Sedimentological investigations supporting management of the mine environment

Veli-Pekka Salonen

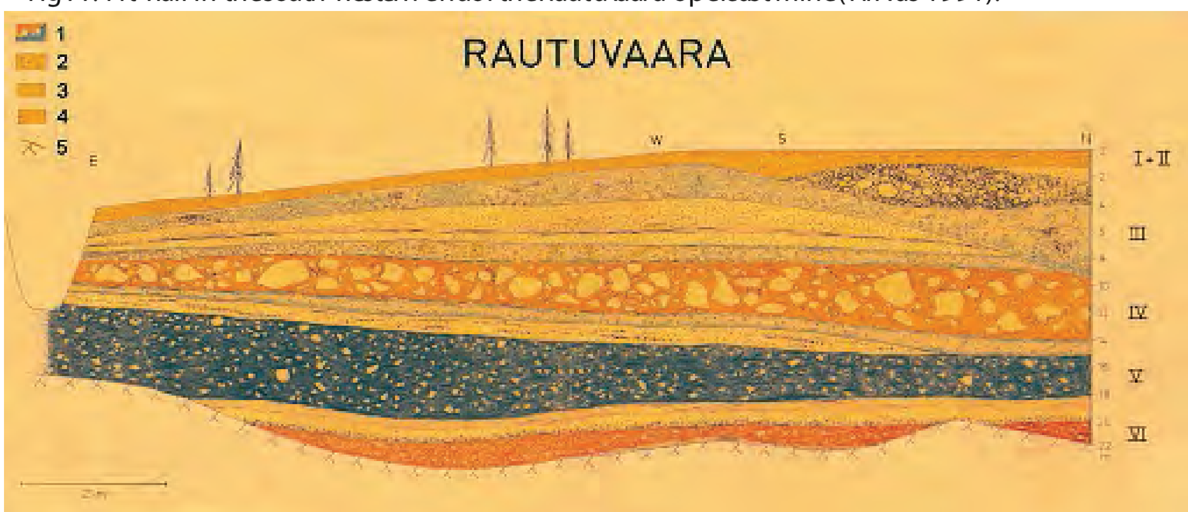
Background

- Large open mine sections have since long time ago been important sites for studying Quaternary stratigraphy and sedimentology
- Studies from open pit sections such as Ryytimaa, Sokli (cores), Hitura, Pyhäsalmi, Lahnaslampi, Vampula and Rautuvaara, have build a solid backbone for the Finnish glacial history

Rautuvaara, Kolari
- one of the classic sites

- the ”Till stratigraphy” of the past has changed into clastic sedimentology

Kuva 77. Rautuvaaran avolouhoksen lounaispään moreenileikkaus.
Fig 77. Pit wall in the south-western end of the Rautuvaara opencast mine (Hirvas 1991).



Till stratigraphy in a cut through the overburden at the Rautuvaara open cast mine
1= till, 2 =gravel, 3 = sand,4= silt nd5=bedrock (Original drawing Pertti Hakala).

Kujansuu 2005

There is still a large number of open questions in Quaternary history, especially in Lapland

- Recent work in e.g. Sokli, Suurikuusikko, Rautuvaara and Hannukainen will significantly increase our understanding

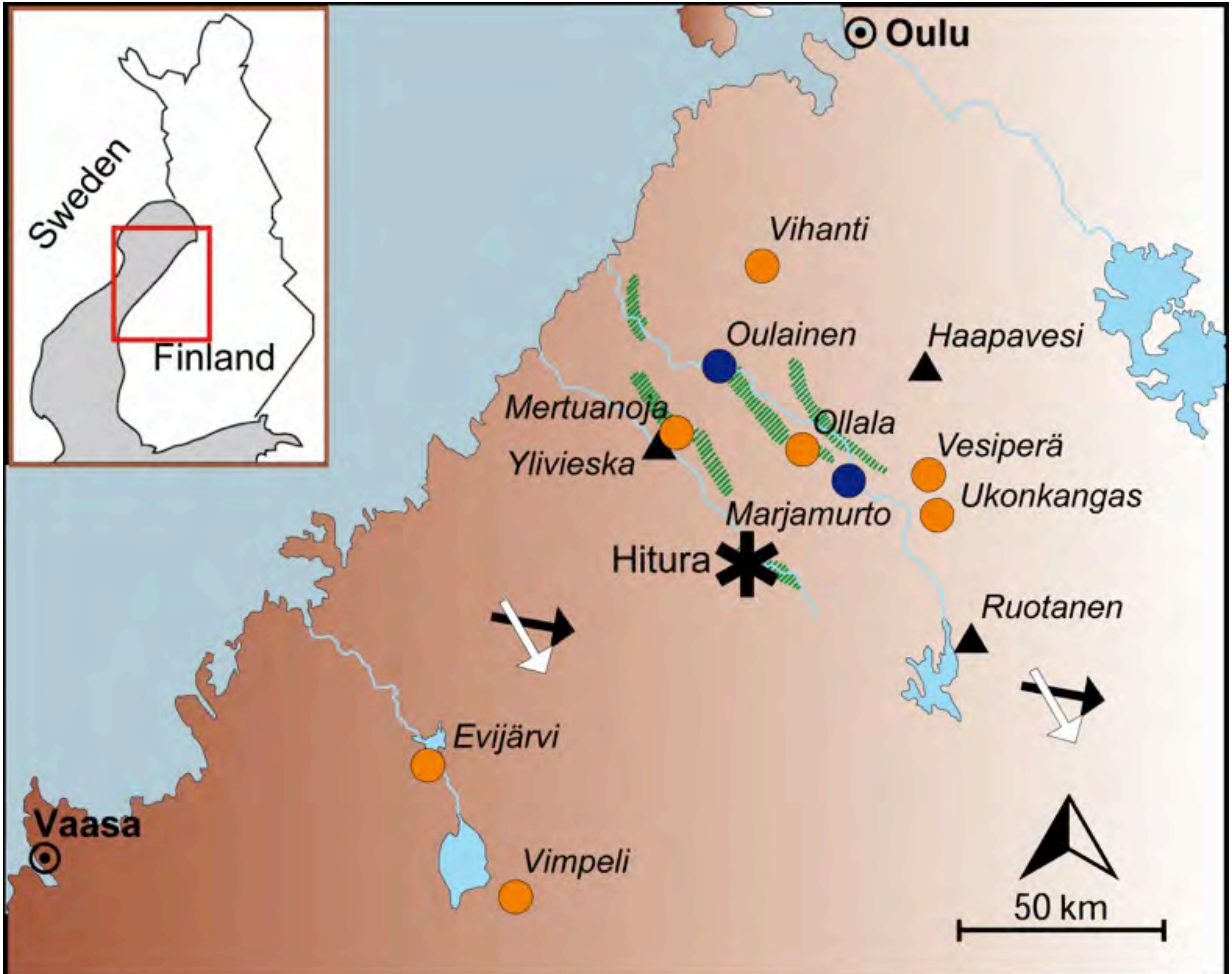
Basic and applied research support each others:

- Mine sites are not only great opportunities for basic research but large sedimentological sections can be of outmost importance for mine environmental studies
- There are many practical reasons to study carefully those large open mine cuttings:

  - Key references for understanding soil properties (GS, density, packing)
  - Sample sites for hydraulic parameters (K-value, T-value etc)
  - Aquifer properties (GW-table, hydraulic units, sediment thickness…)
  - Bedrock DEM reference, GPR reference…
  - Reconstruction of glacial landsystems supports siting mine facilities

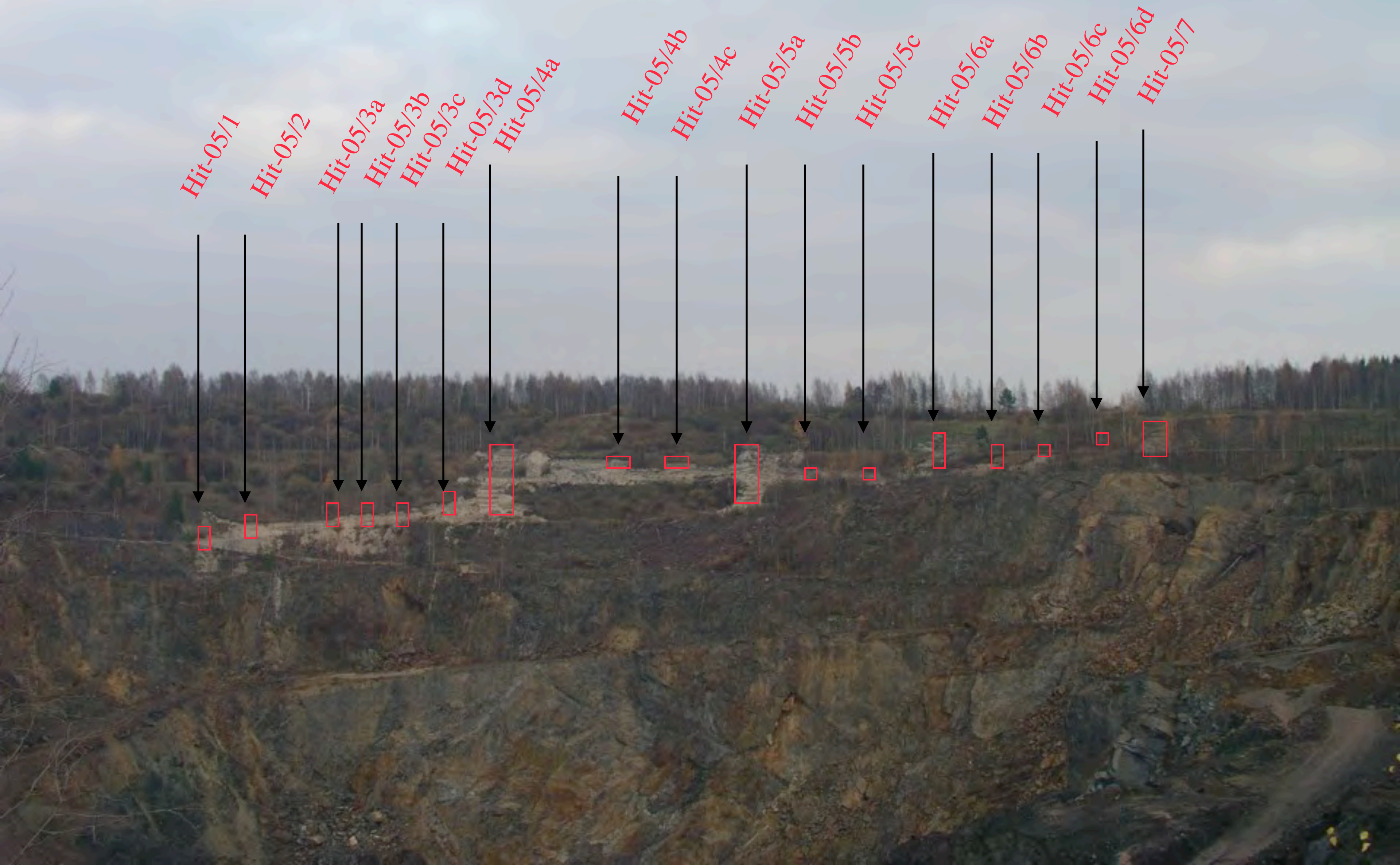
Example Hitura

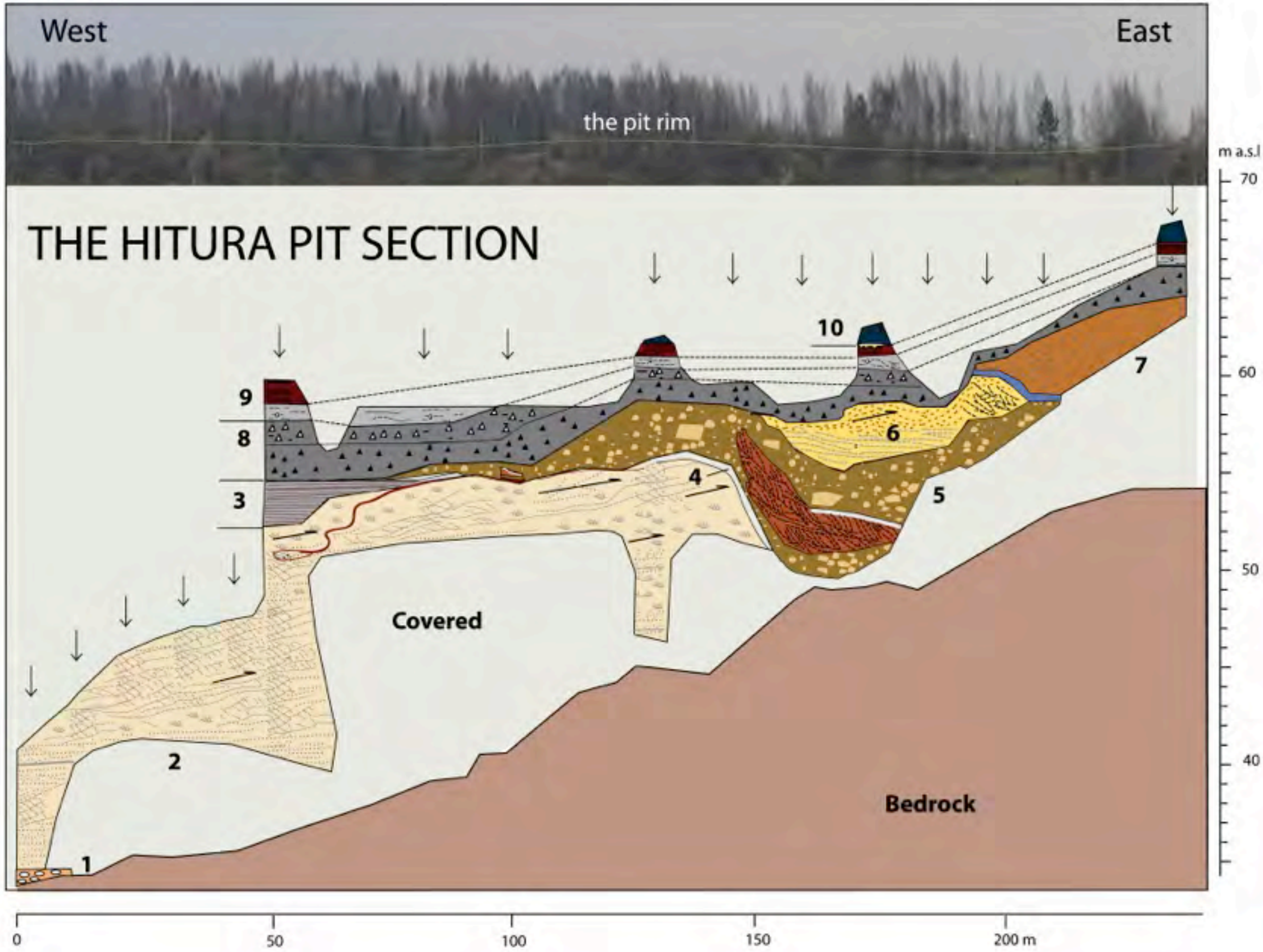
The study area with interstadial and interglacial sites



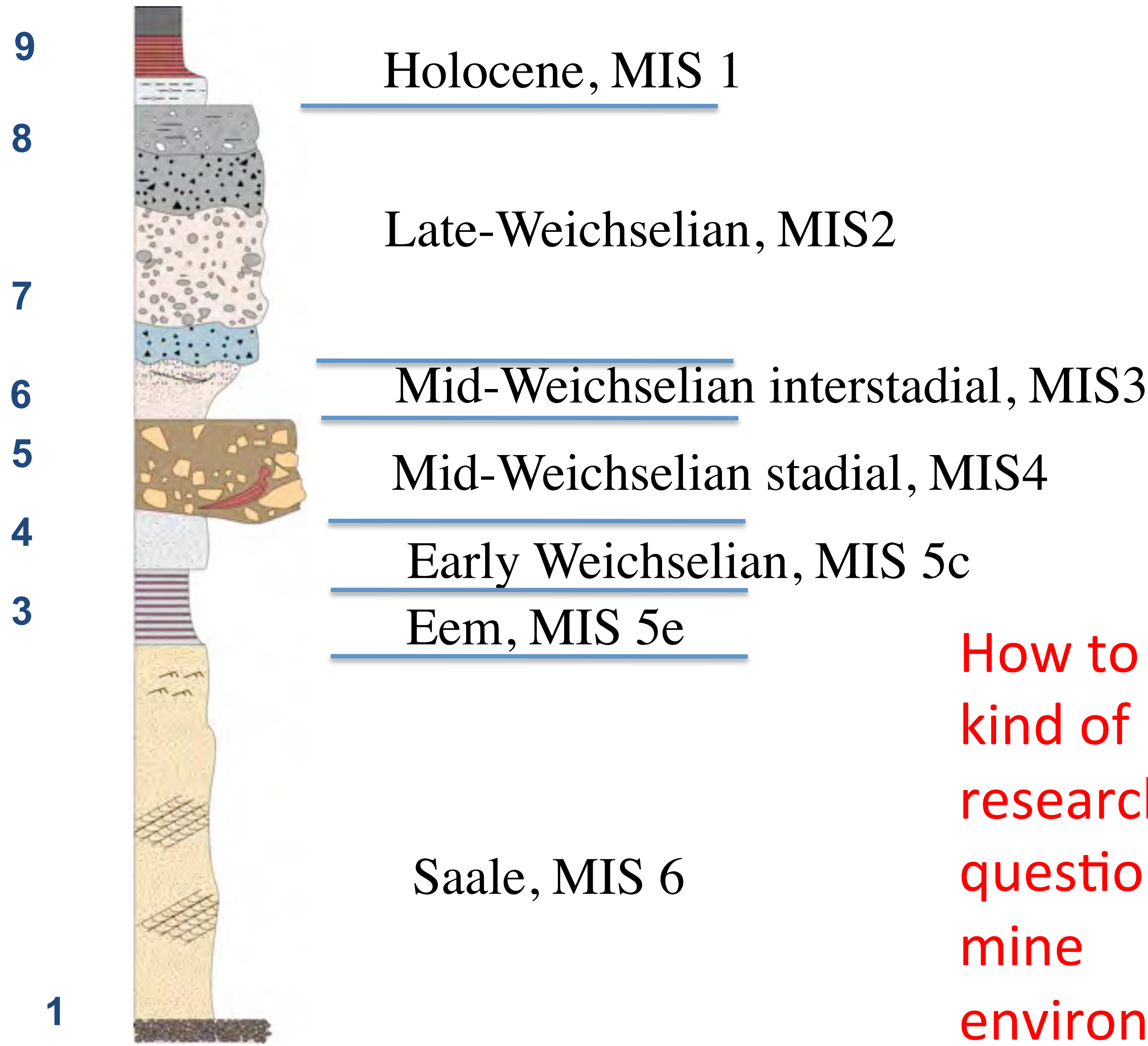
Hitura mine 2003

Sections logged 2006

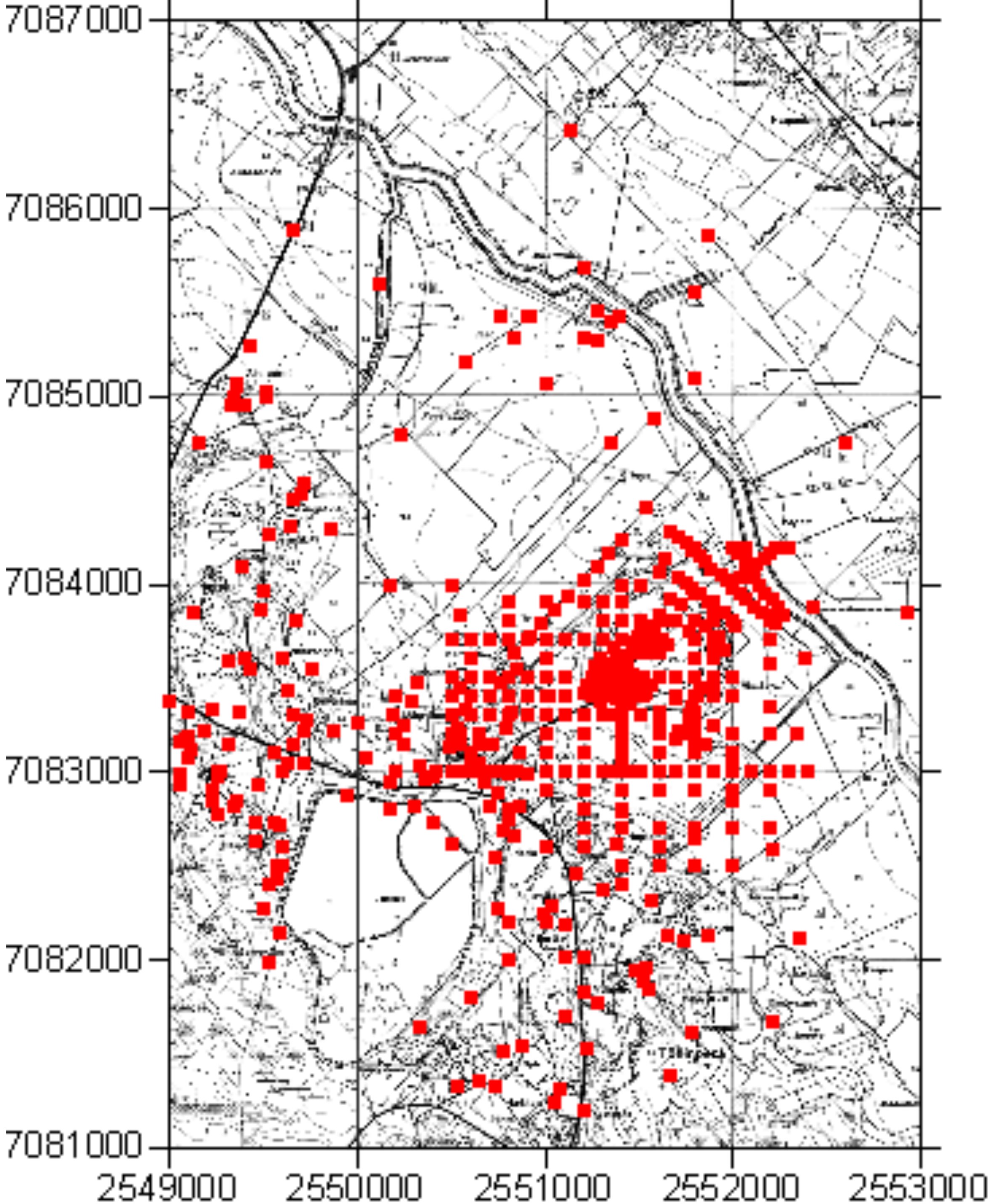



West
East
the pit rim
THE HITURA PIT SECTION
m a.s.l
70
60
50
40
10
9
8
3
4
5
6
7
2
1
Covered
Bedrock
0
50
100
150
200 m

Hitura: units and chronostratigraphic correlation



How to apply this kind of basic research for questions of of mine environment ?



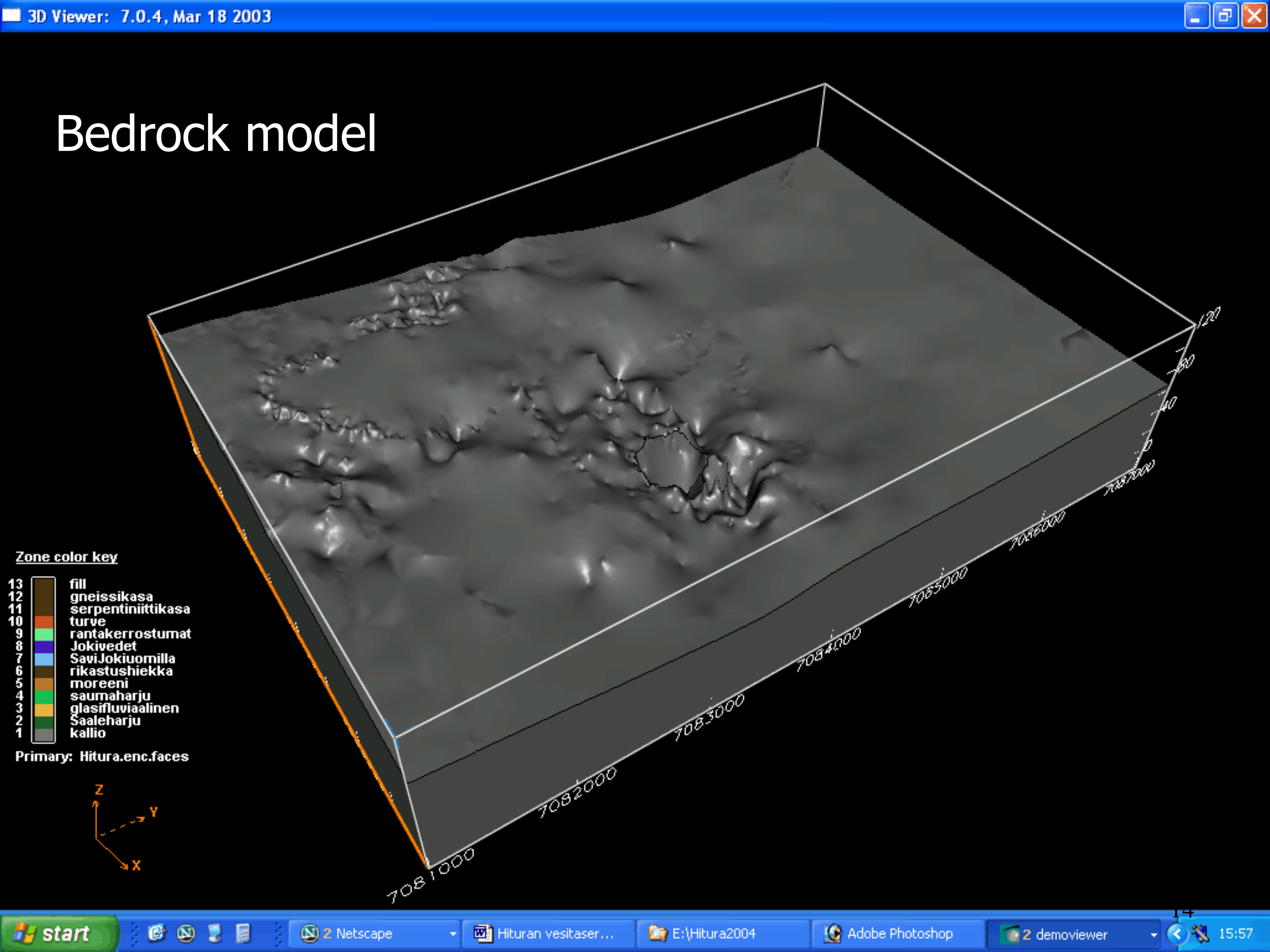
- Reference for 3D sedimentological model

Hitura drillings (ca. 500 points)

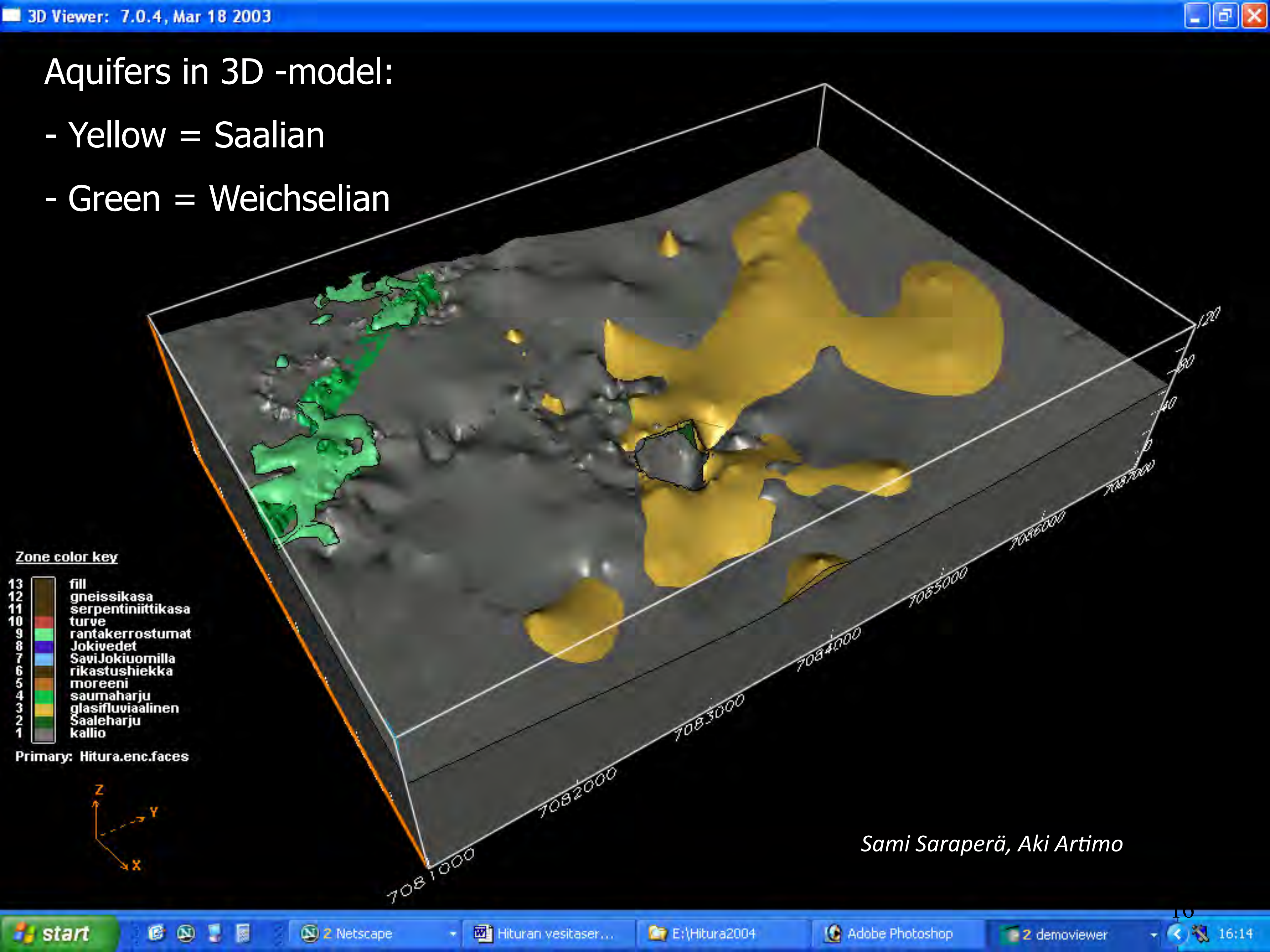
Kristiina Nuottimäki's MSc-thesis

Bedrock surface

Bedrock model




Buried esker aquifer (Saalian)

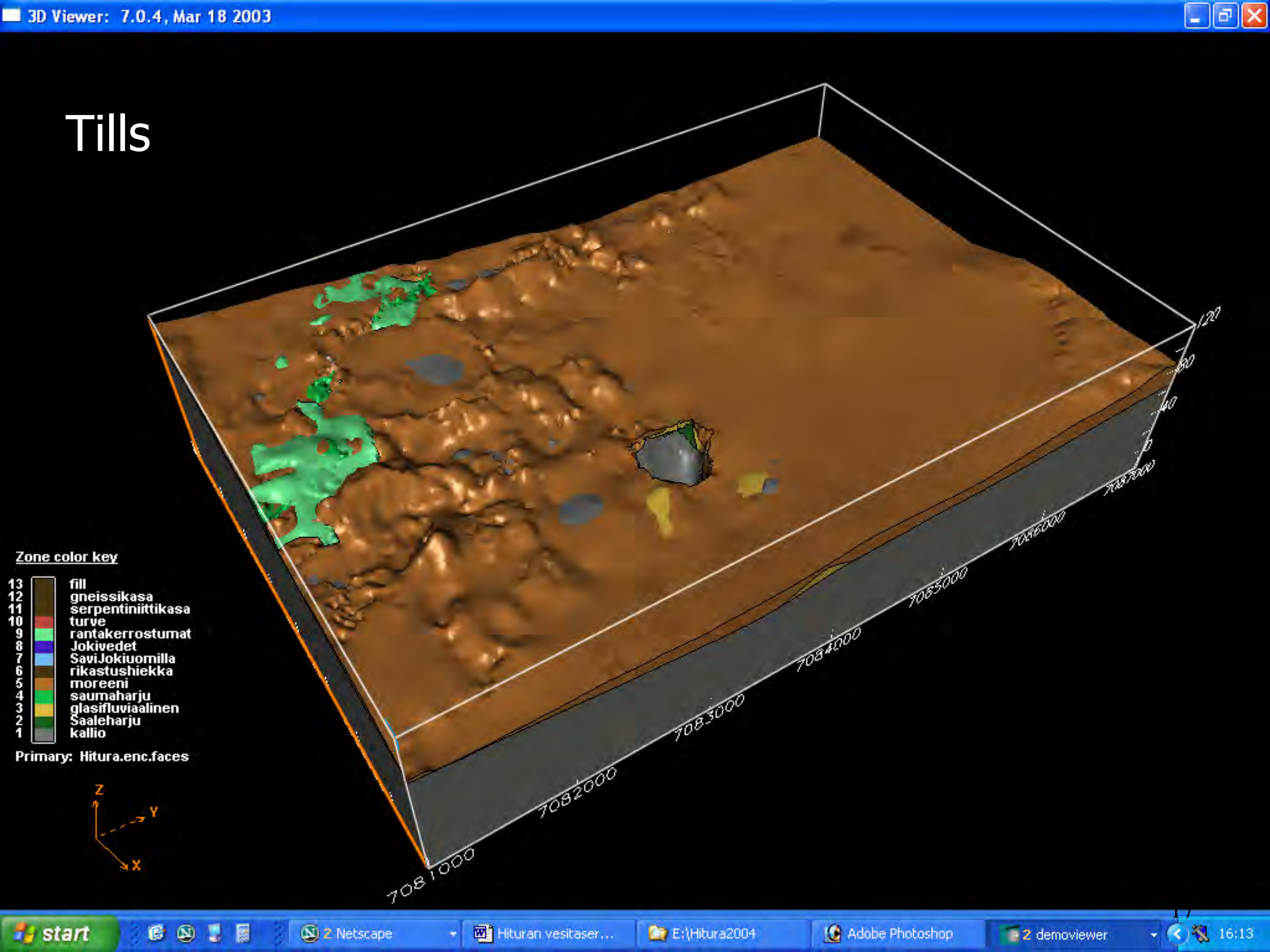


Aquifers in 3D -model:

- Yellow = Saalian
- Green = Weichselian

Sami Saraperä, Aki Artimo

Tills



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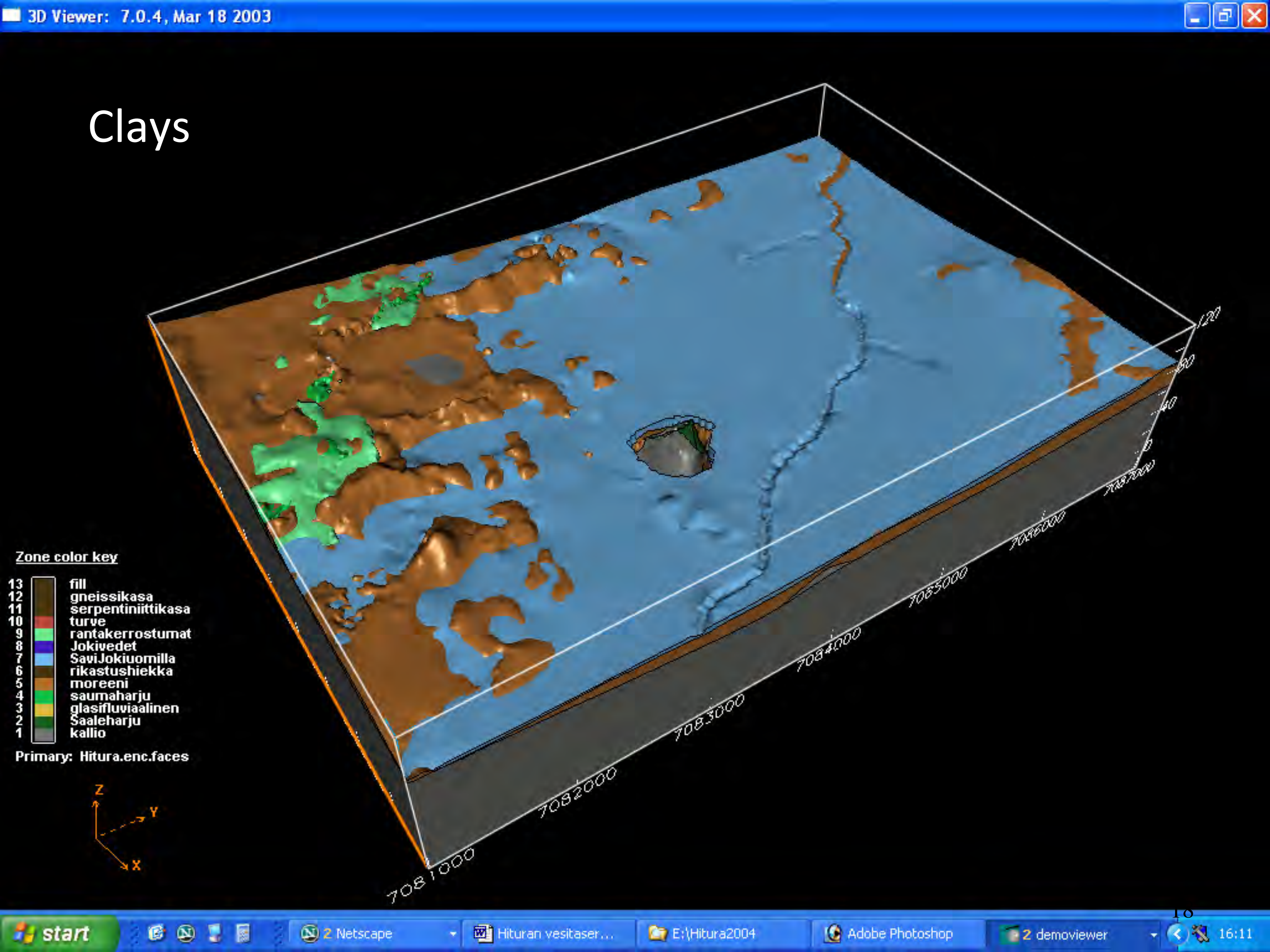
Clays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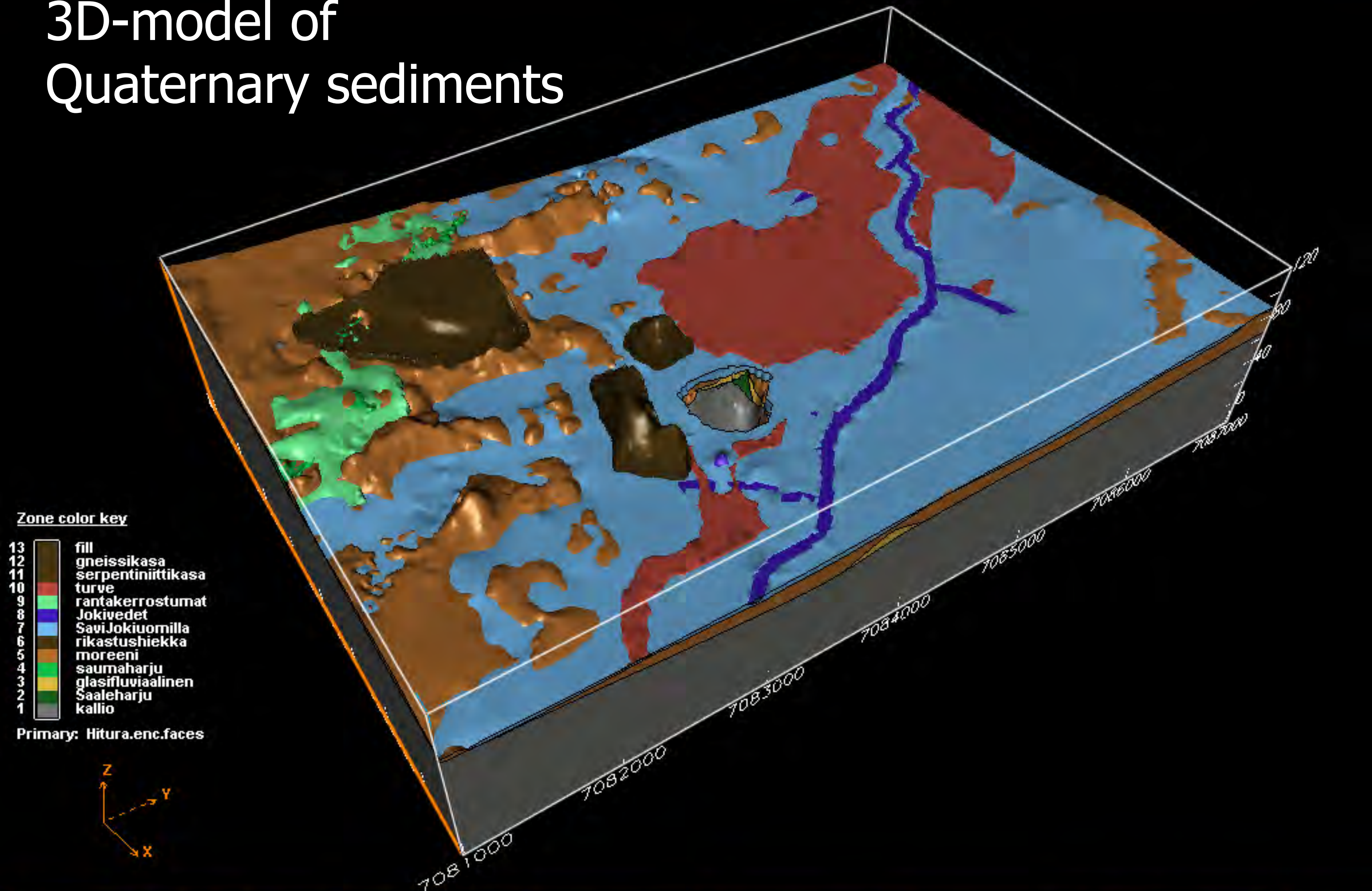
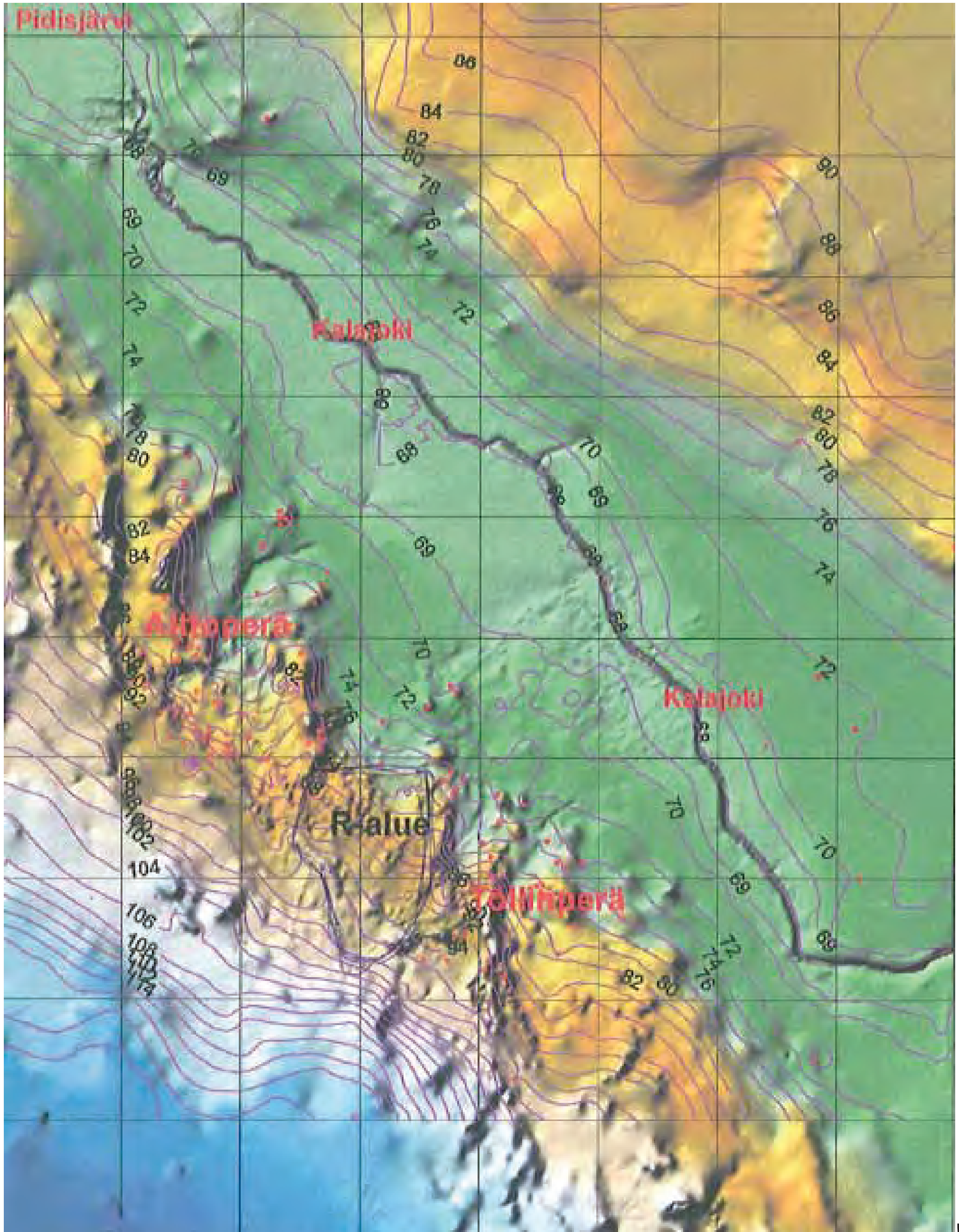
3D-model of Quaternary sediments





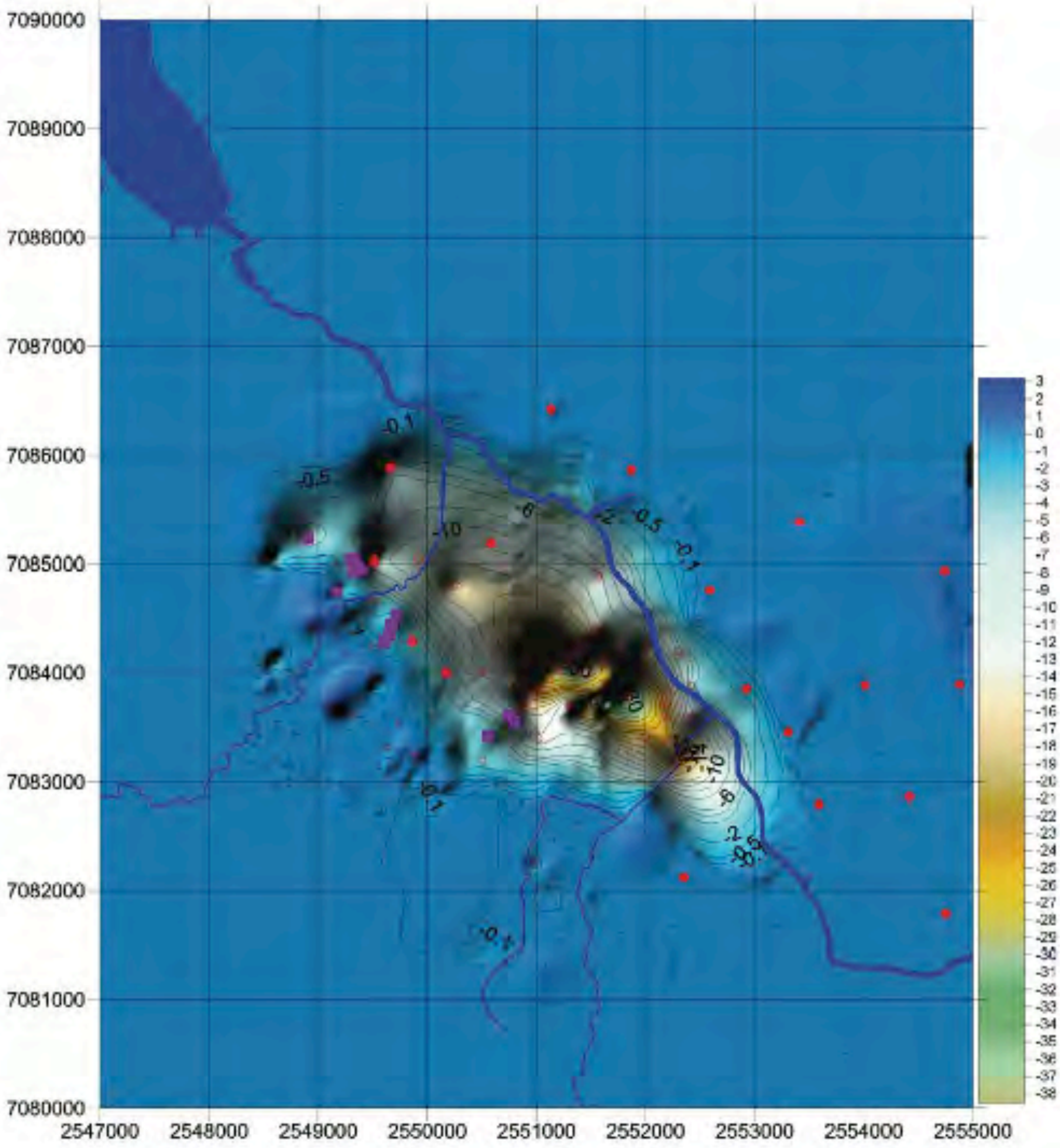
Kuva 14. Pohjaveden korkeussuhteet tulevan kaivoksen läheisyydessä vuonna 1969.

Management of mine waters

- This is a crucial question in all mine-related environmental issues, starting from baseline- and EIA-studies to managemant of a mine and to it's final closure operations

<- Groundwater level in 1969, before mining operations commenced

P. Vainionpää, 2007 (Hitura EIA -document)



Kuivanapitopumppauksen aiheuttama pohjaveden alentuma vuosina 1969-1985.
(musta risti = talousvesikaivo, violetti neliö =kuivunut kaivo , punaiset ympyrät = pohvedentarkkailuputkia

The cone of depression

-When the mine was opened, about 10 000 m^3 of water was drained daily, the pumped volume later stabilized to about 4100 m^3/d.

- Groundwater table was lowered within an area of ca. 10 km^2

P. Vainionpää, 2007
(Hitura EIA -document)

Groundwater flow model around the tailings area, indicating pathways and recharge rates of groundwater

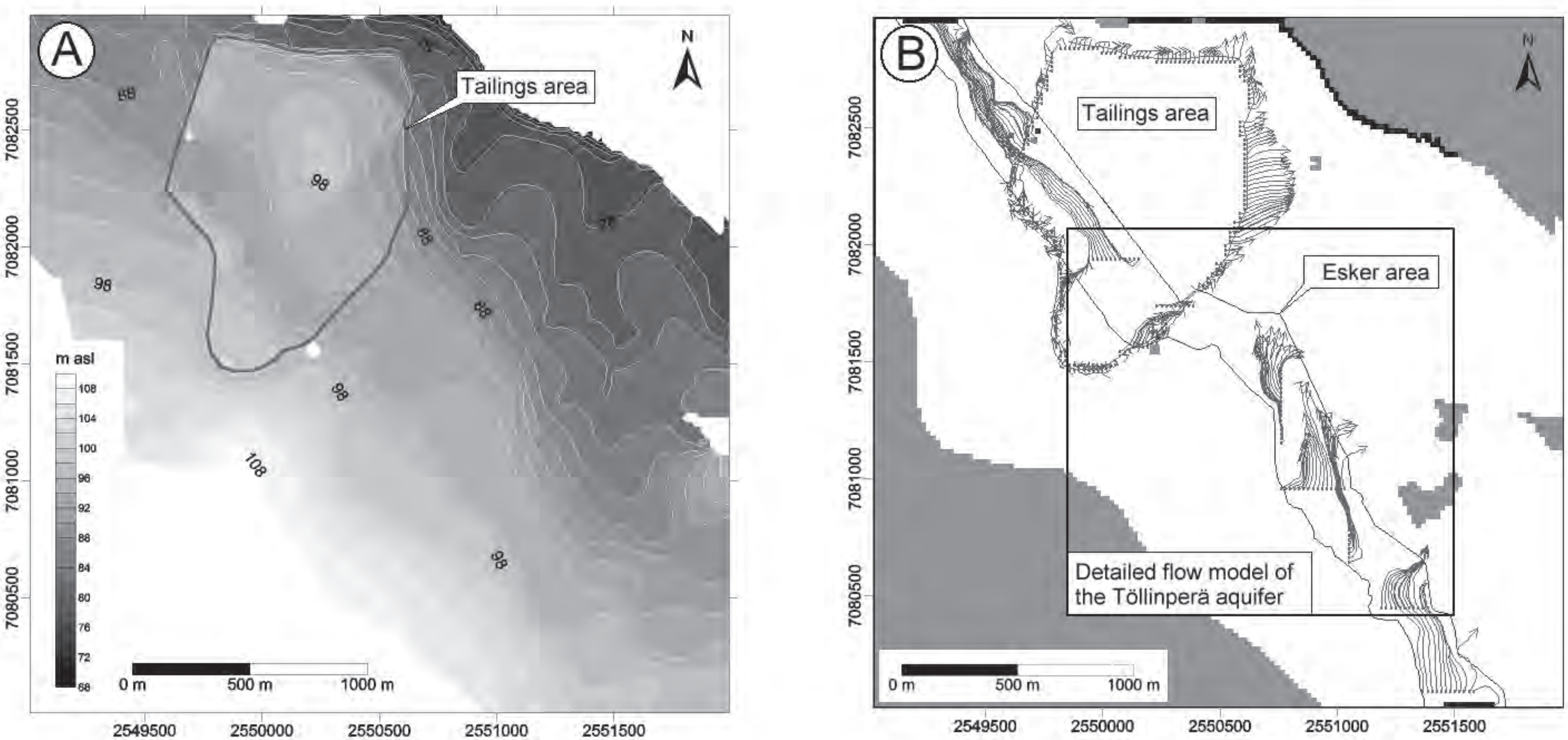
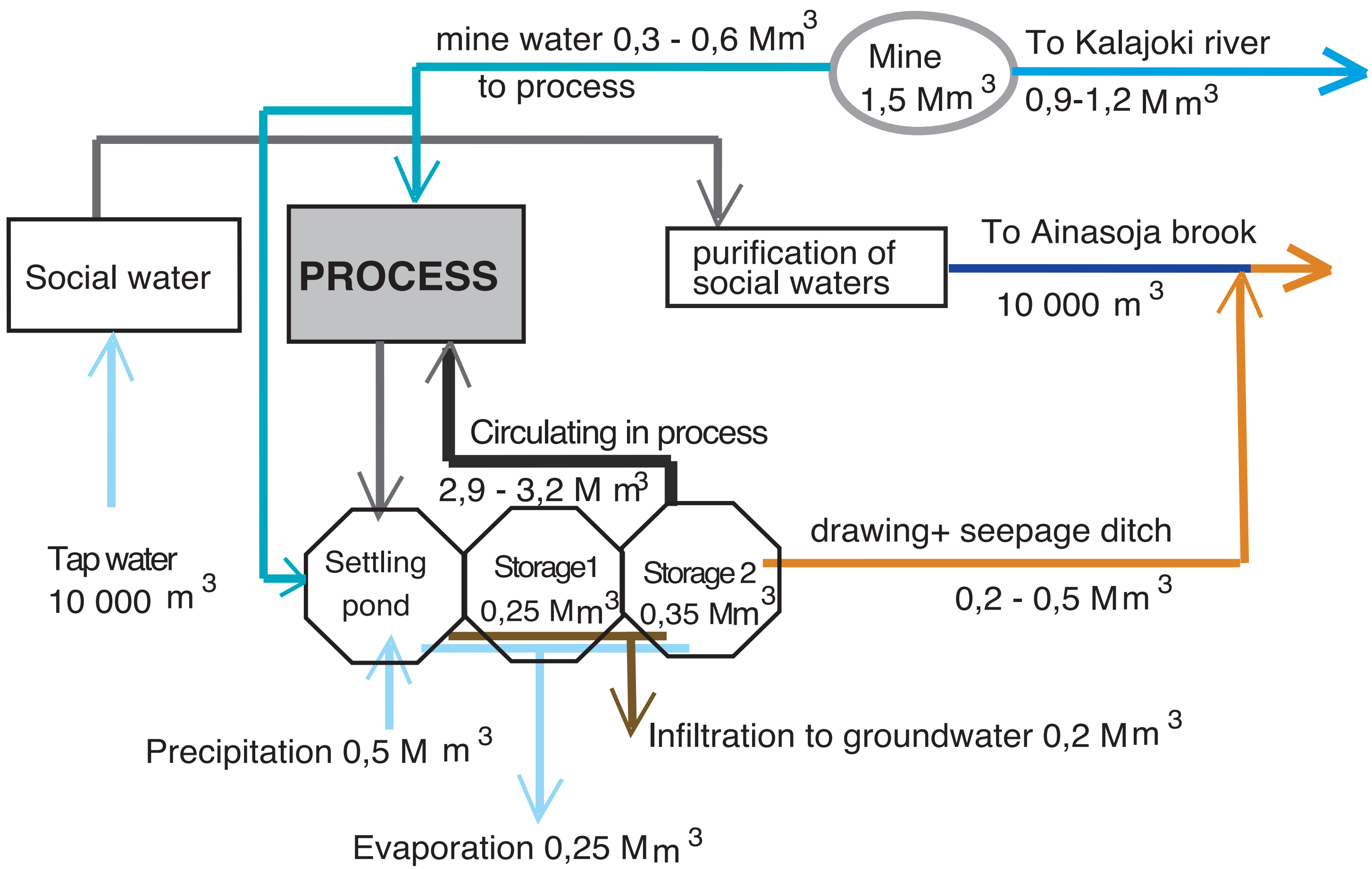


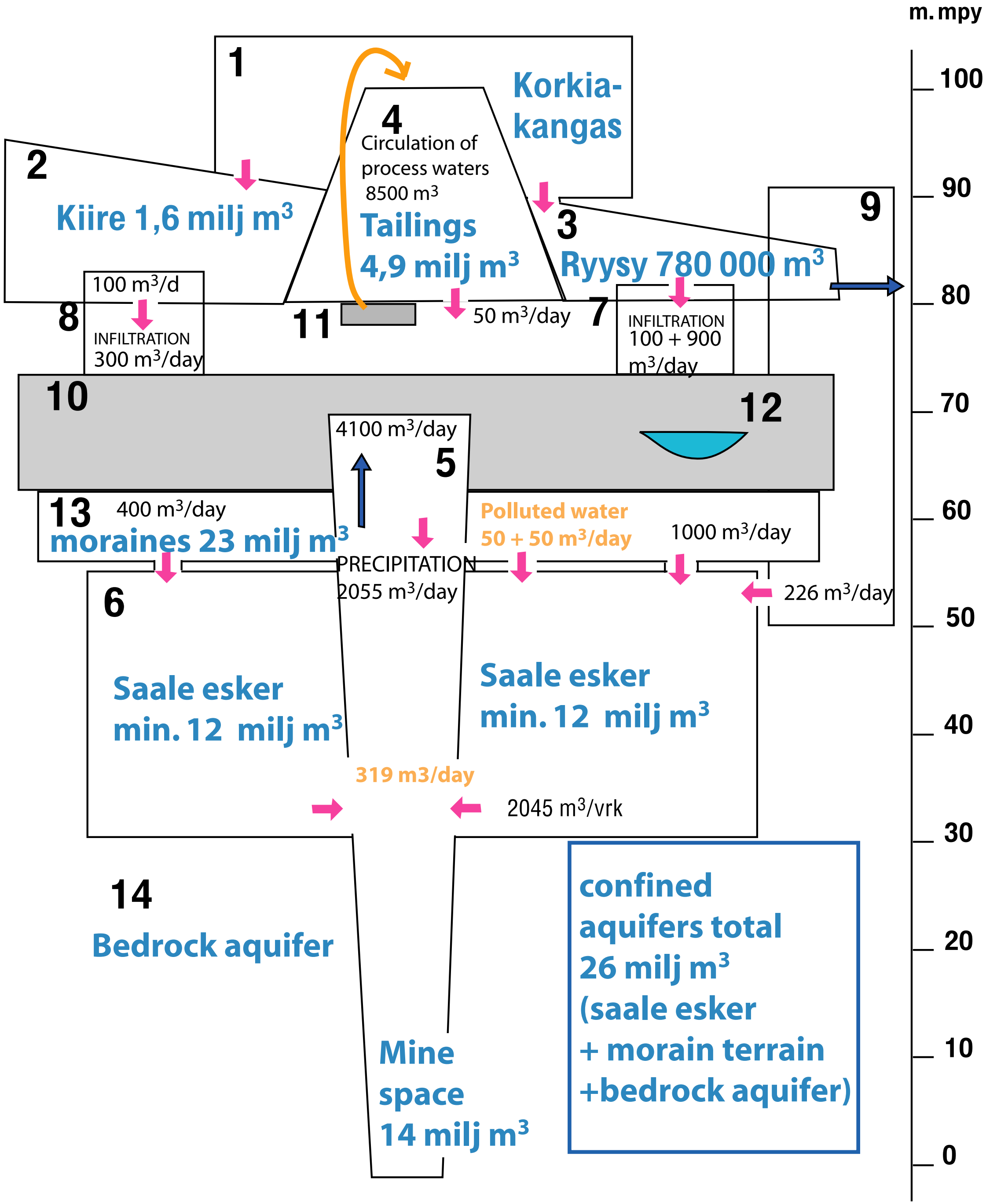
Figure 5. (a) Model calculated hydraulic heads in meters above sea level (asl). (b) Groundwater flow paths from the selected nodes of the model. Presented flow paths indicate the flow during 5 years period.

Heikkinen et al. 2001

Annual water budget of Hitura mine



- When you put this into the geological context, it is possible to manage the entire system

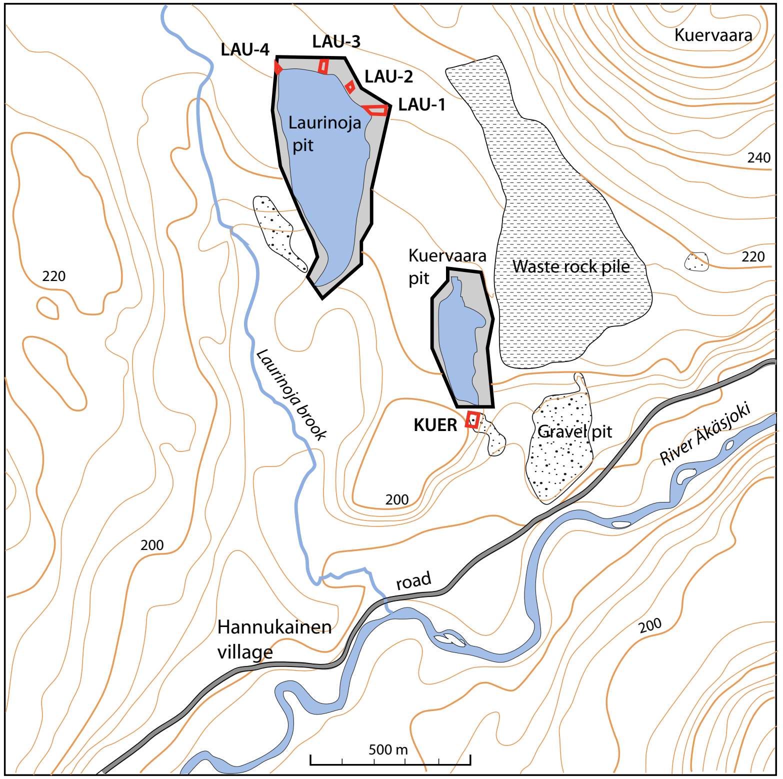


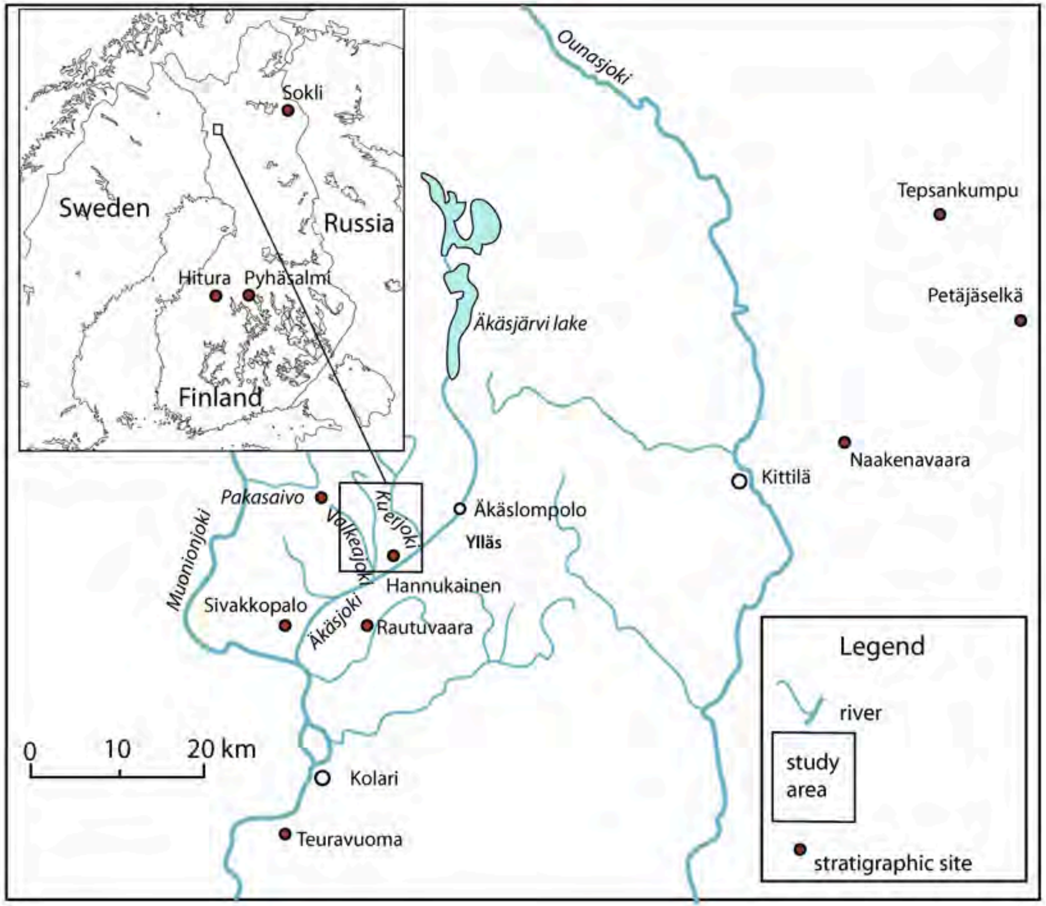
Calculations

- It will take 27 years for open mine and underground space to be filled by water after the mine closure
- The volume of polluted water will be 1,2 milj m³.
- This is only 3 % of all the water filling the mine shafts, pits and galleries
- After that there will be an overflow (and minor groundwater flow) to Kalajoki river
- The overflow will contain 200-300 mg/l SO^4

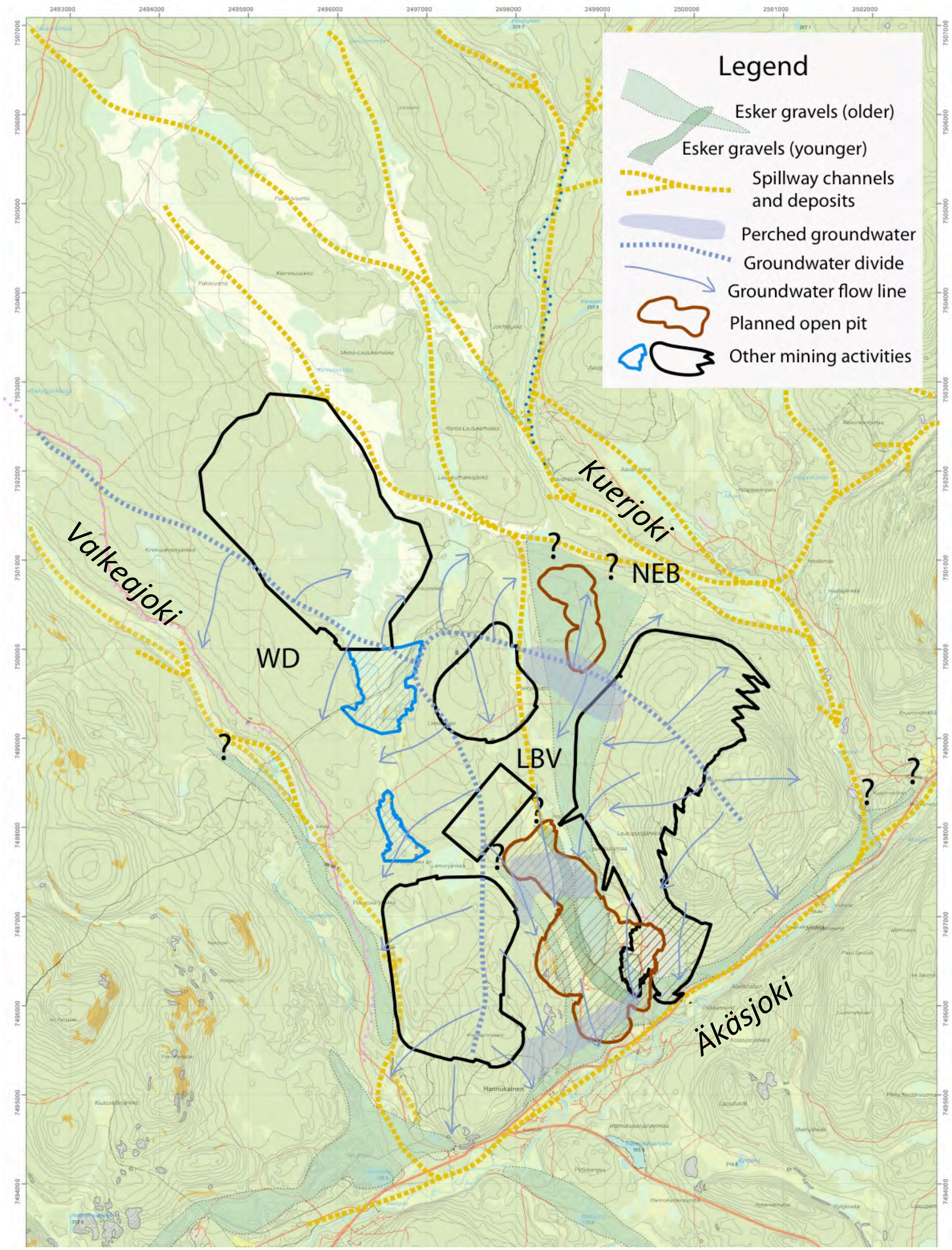
The 2nd example: Hannukainen

Cooperation with Northland mines Oy (Jukka Jokela, Joanna Kuntonen- van't Riet)





The Laurinoja pit, northern wall



Synthesis map

- The area of planned mine pits has in general 10- 30 m of sediment thickness
- Fluvial sediments date back to Mid-Weichselian interstadial and to late Holocene spillway systems
- Sediments are well drained and have a good or moderate permeability
- Open pit mines are associated with large subtill aquifers
- Groundwater system can be divided into three basins, which have direct connection to rivers of today: Äkäsjoki, Kuerjoki and Valkeajoki
- This information is valuable when siting the planned mine facilities

Conclusions

- Environmentally balanced and accepted mining requires high quality understanding of:
  - Sedimentological history of the area
  - 3D models of bedrock DEM and sediment thickness
  - Hydrostratigraphical concept
  - Water balance model

- At the moment there is often an unbalance between the knowledge of ore geology and environmental geology