Geological 3D modeling at Geological Survey of Finland

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At the Geological Survey of Finland (GTK), geological 3D modeling is done at different scales depending on the final application. In future, it will be important to be able to build and present combined 3D models of the Precambrian crystalline bedrock overlaid by the Quaternary deposits in many engineering and environmental geological investigations. 2D data, such as geological observations and geological maps, and 3D data, such as drill hole data, geological sections and elevation models, are already available and stored directly in digital format. At GTK, researchers make queries and extract these data using ArcMap (ESRI product) for their target areas. 3D geological models can be saved using the software specific projects and associated with the short description including the used software, dimensions, coordinates, authors, data and possible references. It will be possible to query 3D models using the geological map showing the 3D model locations and links to the 3D model storage. The 3D models will be also saved as 3DPDF files or Paraview or Geovisionary projects.

In Finland computerized 3D ore modeling has been done since 1980. Figure 1 shows the areas for three recent regional bedrock 3D modeling areas. The 3D modelling results of the central Lapland have been recently published by Niiranen et al. (2014). This modelling work is still in progress. Vihanti-Pyhäsalmi mining area was modeled in the ProMine project 2009 - 2013 (http://promine.gtk.fi/). 3D modelling of the Outokumpu mining area began in the project concentrating in 3D modelling methods (Laine (ed.) 2012). 3D modelling continued in the project Developing numerical 3D modelling methods at GTK and resulted a 3D model of the Outokumpu association hosting the Cu, Ni and Co deposits (Saalmann and Laine, 2014). The 3D modelling of the Outokumpu mining district is also a work in progress (e.g. Aatos et al. 2014). Figure 1 shows the location of the Olkiluoto nuclear waste site under construction. GTK is involved in building the 3D geological model of the bedrock surrounding the future Olkiluoto nuclear waste site (e.g. Aaltonen et al. 2010).

3D models of surficial, Quaternary deposits, are often used for urban geological applications, geometries for groundwater flow modeling or in environmental studies. 3D modeling of Quaternary deposits differs from the one of the Precambrian formations with the fact that, in most cases, it is possible to define a soil layer stratigraphy as nearly horizontal layers younging upwards. However, this is not always the case, for example, along the moraine ridges soil structures are very complicated. 3D models for several practical applications require the combination of bedrock models with surficial formations. Figure 2 shows Patamäki 3D model as an example of the 3D model of the Quaternary deposits (Okkonen et al. 2011).

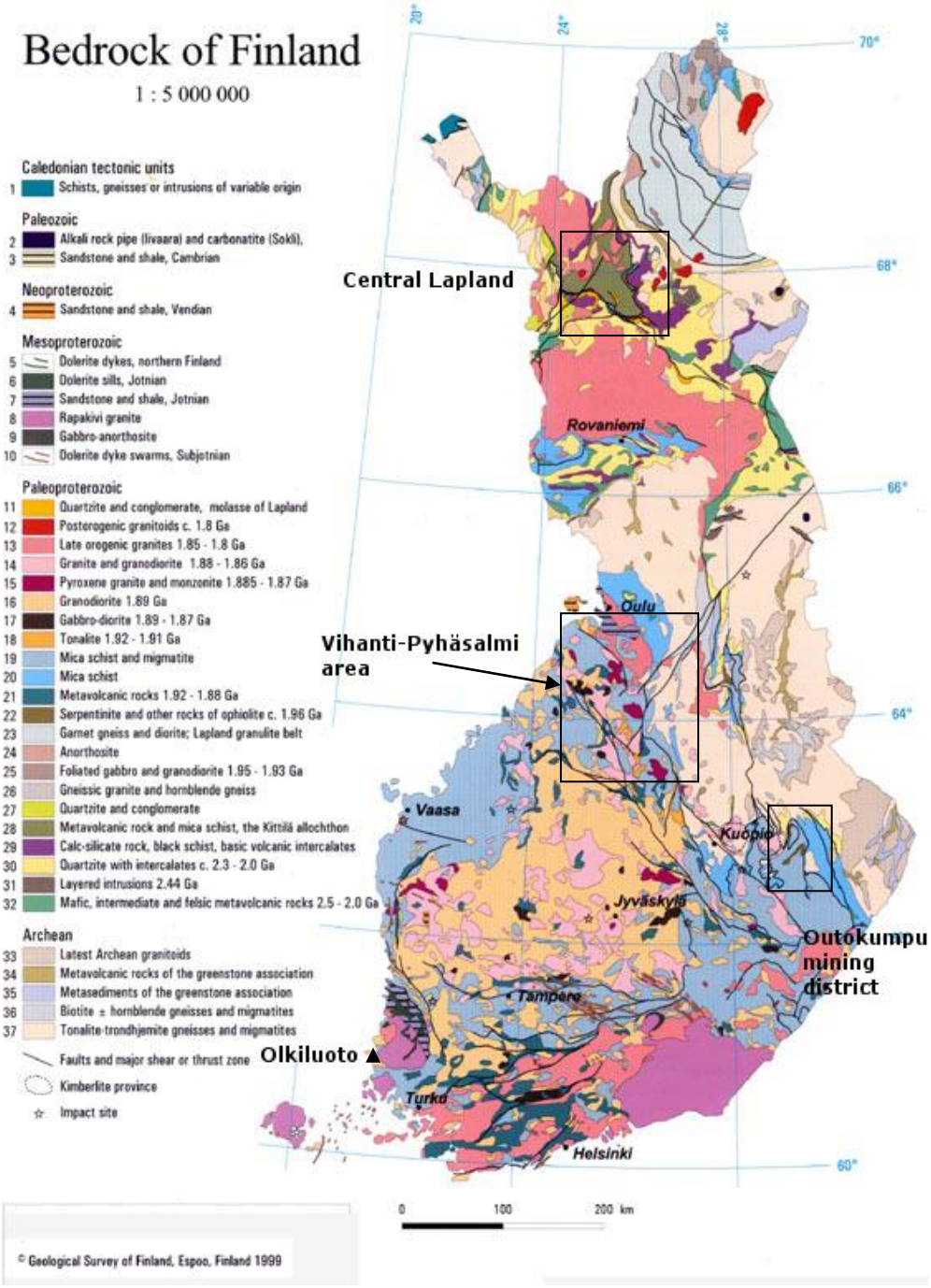

Figure 1. Locations for regional 3D bedrock modeling targets.

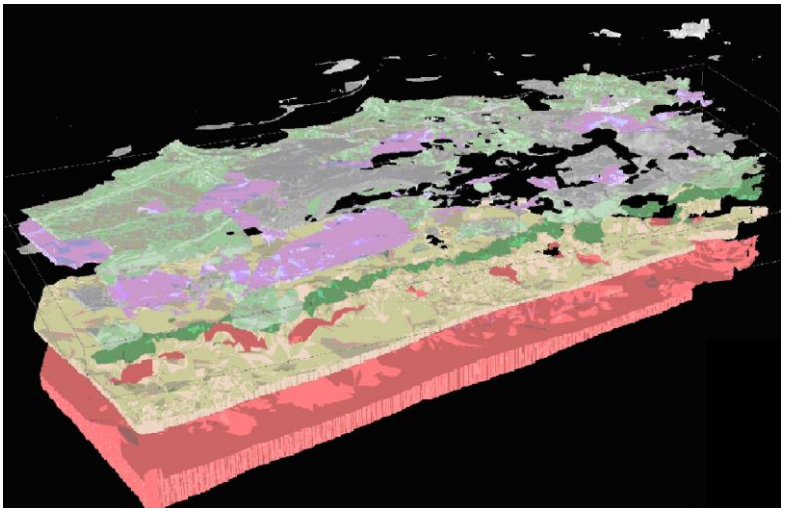

Figure 2. The Patamäki 3D geological model of Patamäki groundwater area (red = bedrock, light brown = moraine, dark green = gravel, lila = silt, light green = sand, darker light green = fine sand) (Okkonen et al., 2011)

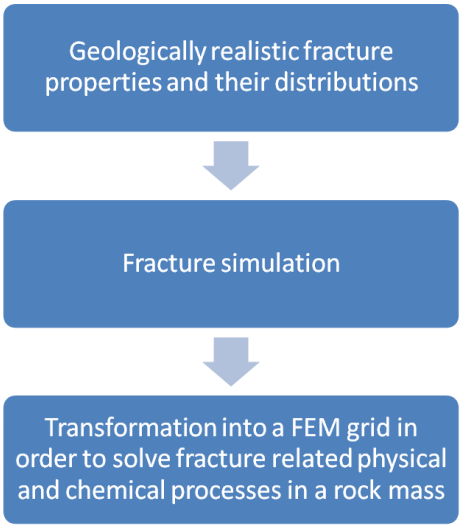

Figure 3. The use of geologically realistic fracture patterns in fracture simulation, in groundwater modelling and in estimating heat transfer in a rock mass.

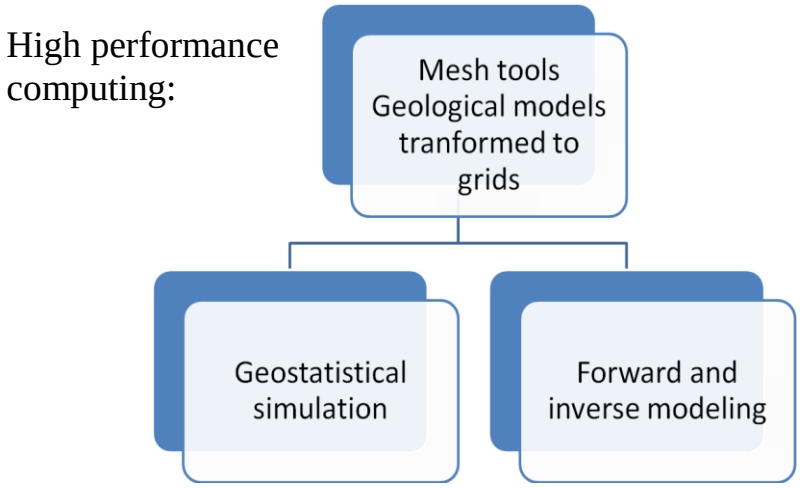

Figure 4. Development of tools in order to use high performance computing in 3D modeling.

Based on various GTK 3D models it was reasonable to begin with storing 3D models directly using specific 3D formats of the used 3D modeling software. In the future:

1) A more general 3D database could be built beginning from the regional 3D modeling targets. The main problem lies in that geological interpretations change in time with new data and theories. It is not easy to update complicated models.
2) In addition to the geometrical geological 3D models, CEM (Common Earth Model; e.g. Martin et al. 2007) grids will be used to present 3D distribution of physical and chemical properties together with lithology, fracture properties or soil type. These will be important, for example, in computation of groundwater flow, ore resource estimates and thermal capacity of the soil and/or bedrock. The important development work is done within fracture simulation of the crystalline bedrock in order to estimate the rock properties related to fracturing (Fig. 3). Building of 3D grids, detail enough, prerequisites high performance computing and tools for building and analyzing these huge 3D grids (Fig. 4).
3) It will be also necessary to include geological information into the BIM models (Building Information Modeling, which is a model-based process for planning, designing, constructing, and managing buildings and infrastructure).

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