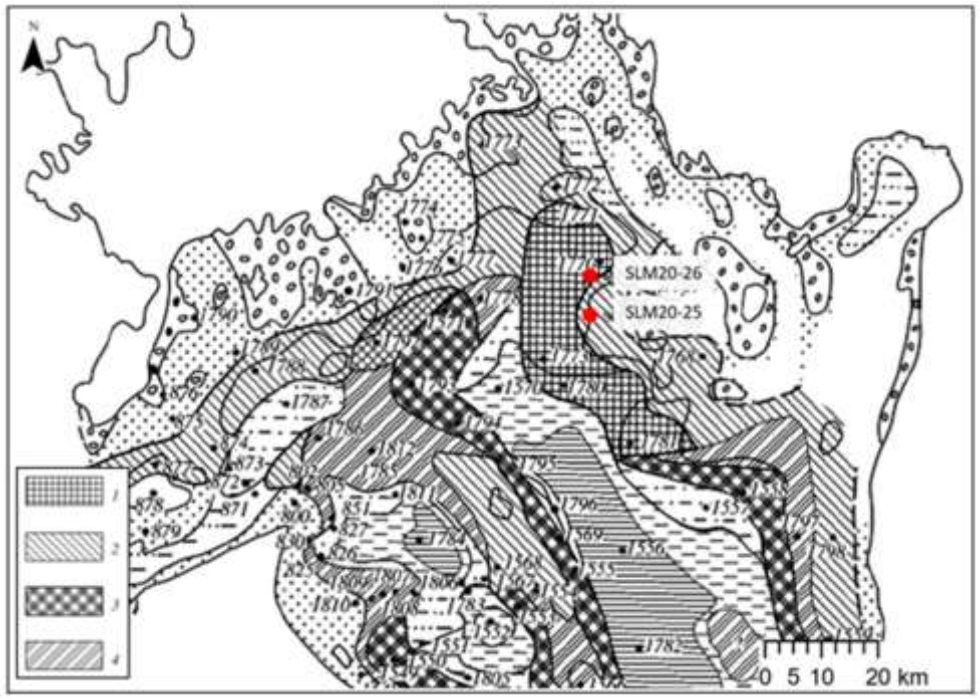


Juhkama 2018



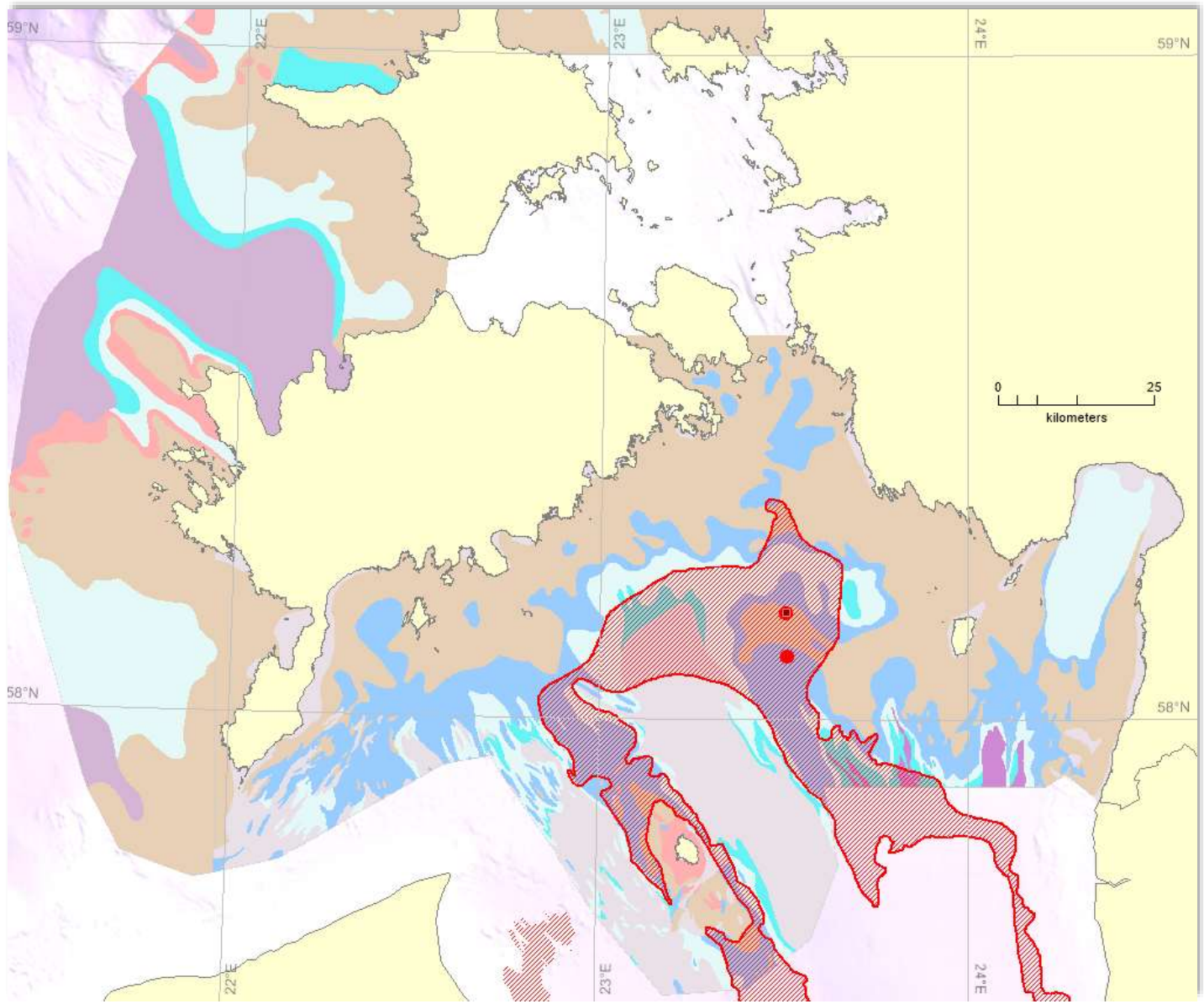
- **Could the source of reducing fluids and dissolved Mn be in underlying sediments and rocks?**
- **Possibly; REE systematics are consistent with non-marine source**

Fe-Mn concretions distribution in Gulf of Riga



Baturin & Dubinchuk, 2009

1. and 2. – crust concretions
3. and 4. – spheroidal nodules

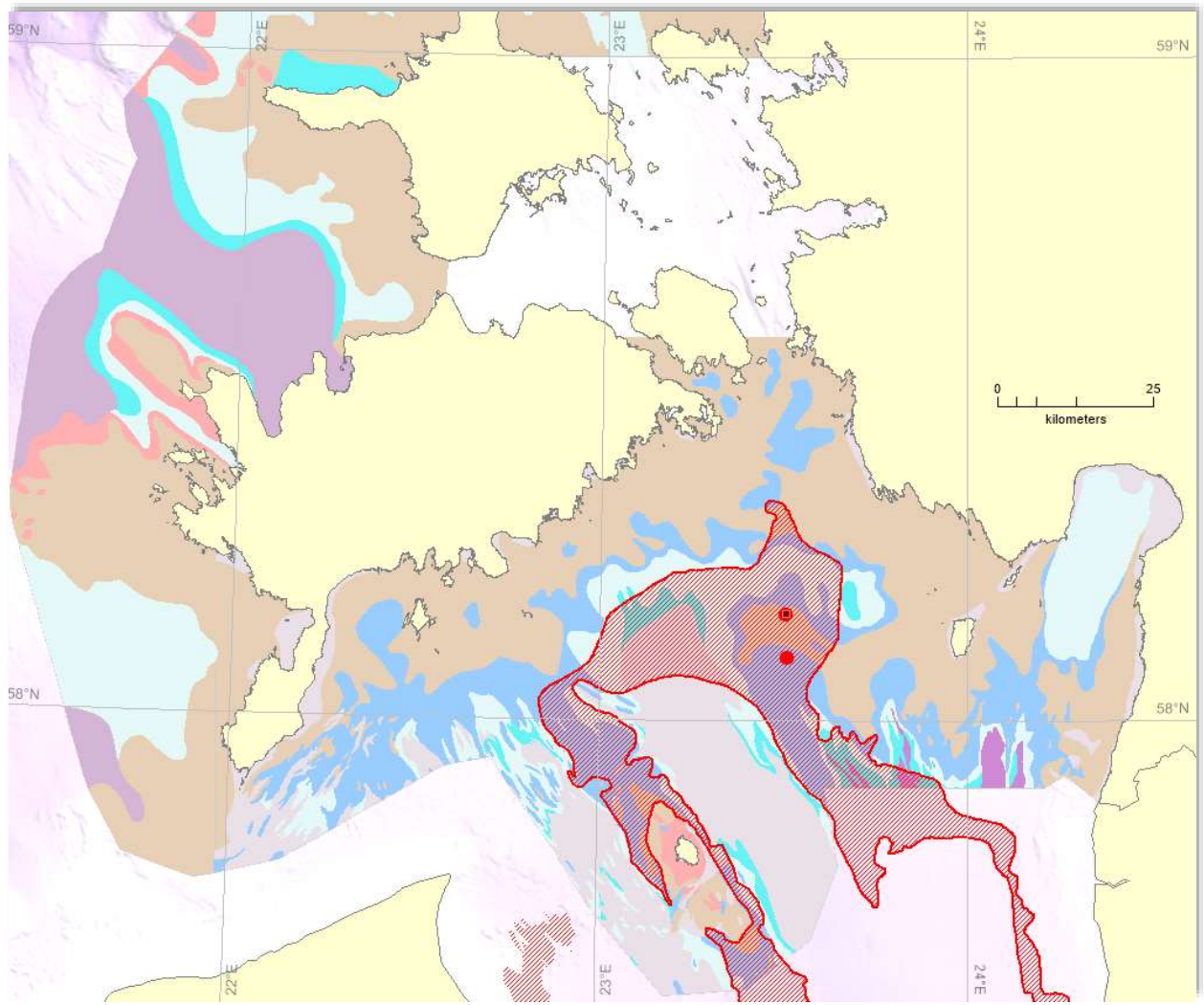


Stiebrins and Väling, 1996. Bottom sediments of the Gulf of Riga in scale 1:200 000

Development and implementation of methodology for assessing the environmental status of seabed sediments (2020–2022)







Joint initiative by EGT, GTK and Stockholm University (SU) to study sediments, porewaters and microbial communities of Fe-Mn concretion areas of Gulf of Finland



Sampling cruise using SU R/V Electra in September 2022

GEOLOGICAL SURVEY OF ESTONIA



Thank you!