



GEOLOGICAL SURVEY OF ESTONIA

Overview of the phosphorite and black shale exploration

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Outline

- 1 Project overview
- 2 Geological background and previous explorations
- 3 3D modelling
- 4 Main results of exploration
- 5 Summary

Aim of the study

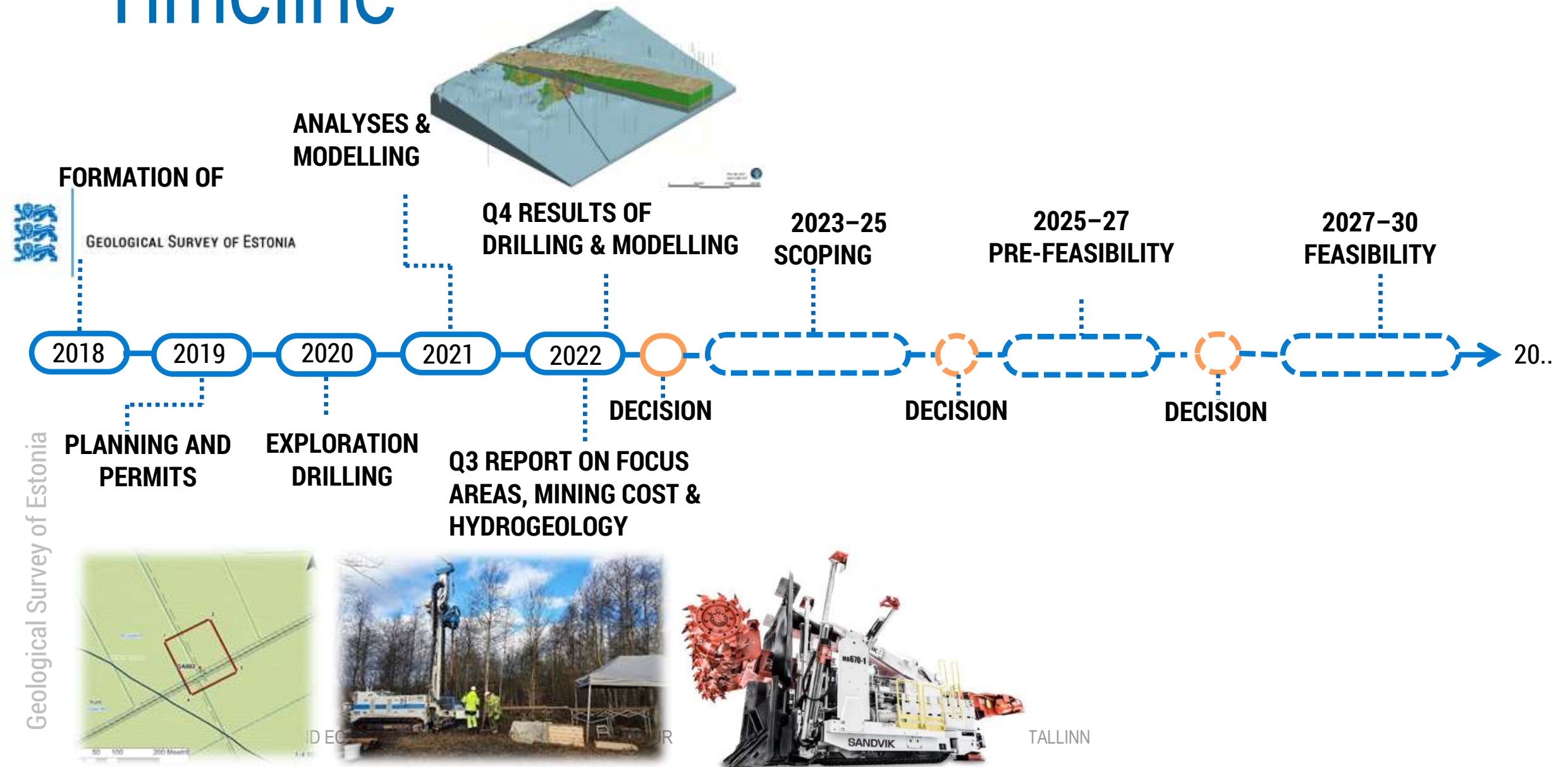
Evaluate the economic potential of phosphorite and associated resources and prepare materials for follow-up stages led by state.

Current phase includes:

- Digitalization of historic data.
- Resource modelling.
- Exploration drilling.
- Validating historical drilling information.
- Choosing focus areas.
- Preliminary mining and beneficiation unit cost calculations.

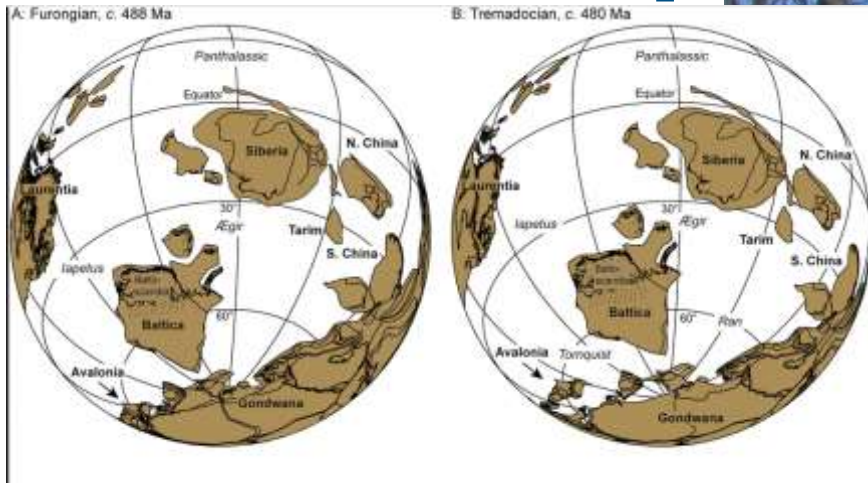
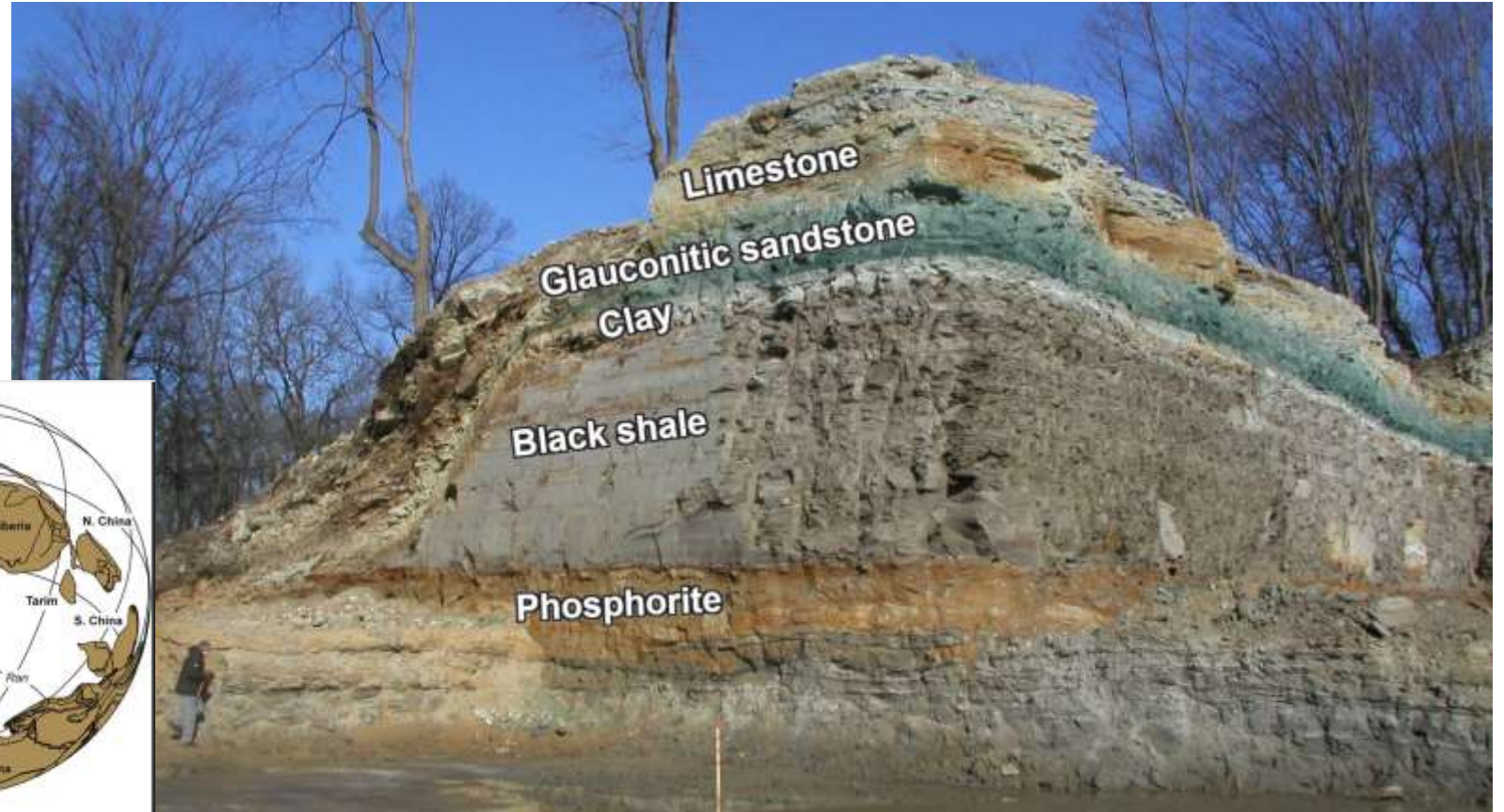


Timeline



Geological background

- Transition from Cambrian to Ordovician
- Transition from clastic to carbonaceous sediments



The maps are based on the BugPlates2014 software (Torsvik, 2009) with modifications Stouge et. al. (2020) <https://doi.org/10.1016/j.palaeo.2019.04.007>

ON BOTH SIDE OF THE GULF 21-22.04.2022 TALLINN

Photo: G. Baranov

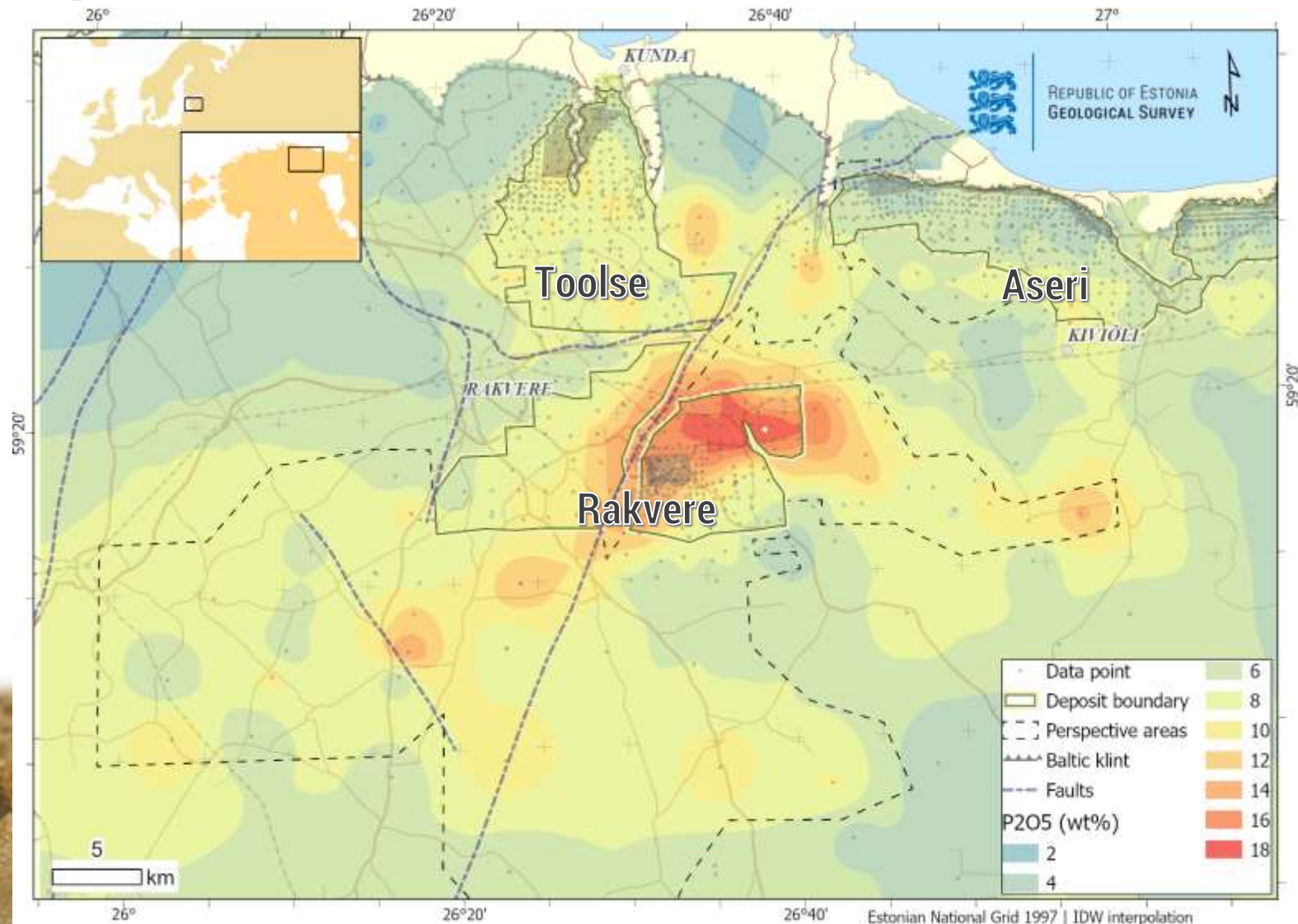
Historic exploration in N-E of Estonia

- Extensive exploration of phosphorite from 1950s to late 1980s and then a standstill for about 30 years.
- Thousands of drill holes have been drilled and tens of thousands of samples have been analysed.
- Small number of cores in poor condition have been preserved.
- Reports are preserved in the Geological Archive and digitalized (.pdf's) versions can be publicly accessed <https://fond.egt.ee/fond/>
- Focus in phosphorite were P_2O_5 , MgO, CaO and Fe_2O_3 , a few analysis of REE's.



Phosphorite deposits

- Toolse 57.6 Mt P_2O_5
- Rakvere 221 Mt P_2O_5



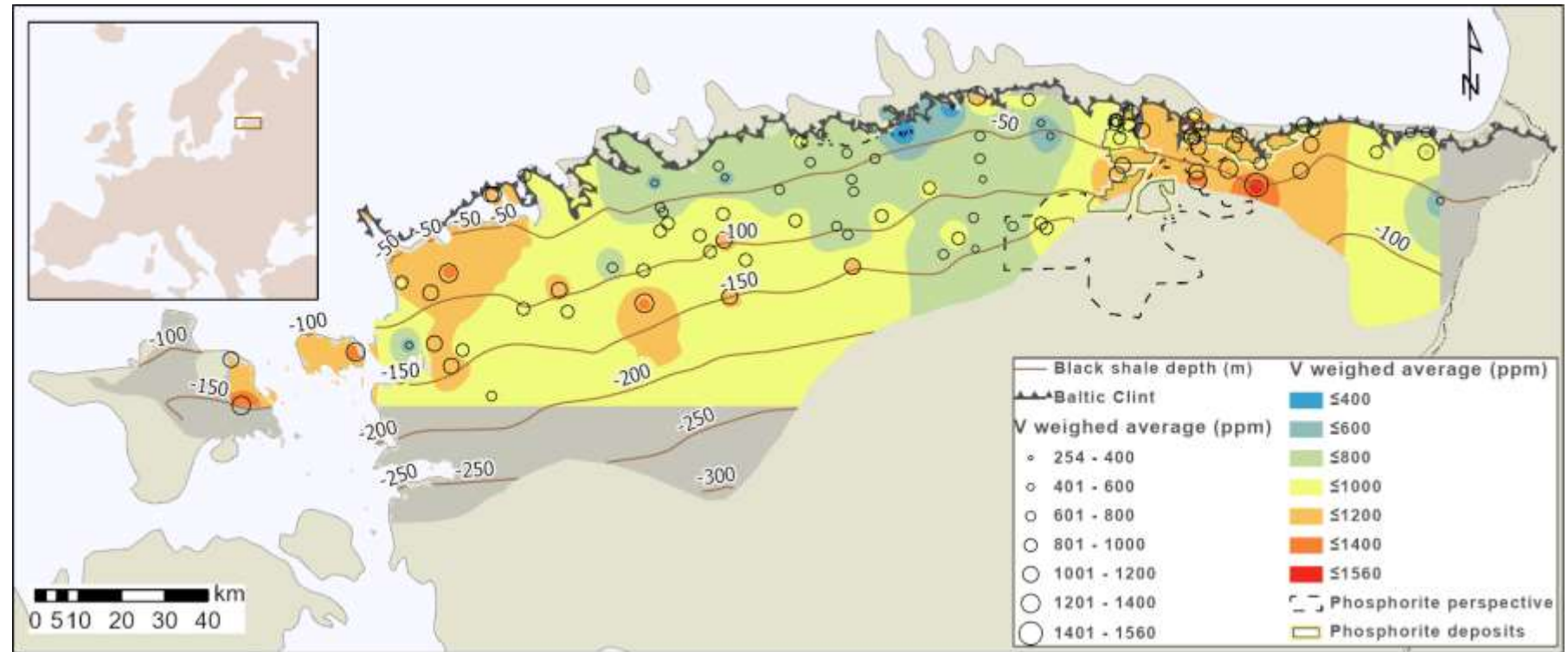
Black shale

Mainly enriched in V,
Mo, U

Distribution of
vanadium

Similar also for U, Mo

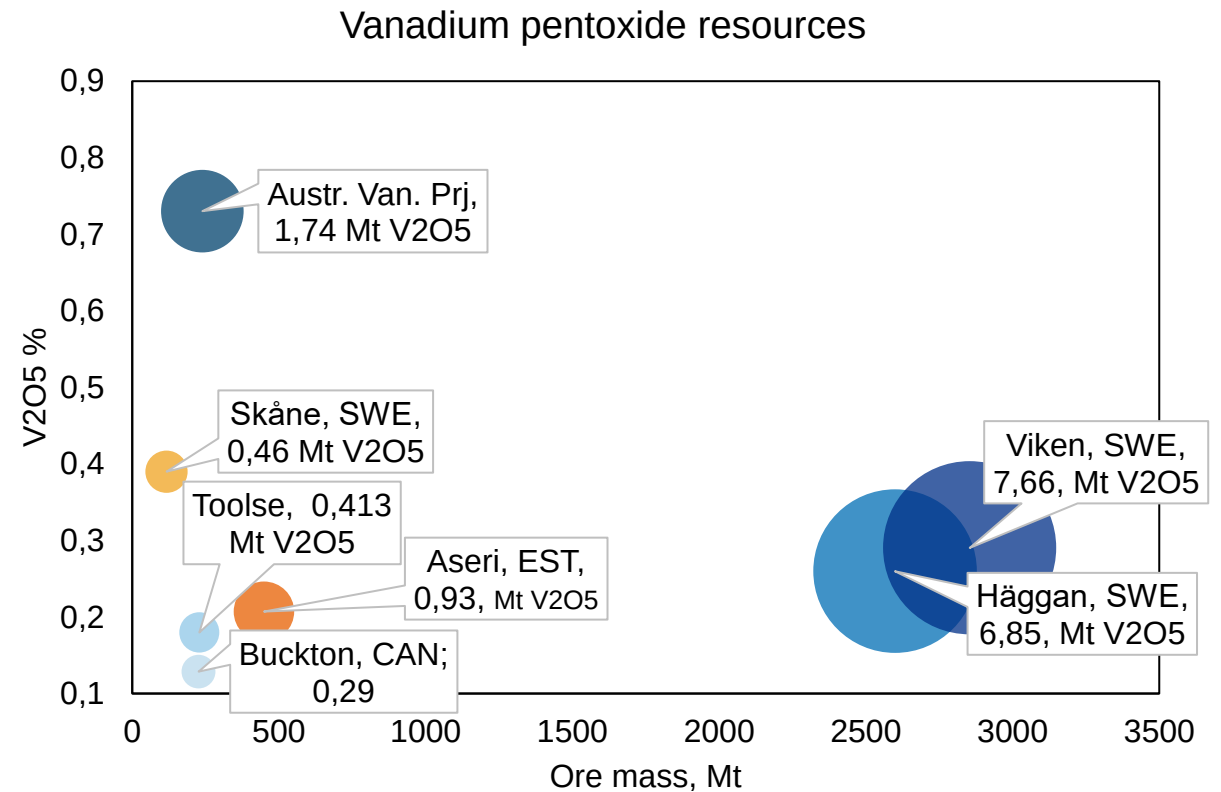
Resource or an
environmental
challenge?



Black shale resources

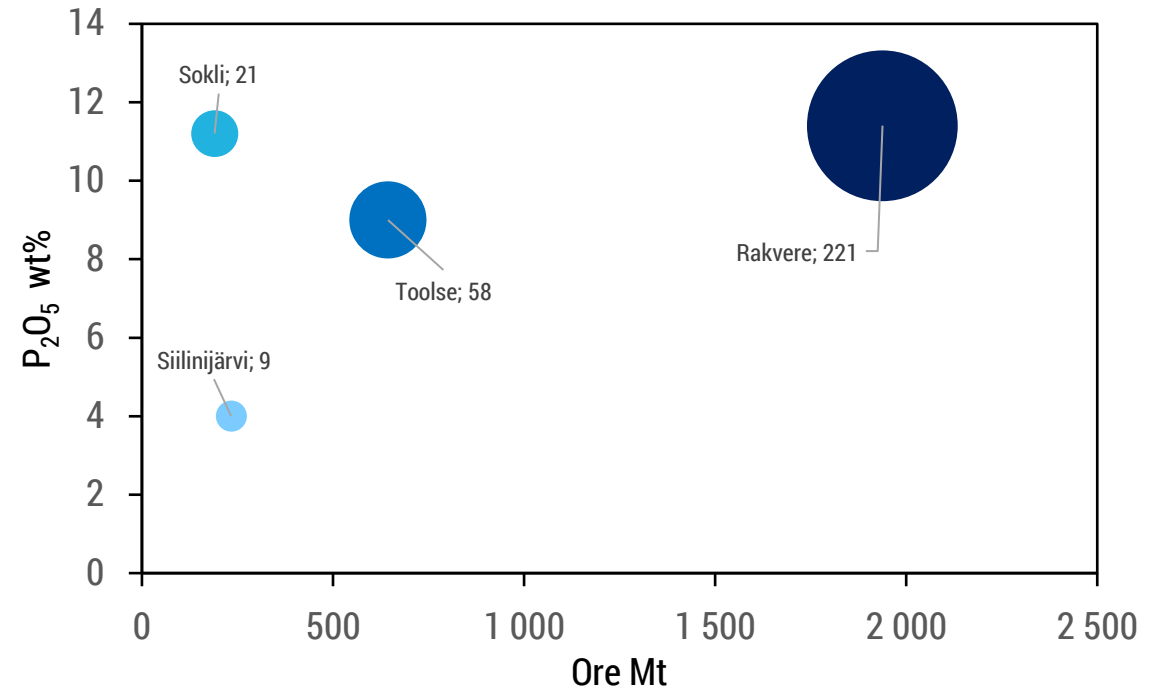
Toolse theoretical (109 km²)

- 229 Mt (413 000 t V₂O₅ @0.18 % average)
- Entire deposit is not minable due to land usage etc. conflicts



Phosphorite resources

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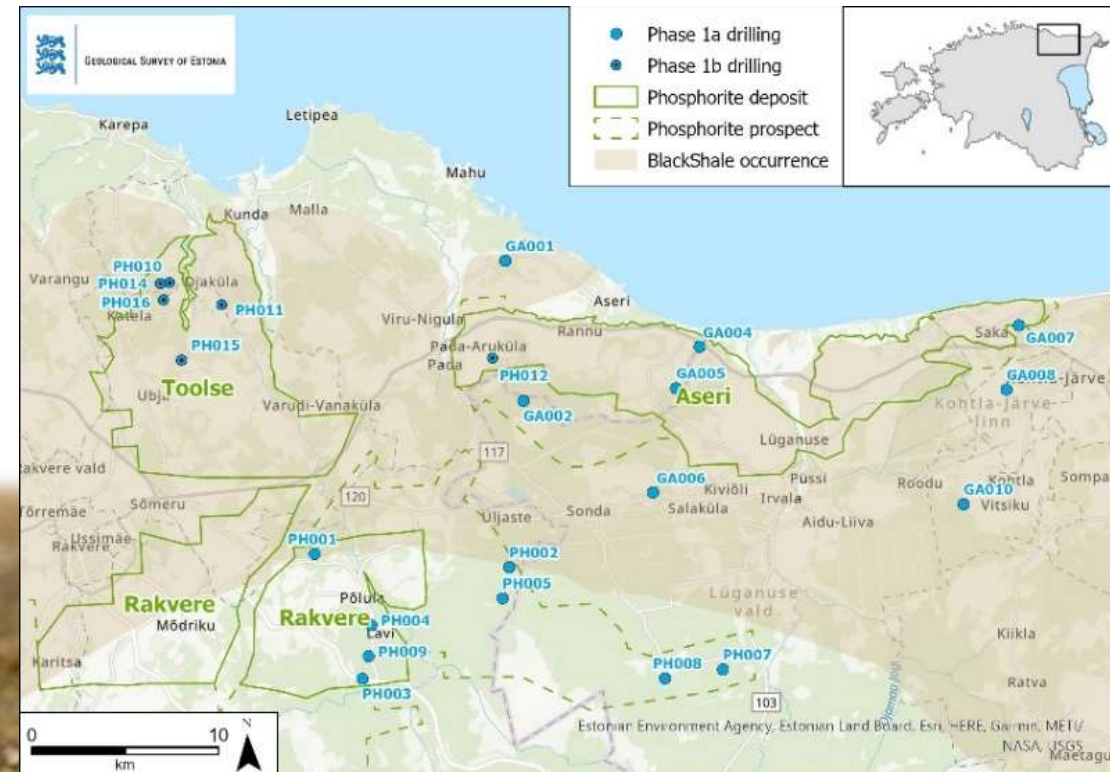
Geological & resource modelling

- Video



Recent drilling campaign

- Core drilling - 37 drillholes, depth up to 116 m, total ca 1800 m.
 - Geological description
 - Geochemical analyses
 - Measurements of geotechnical properties and preliminary mine drift stability calculations
 - Spatial analysis to identify most perspective exploration areas
 - Mining and beneficiation unit cost calculations as well as hydrogeological impact modelling for most prespective areas



Main results

Rakvere

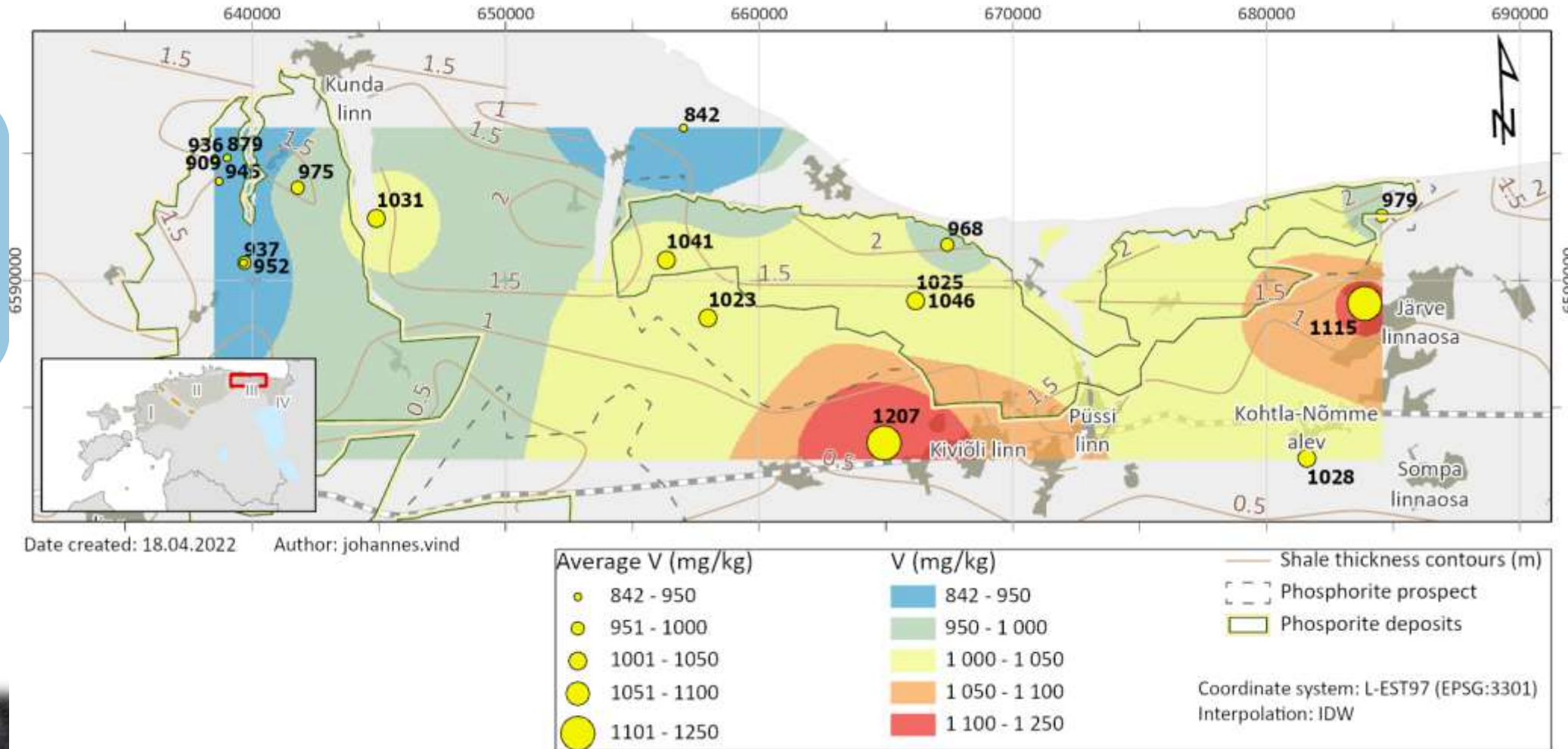
- Measured vs model estimated P_2O_5 +17%
Without one significant outlier +4%
- **ΣREE** abundance 200-300 g/t. Estimated no significant increase after ore beneficiation
- **Dry bulk density** is lower compared to historical resource estimate
- Measured vs model estimated phosphorite seam footwall elevation average difference 1,7m

Toolse

- Measured vs model estimated P_2O_5 -2%
- **ΣREE** abundance 300-400 g/t, estimated after ore beneficiation 1200-1300 g/t
- **Dry bulk density** almost equal to historical resource estimate
- Measured vs model estimated footwall elevation average difference 0,6 m
- Black shale **V** average 942 g/t (historical 1040 g/t)
 - Length-weighted, including various interlayers

Black shale Results

Vanadium increases laterally towards south-east

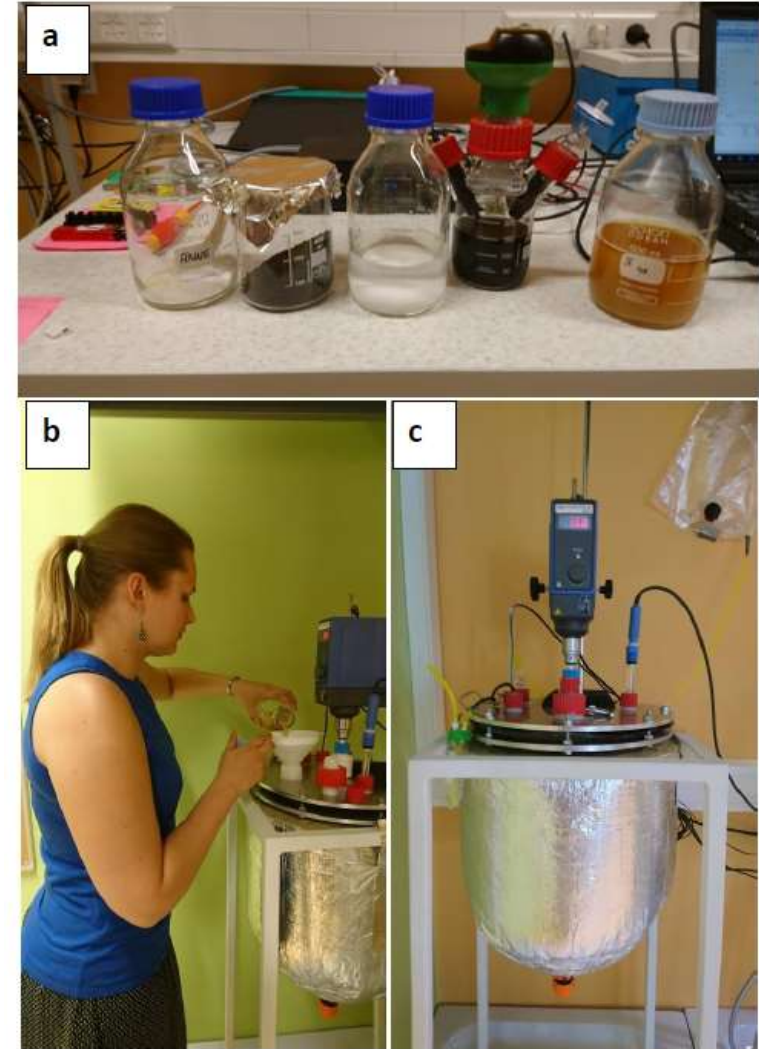


Tehnology studies

RITA



- GSE has done preliminary tests with main commercial technologies for phosphoric acid production.
- Economic technology for REE and V separation needs to be developed.
- Technology studies are funded by Estonian Research Council and executed by UT and TalTech Universities.
- Results are expected Q1 2023.



Summary & outlook

- Re-evaluate the phosphorite and black shale potential.
- The work so far has focused on digitalizing and re-evaluating existing information.
- Drilling campaign with more focus on associated resources.
- Focus areas with preliminary mining and beneficiation unit cost calculations as well hydrogeological impact modelling TBA Q3 2022.
- Exploration report TBA Q4 2022.



Source: https://www.rocktechnology.sandvik/en/products/mechanical-cutting-equipment/roadheaders-for-tunneling/?utm_source=google&utm_medium=cpc&utm_campaign=&utm_term=%



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EESTI
GEOLOOGIAATEENISTUS

Wise decisions are based on best knowledge

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