



SOIL AND BEDROCK CONDITIONS TO BE EXPECTED IN TALLINN – HELSINKI TUNNEL CONSTRUCTION

Geological Survey of Finland
Ossi Ikävalko

Strait Crossing 2013, Bergen

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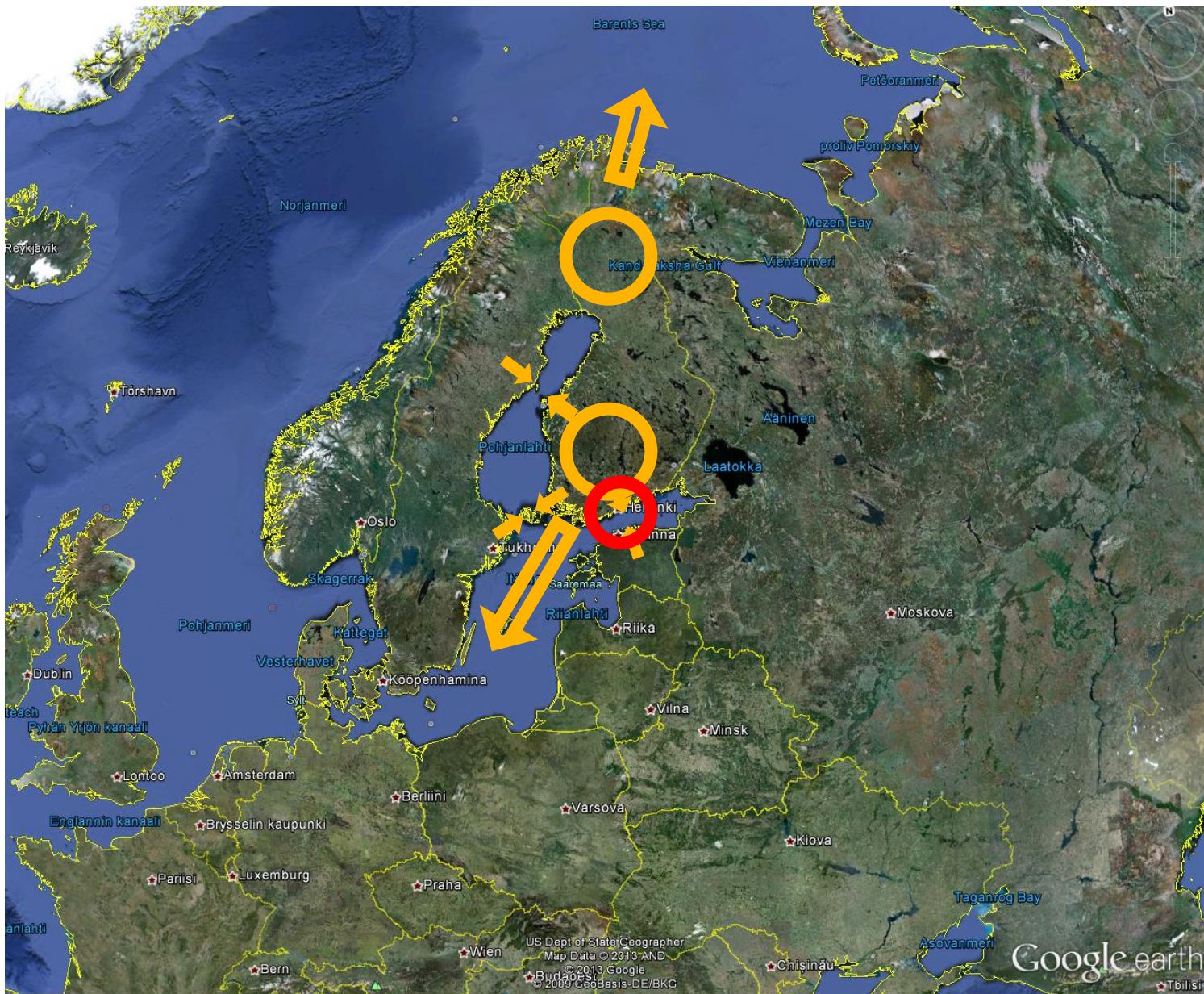
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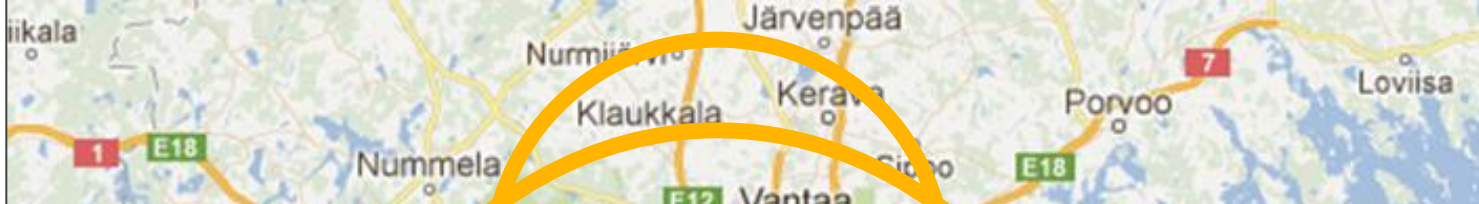
Sten Suuroja, Geological Survey of Estonia, s.suuroja@egk.ee

- Based on compilation and analysis of existing geological data in tunnel area in Estonia, the work is done by Geological Survey of Estonia, 2012
- Commissioned by Geotechnical Division of the City of Helsinki and Geological Survey of Finland
- Main objective was to create a preliminary 3D –model of the geological main units near the coast of Tallinn for tunnel construction suitability estimation of the bedrock

The Helsinki-Tallinn railway tunnel

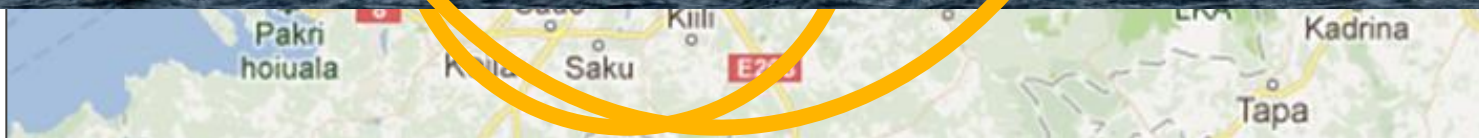
- The idea of a rail tunnel was created at the Finnish Geotechnical Society in 1992
- first preliminary feasibility study by Usko Anttikoski in 2007
- The debate about the tunnel construction has been intensive (2011 – 2013), critical voices have been strong, but the tunnel has got more and more acceptance.
- The political acceptance of the idea by decision makers is also growing, and the idea has developed from fantasy to vision.
- on the basis of the meeting of the mayors of the cities of Helsinki and Tallinn a Feasibility Study Working Group was established
- Helsinki -Tallinn Transport and Planning Scenarios Project (H-TTransPlan), final report 2012
- Only a few geological investigations have been done in the sea area





6 million yearly passengers
12 000 weakly commuters from Estonia
20 daily connection

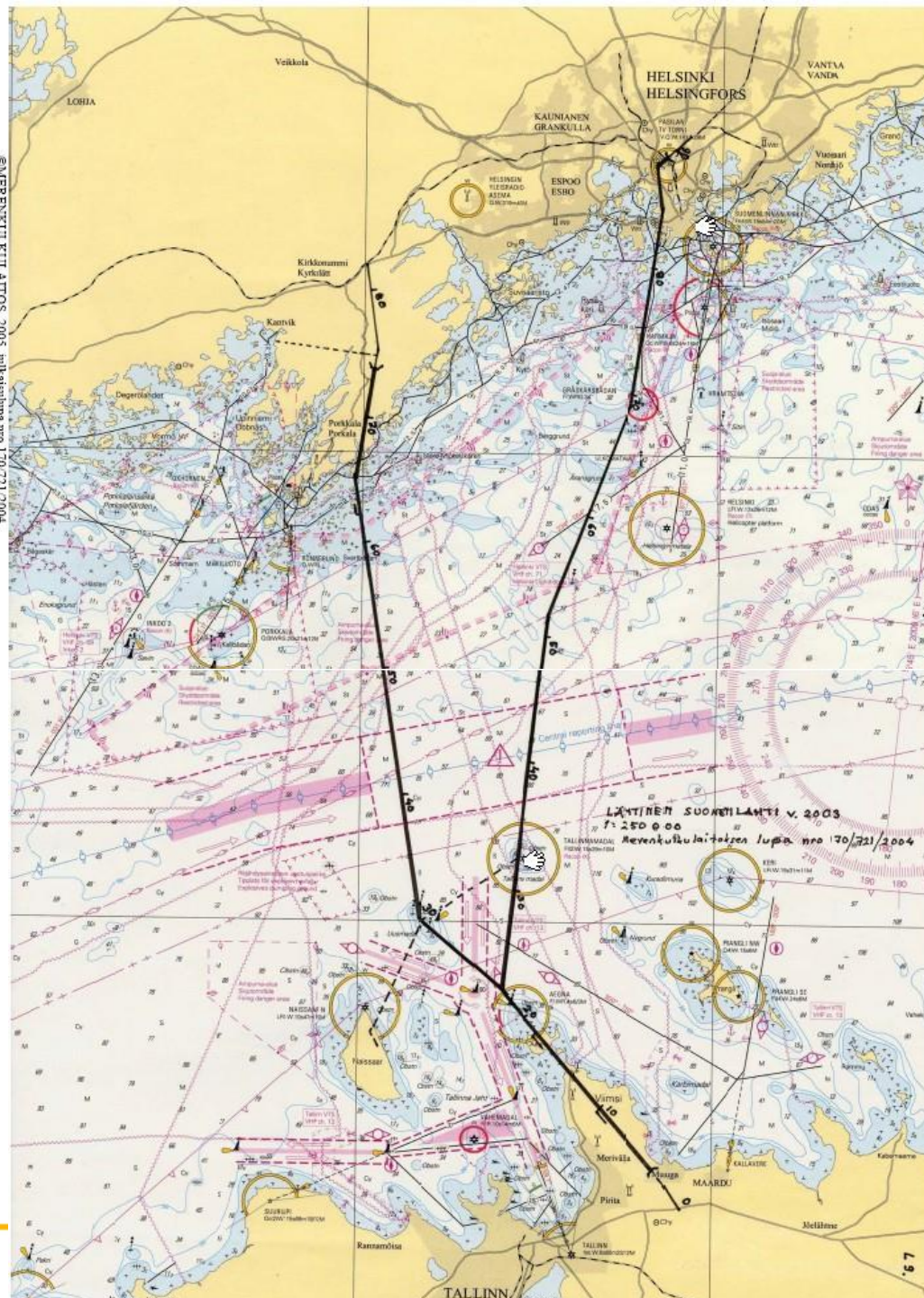
TWIN CITY TALSINKI



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Reference: Usko Anttikoski, 2007

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Technical overview

- The world's longest undersea tunnel (vision, “extreme crossing”)

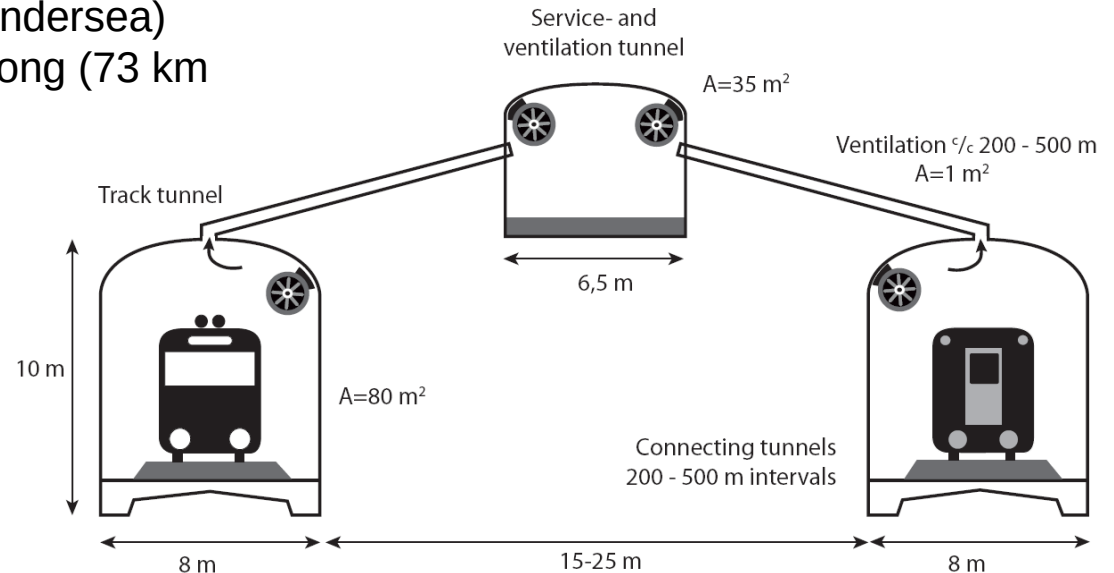
- Two alternatives: 70 km long (58 km undersea) Kirkkonummi-Tallinn tunnel and 85 km long (73 km undersea) Helsinki – Tallinn tunnel

- Shallows on both coasts will be used (artificial islands) to build access tunnels service shafts and ventilation exhaust

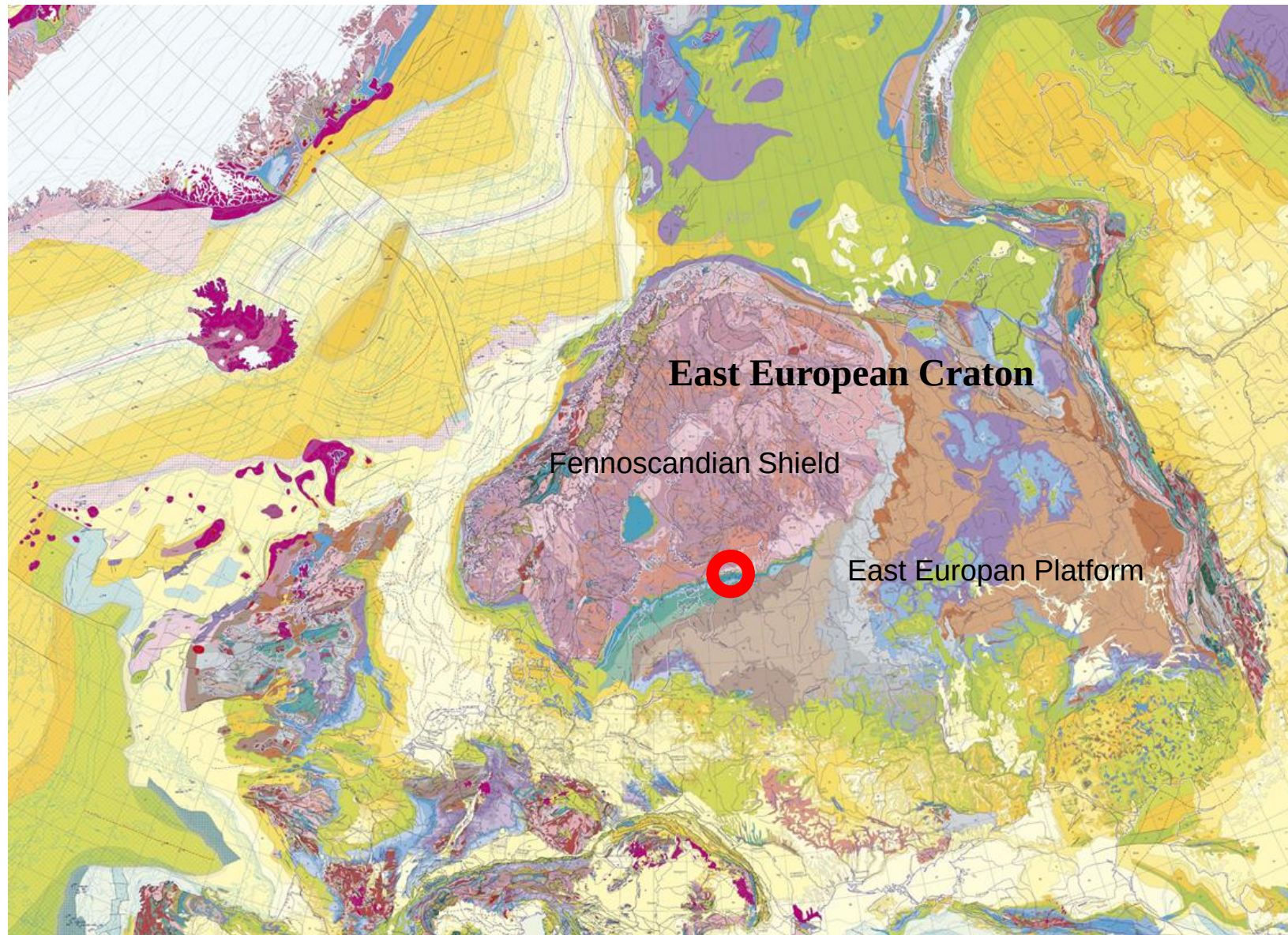
- The construction costs of the tunnel have been estimated to be €2.3 – 2.7 billion (preliminary feasibility study, Anttikoski, 2007)

- The type of tunnel system would be two track tunnels (2 x 70 square metres) and a separate service tunnel (30-40 square metres)

- The lowest point of the tunnels is estimated to be about 220 meters below the sea, maximum tunnel longitudinal inclination about 1.2 – 2.0 %.



The 1.5 Million International Geological Map of Europe And Adjacent Areas – IGME 5000

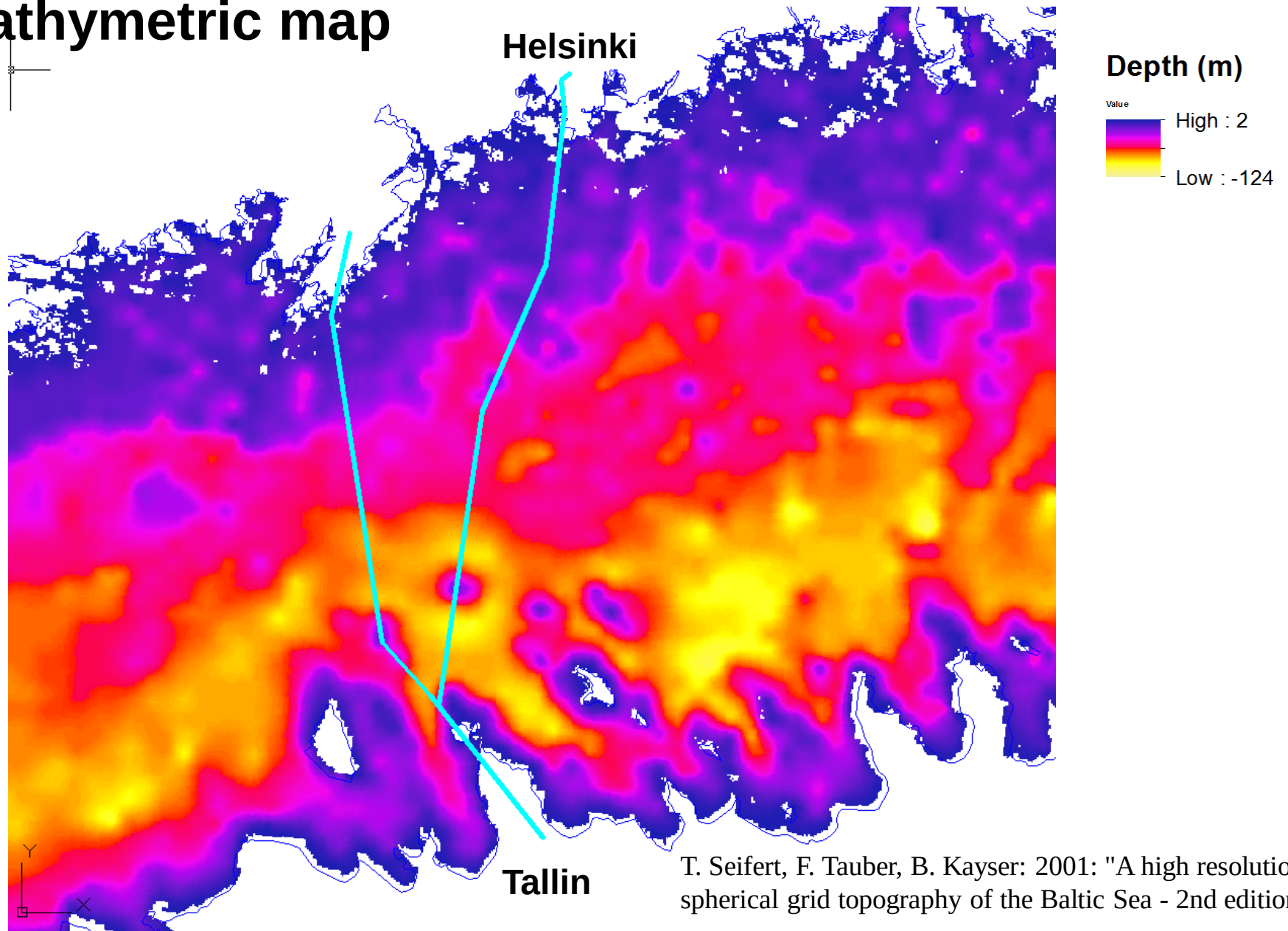


http://www.bgr.de/karten/igme5000/igme5000_finalversion2005_g.jpg

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Bathymetric map



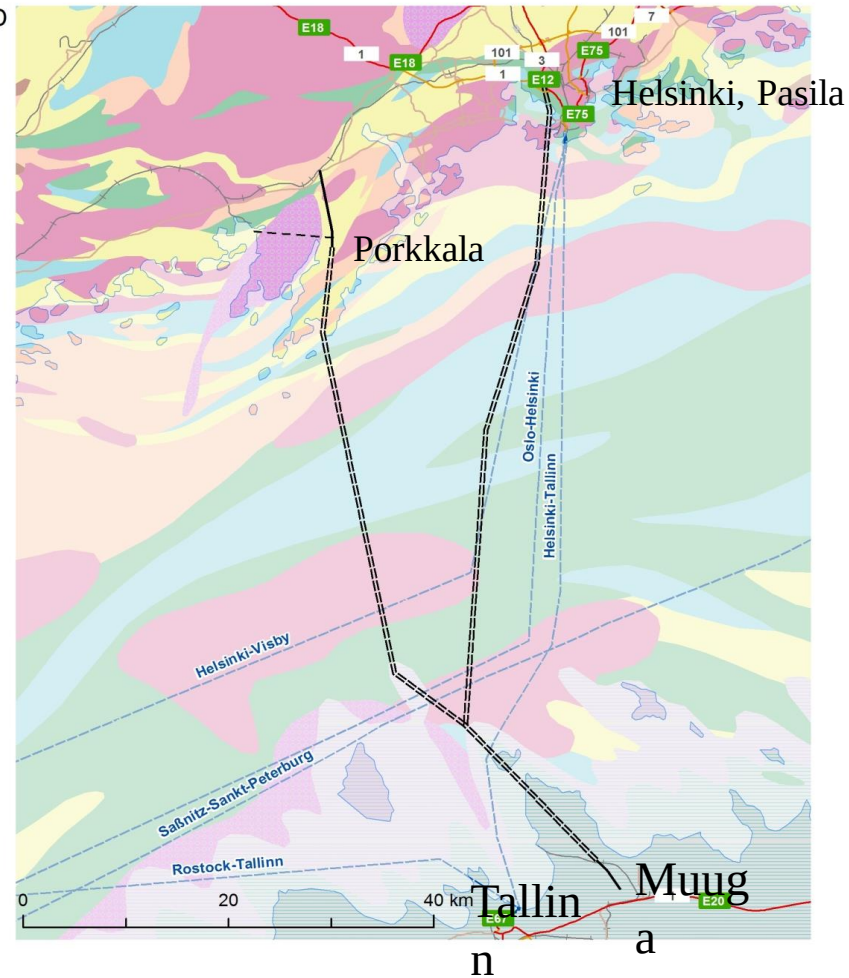
T. Seifert, F. Tauber, B. Kayser: 2001: "A high resolution spherical grid topography of the Baltic Sea - 2nd edition"

Possible tunnel lines according to U. Anttikoski, 2007

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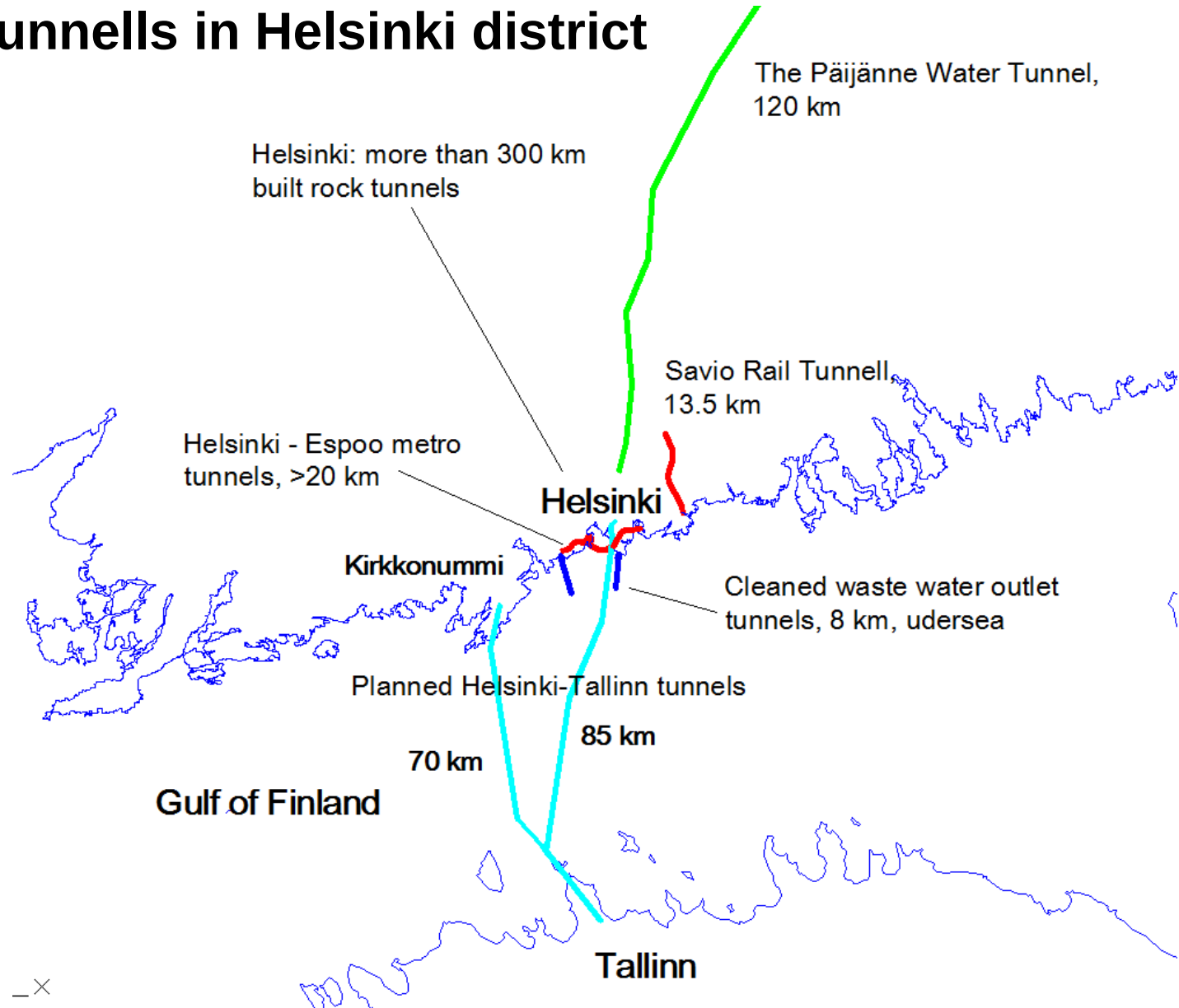
GEOLOGICAL MAP OF THE FENNOSCANDIAN SHIELD

-  Limestone, marl, coal, oil shale, shale, siltstone, sandstone, conglomerate (Middle Cambrian to Permian)
-  Sandstone, conglomerate, siltstone, shale (Vendian to Lower Cambrian)
-  Granite, monzonite, syenite (c. 1.65-1.62 Ga)
-  Granite, pegmatite (c. 1.85-1.75 Ga)
-  Granodiorite, tonalite, granite, monzonite, syenite and metamorphic equivalents, in part hypersthene-bearing (c. 1.91-1.88 Ga, in part as young as c. 1.84 Ga)
-  Gabbro, diorite, ultramafic rock and metamorphic equivalents (c. 1.91-1.88 Ga, in part as young as c. 1.84 Ga)
-  Mafic metavolcanic rock (c. 1.90-1.88 Ga)
-  Felsic to intermediate metavolcanic rock (c. 1.90-1.88 Ga)
-  Metagreywacke, metasiltstone, metasandstone, mica schist, graphite- and/or sulphide-bearing schist, paragneiss, amphibolite intercalations (c. 1.95-1.87 Ga and possibly older)



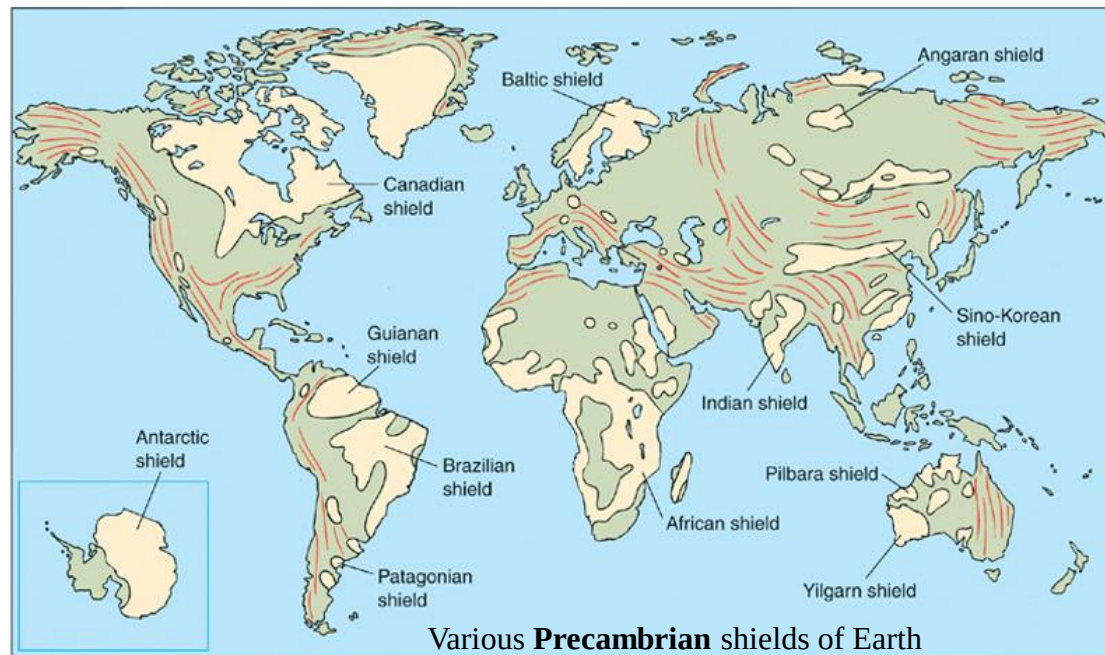
Possible tunnel lines according to U. Anttikoski, 2007

Build rock tunnells in Helsinki district



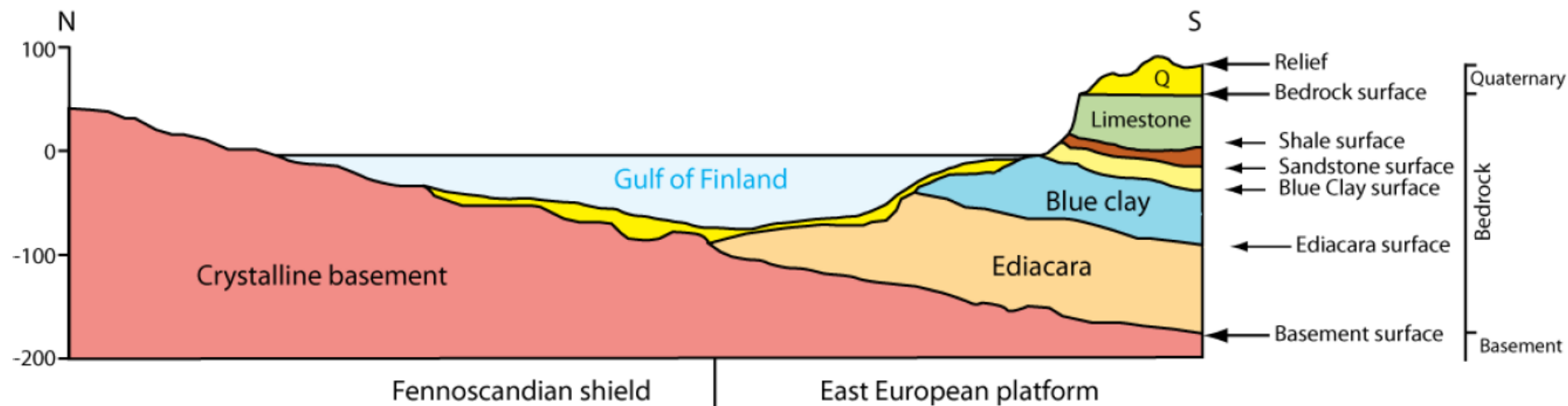
Good and hard bases for the underground construction in Finland

Precambrian crystalline bedrock provides a good bases for the underground construction



Various **Precambrian** shields of Earth

Schematic cross-section through the Gulf of Finland



Bedrock outcrops

Finland



Photo: O. Ikävalko



Estonia

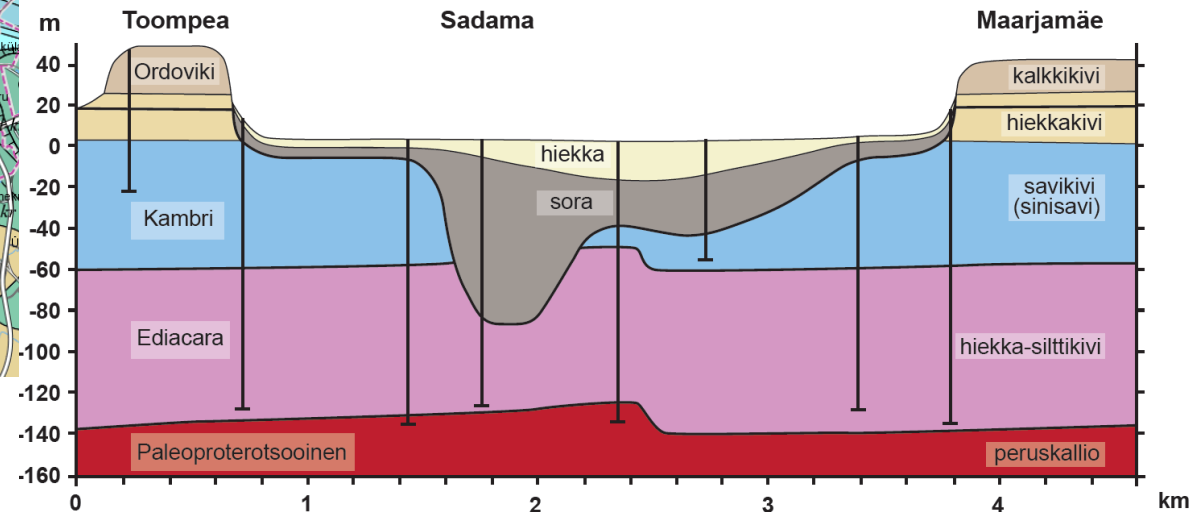
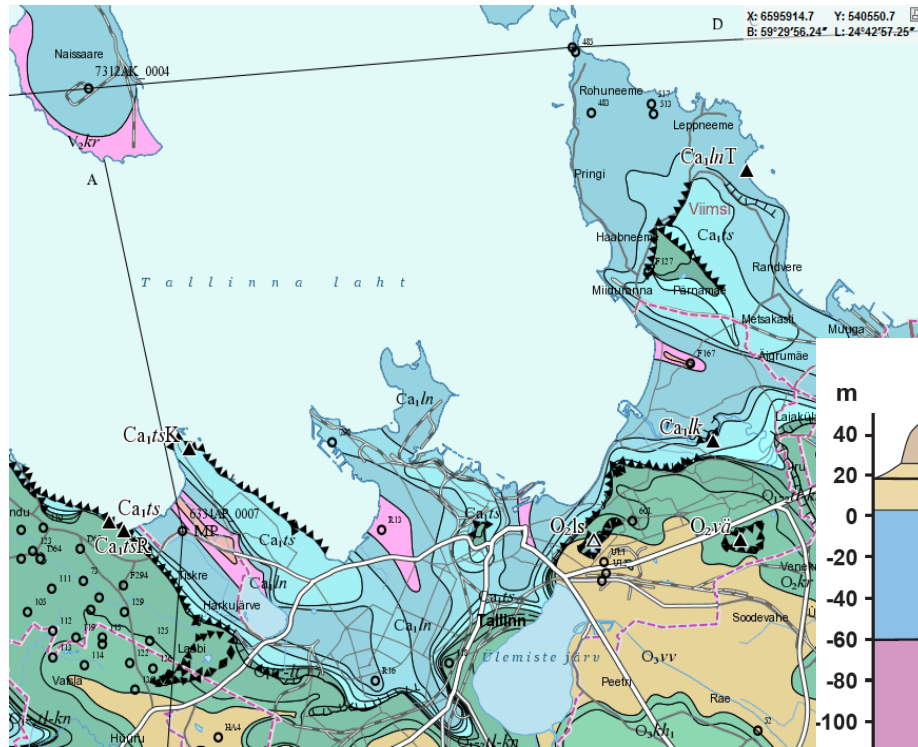


Photo: <http://www.klint.envir.ee/klint/eng/12.html>

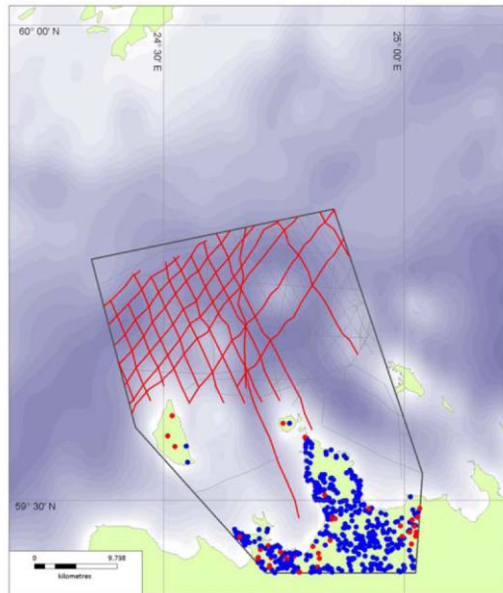


Blue Caly of Lontova <http://www.klint.envir.ee/klint/eng/12.html>

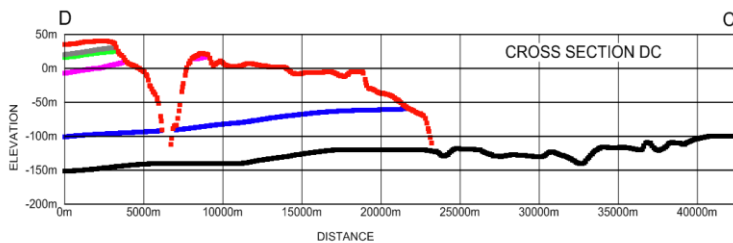
Geology of Estonian coast, Baltic klint and buried valleys



3D –model of main geological units in front of Tallinn



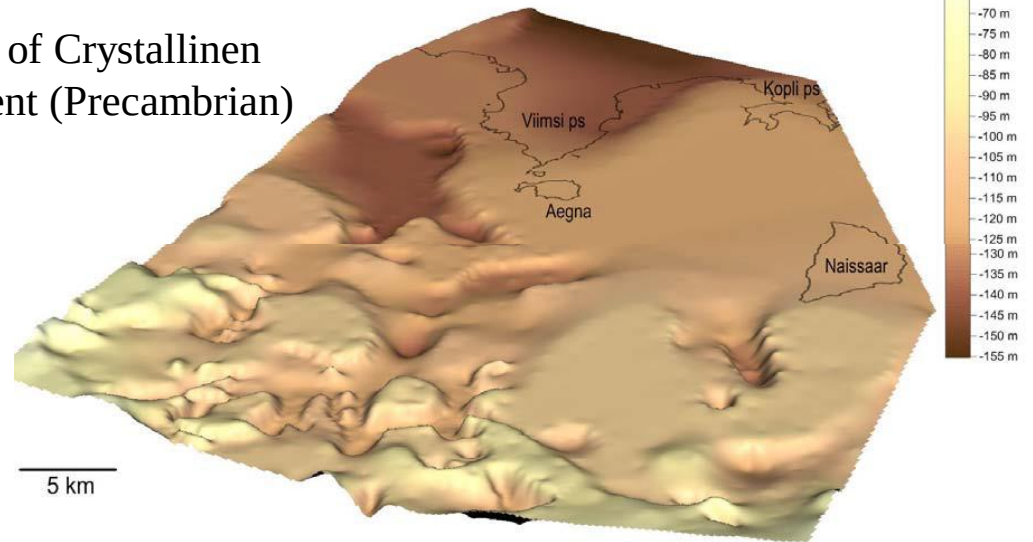
Study area



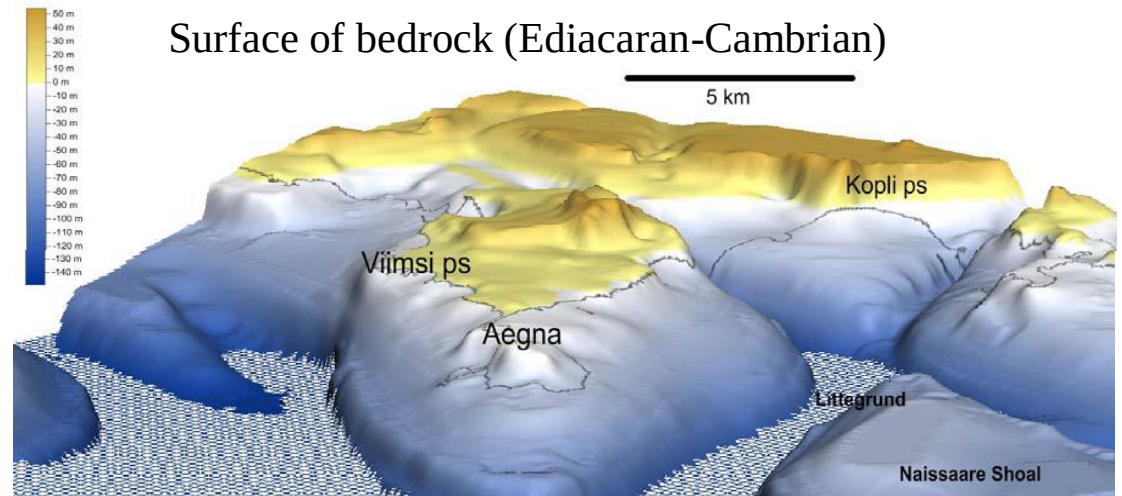
UPPER SURFACES:

- SEDIMENTARY BEDROCK — SHALE — BLUECLAY
- BASEMENT — SANDSTONE — EDIACARA

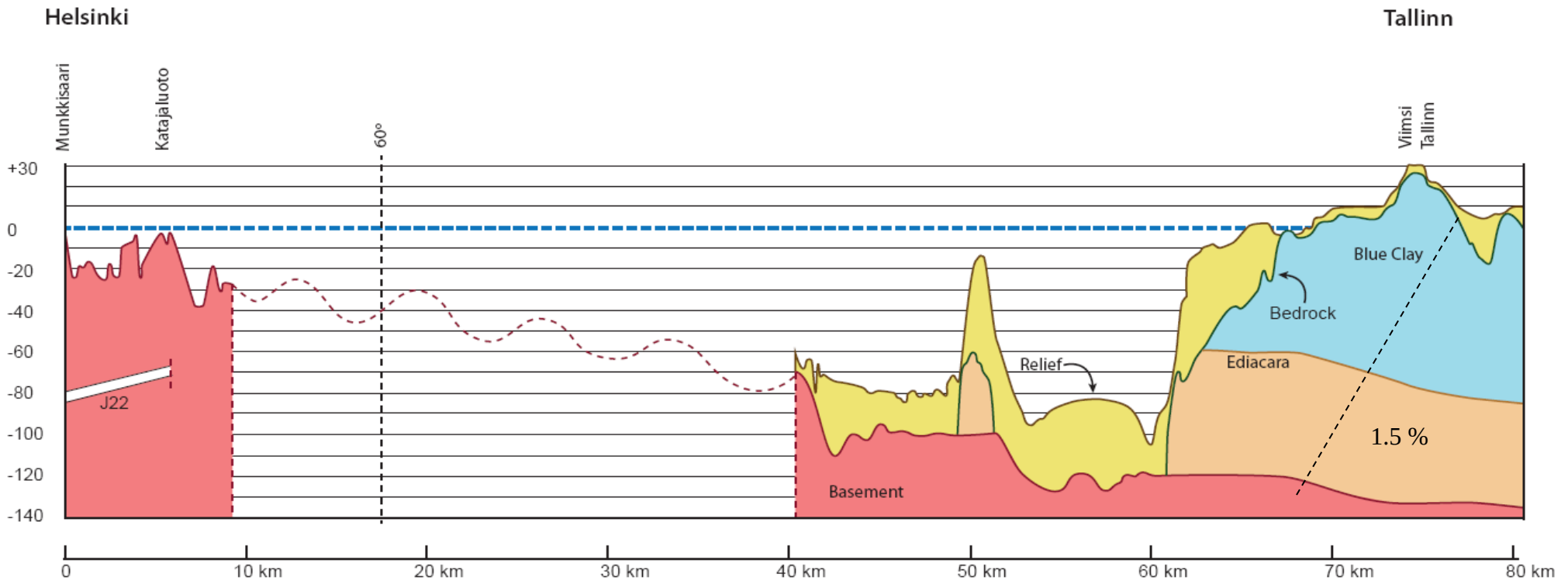
Surface of Crystalline basement (Precambrian)



Surface of bedrock (Ediacaran-Cambrian)



Cross-section of the Gulf of Finland based on the 3D -model



Physical-mechanical properties of different formations along the Tallinn-Helsinki tunnel

1= volumetric weight, 2= compressive strength, 3= porosity,
4= P-wave velocity ca. 6000-6500 m/s, 5= thickness of formation.

		1	2	3	4	5
		G/Cm3	Mpa	%	m/2	m
Precambrian gneisses	A	2.65 - 2.75	110 - 240	0.1 - 0.2	6000 - 6300	
Rapakivi granites	B	2.65	100 - 200	0.1	6000 - 6500	
Weathered crystalline besement	C	2.0 - 2.6	1 - 100	1 - 20	2000 - 5000	1 - 20
Sandstones	D	2.0 - 2.3	1 - 25	10 - 20	2000 - 3000	n. 60
Siltstone	E	2.25 - 2.35	5 - 25	10- 15	2500 - 3500	1 - 2
Sandstones	F	2.1 - 2.2	1 - 5 Mpa	20 - 25	2500 - 3000	15
Blue clay	G	2.3 - 2.4	2 - 4 Mpa	8 - 10	2000 - 2500	45
Limestone	H	2.55 - 2.65	100 - 150	0.1 - 5.5	4000- 5500	20
Glauconite sandstone	I	1.95 - 2.1	1 - 20	1 - 10	2500 - 3000	2
Alum shale	J	1.9 - 2.0	40 - 50	1 - 10	3500 - 4000	3.5
Sandstones	K	2.1 - 2.8	1 - 40	1 - 20	2500 - 3500	3- 8
Quaternary loose sediments	L	1.5 - 2.2	< 1	10 - 30	1500 - 2000	0 - 60

A= Rocks of Jägala complex, B= Naissaar and Neeme rapakivi, C= Weathered crystalline rocks. D= Ediacaran sandstones, E= Ediacaran siltstone, F= Cambrian quartzose sandstones of the Tiskre formation, G= Cambrian blue clay of the Lontova formation, H= Ordovician limestone, I= Ordovician glauconite sandstone of the Leetse formation, J= Ordovician alum shale of the Türisalu formation, K= Ordovician sandstones of the Kallavere and Ülgase formations, L= Quaternary deposits

Physical-mechanical properties of the rocks divided into 8 groups.

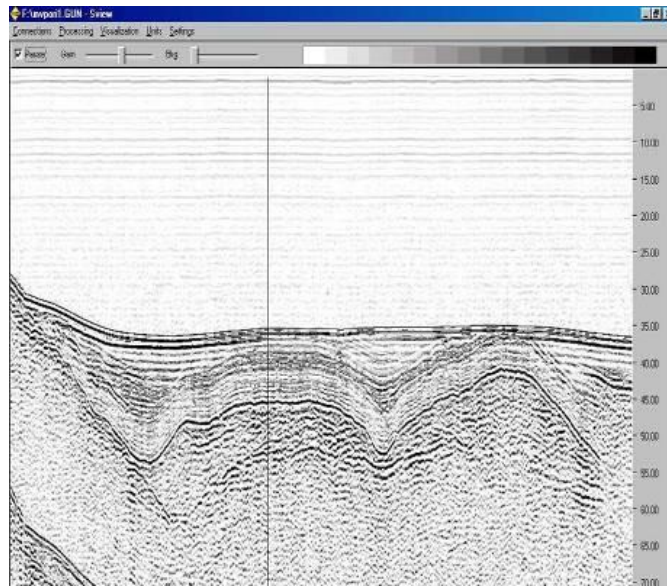
Complexes from 2 to 6 represent the sedimentary rocks, collectively called bedrock. Bedrock is, partly or completely, eroded by later processes.)

Complex no.	Thickness m	Properties tbl. 1	Construction conditions	Tunnel km incl. 1.5 %	Formation
1	0 - 60	L	Very difficult	outside tunnel	Quaternary deposits;
2	20	H	Good	outside tunnel	Ordovician limestones;
3	10	J,I	Very challenging	outside tunnel	Lower-Ordovician alum shale and glauconitic sandstone
4	15 + 10	I,K	Very challenging	2	Lower-Cambrian and Lower-Ordovician sandstones;
5	60	G	Good	4	Blue clays (Lükati and upper part of Lontova formations);
6	60	D, E	Very challenging	4	Ediacaran silt- and sandstones (Kroodi formation);
7	15	C	Challenging	1	Weathered crust of basement
8	(km)	A, B	Very good	63	Precambrian basement metamorphic and igneous rocks

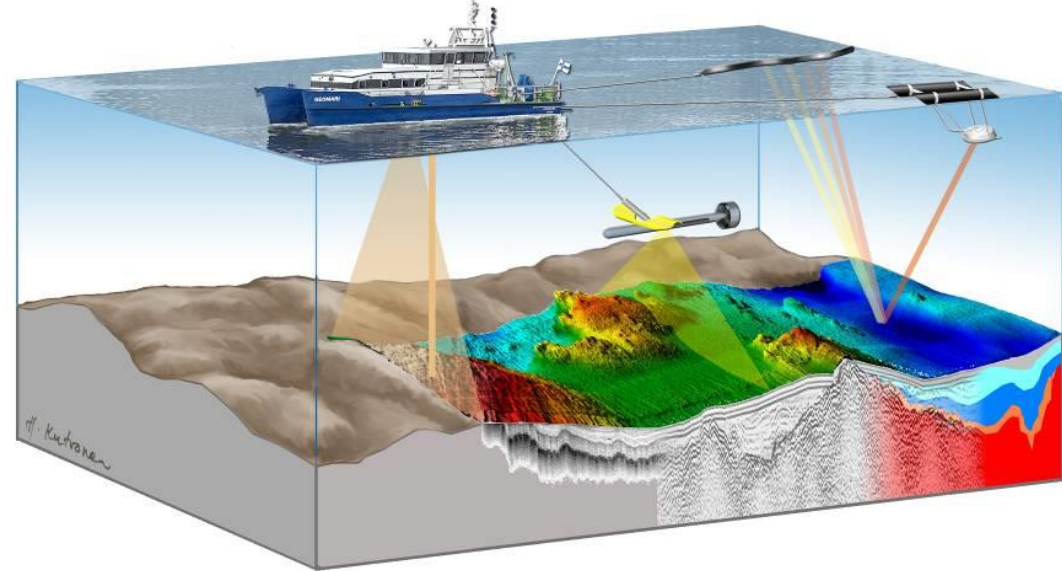
Investigation to be done in the future

Use of different methods to measure:

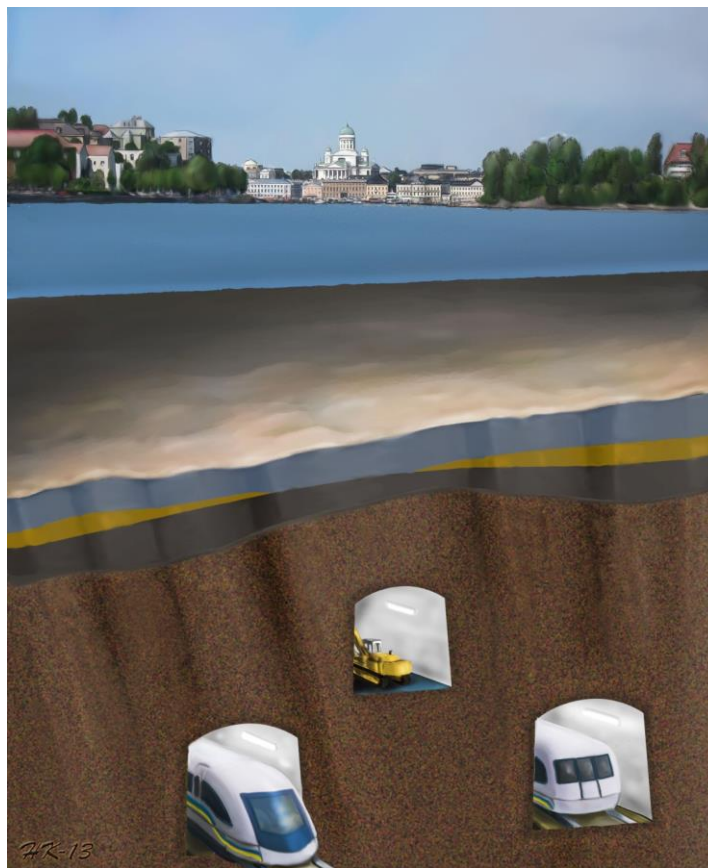
- Depth of bedrock surface
- Weakness zones in bedrock



Acoustic-seismic methods



Continuous seismic reflection profiling provides information in the sedimentary sequences overlying the bedrock and/or crystalline basement



Thank you for Your attention !

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