Feasibility Study of the Einstein Telescope - Geological exploration

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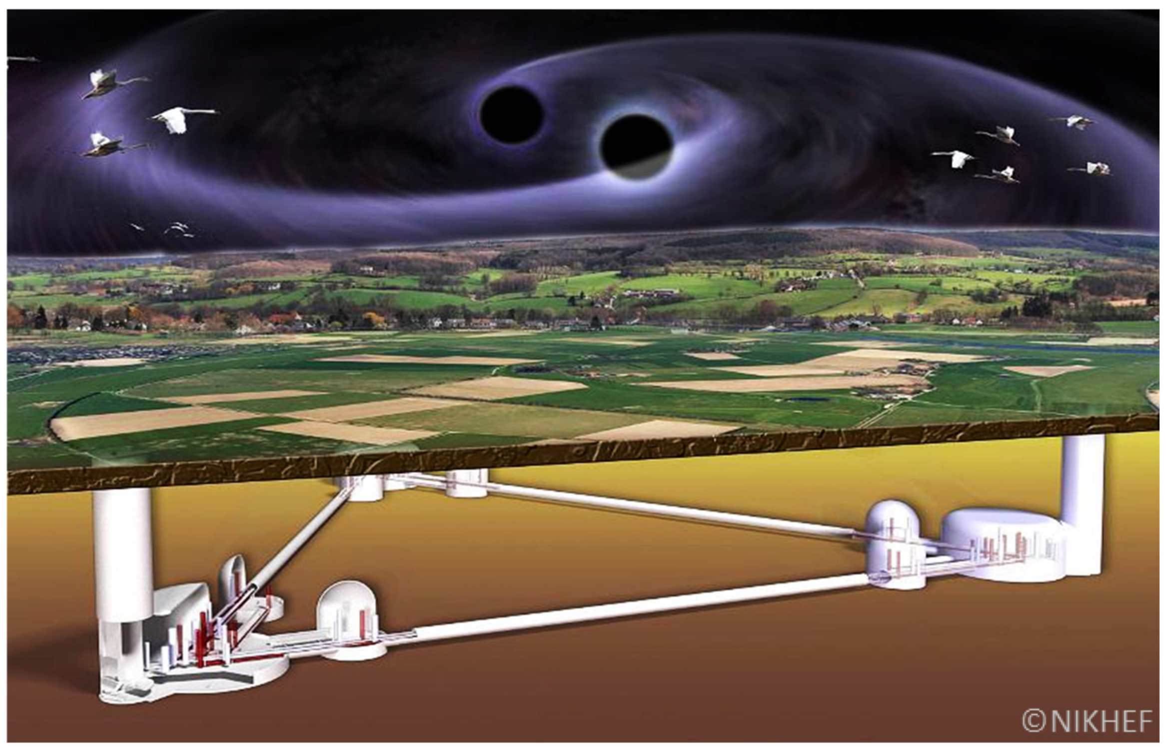
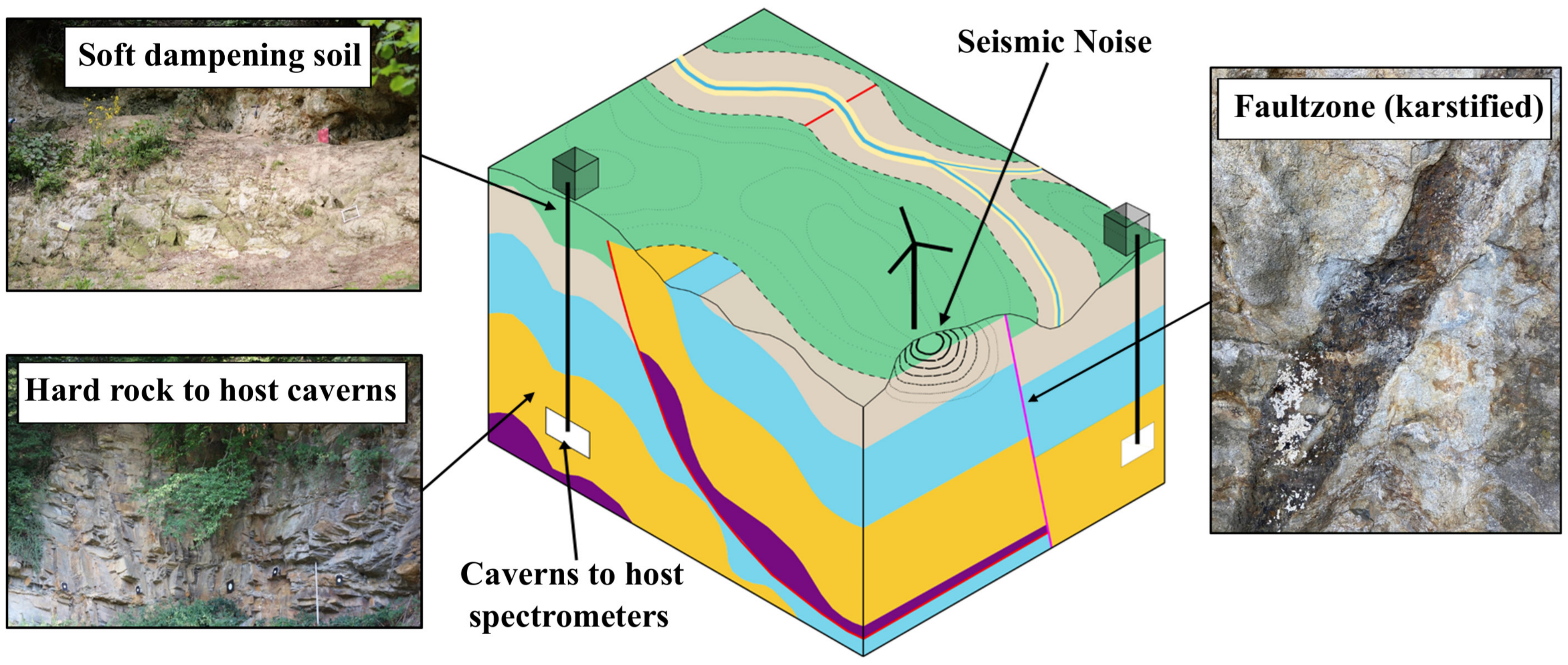
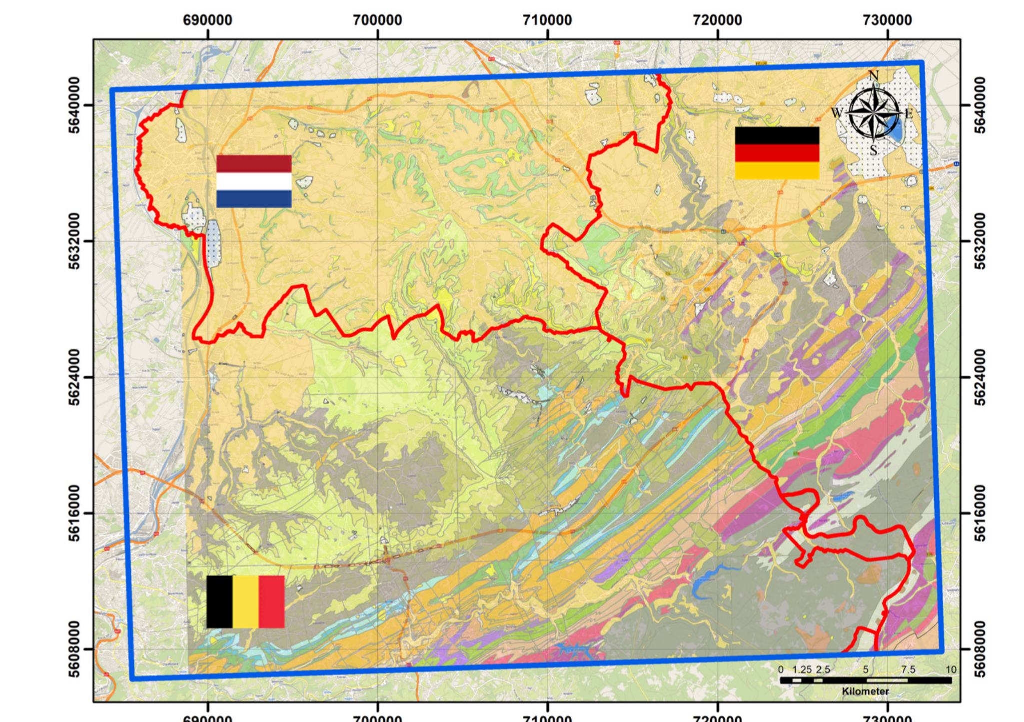
The Einstein Telescope (ET) is an advanced, third generation gravitational wave observatory, currently in the planning stage in Europe. The ET project involves the construction of a triangular shape underground facility with 10 kilometres long arms. At the corner points of the three arms, large caverns host the infrastructure needed for the spectrometers. The border region between the Netherlands, Belgium and Germany is considered a potential location and will be further investigated in a feasibility study funded by the European Union, the Dutch Ministry of Economic Affairs, the Land of North Rhine-Westphalia, the Province of Flemish Brabant, the Province of Belgian Limburg, the Province of Dutch Limburg, Flanders and Wallonia.
Stable underground conditions with minimal ambient noise are essential for the interferometers to be hosted in the ET corner points. A detailed geological, structural, hydrogeological and geotechnical model is required to ensure the desired performance of the underground infrastructures. The current multi-disciplinary feasibility study allows to collect the required data to (1) optimise the location and orientation of the ET triangle and corner points, (2) plan the construction of subsurface caverns and tunnels, (3) model the tunnelling operation in terms of methodology, machinery and time frame, (4) construct a sophisticated, three-dimensional, cross-border geological model of the study area, (5) evaluate the geological risks of the border region between Germany, the Netherlands and Belgium and (6) establish new surveillance methods. The data presented here are based on studies of geological maps, on measurements already carried out and on various political boundary conditions. In addition, further planned work is described and presented.

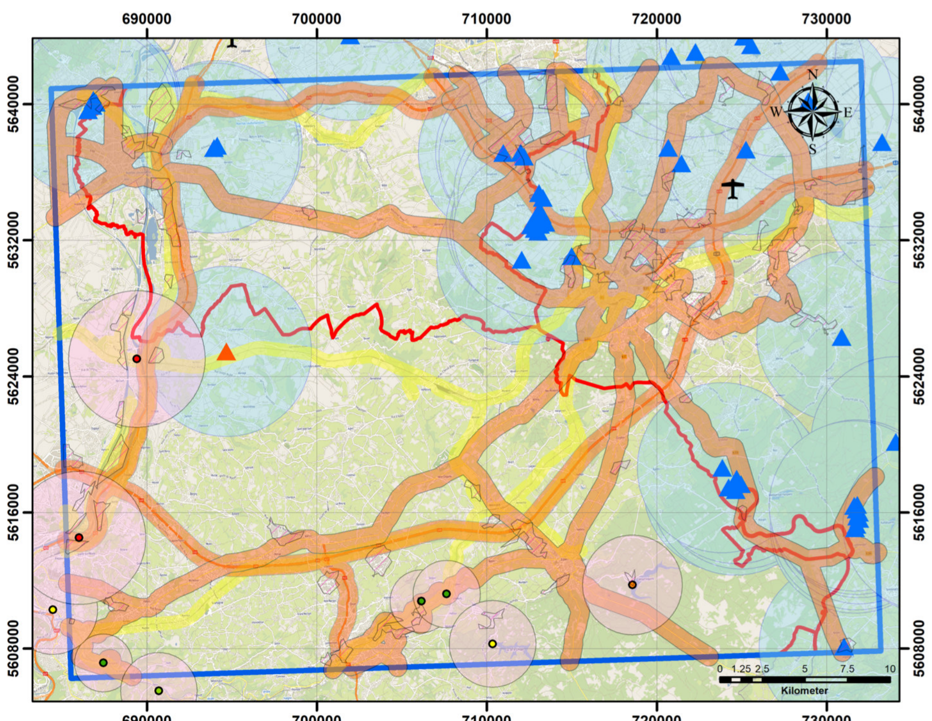


The expected sequence of geological layers in the Rhine-Meuse region is well suited for the construction of a gravitational wave detector, as disturbing influences are attenuated by a layer of loose chalk sediments at the surface. At the same time, a stable bedrock offers good conditions for the construction of the caverns in the corner points. Part of the feasibility study is therefore to create a high-resolution 3D model of the bedrock to ensure optimal positioning of the caverns.





The map shows the cross-border geological map based on the records of the different geological services (Geologischer Dienst NRW, Service géologique de Wallonie, Rijks Geologischen Dienst, Databank Ondergrond Vlaanderen). An effort has been made to homogenize the surface geology between the three countries.

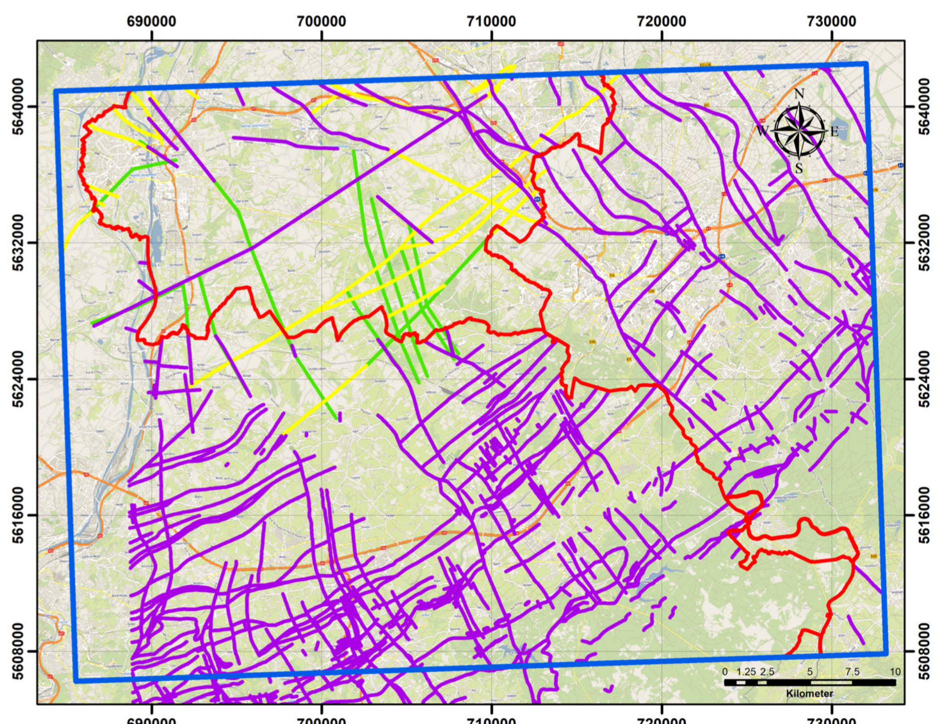


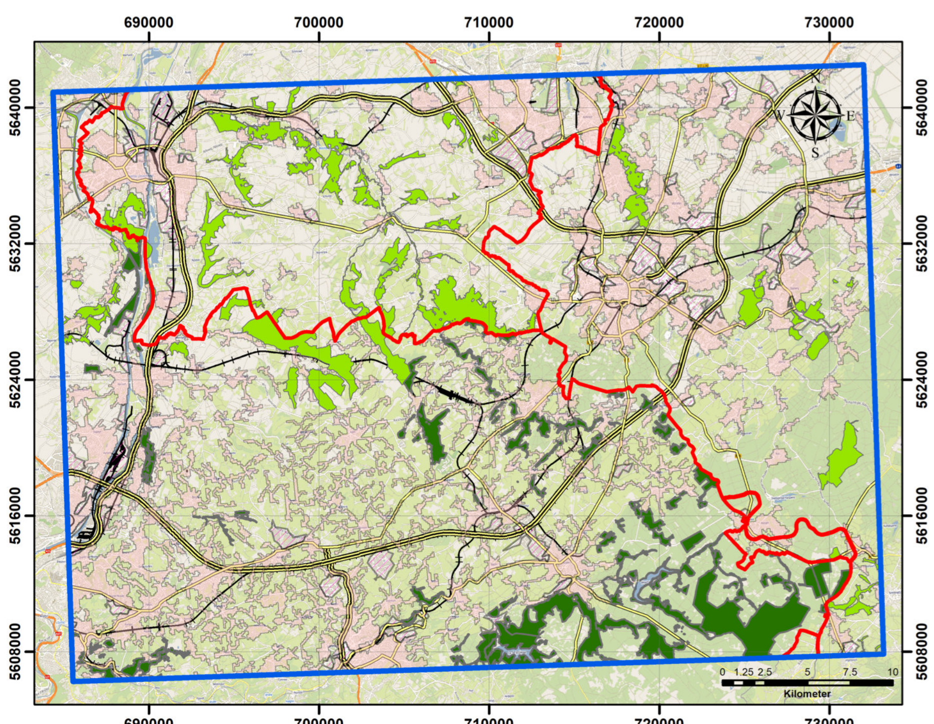
Seismic noise

The seismic noise plays a significant role in the performance of the Einstein Telescope. The map on the left hand side shows the primary source of seismic noise within the ET study area. The sources include the windmill parks, major roads, railways and hydropower turbines. As an initial step, a critical distance or "no-built zone" is estimated for each of these sources, allowing to optimize the suitable location of the ET triangle for further in-situ exploration.

Surface Fault-Traces

The map on the right shows the known fault zones in the ET study area. The fault zones are an important boundary condition for the positioning of the corner points of the Einstein Telescope. Due to their considerable influence on the underground infrastructure, especially on the cavern structures, they are a significant cost driver and must therefore be known as far as possible in terms of type and location.





Landuse in the ET region

The map outlines the landuse within the ET study area, including major roads, railways, residential and industrial areas as well as Natura 2000 nature protection areas.

Boreholes >20 m deep

The map on the right shows the existing boreholes within the ET study area as well as 6 planned deep boreholes (+ 250 m, shown in stars) to be drilled within the project. The borehole analyses provide vital information on the hydro-mechanical characteristics of rocks that may be encountered during construction of ET underground infrastructures. One of these boreholes has already been drilled and is in operation as the permanent Seismic measuring station Terziet (red star).