# 3D-NORGE: A NEW PROJECT TO BUILD A 3D BEDROCK MAP OF NORWAY

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## 1. INTRODUCTION

Several reasons exist for making a 3D bedrock model of onshore Norway.

- From a mineral resource viewpoint, the state of surface mapping of resources has perhaps reached a stage where the discovery of new deposits is increasingly more unlikely without utilising a 3rd dimension.
- In the last 5 years there has been a marked increase in the interest and investment in mineral resources, both from government funding to the NGU and from the minerals industry.
- We don't have one.

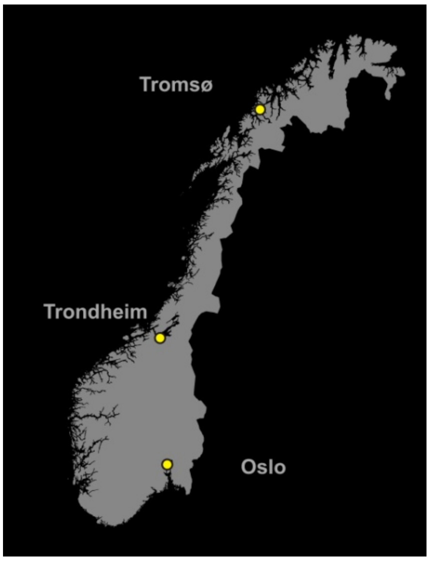



**Figure 1: 2D Map of Norway showing the locations of Oslo, Trondheim (where the main office for NGU is located) and Tromsø in the far north.**

It was therefore decided to initiate a 4 year project at the Geological Survey to create a fully 3D bedrock model covering the whole of Norway. This project was officially started on the 1st March 2014 and is still in the early development stages. In this abstract we will demonstrate what we have already started with, what we plan to do and how we plan to do it.

## 2. THE TOOLS WE WILL USE

### 2.1 Software Package

One of the main starting point for making a model of the bedrock geology onshore is that the geology is very complex. We therefore need a modelling package that is able to faithfully portray the complex structures in 3 dimensions. Several different software packages, both pre-existing at NGU and new software were examined. in the end ***3D MOVE*** was chosen for its user friendliness and ability to model complex structures. The software was bought at the start of the project and time has been allocated to learning how to use the software.

### 2.2 Digital elevation model

We use a 10m x 10m DEM created by Kartverket, the national mapping authority in Norway. This is in .jpg format. We have divided the file up into three su-domains covering the whole of Norway. Figure 2 shows the southernmost sub domain.

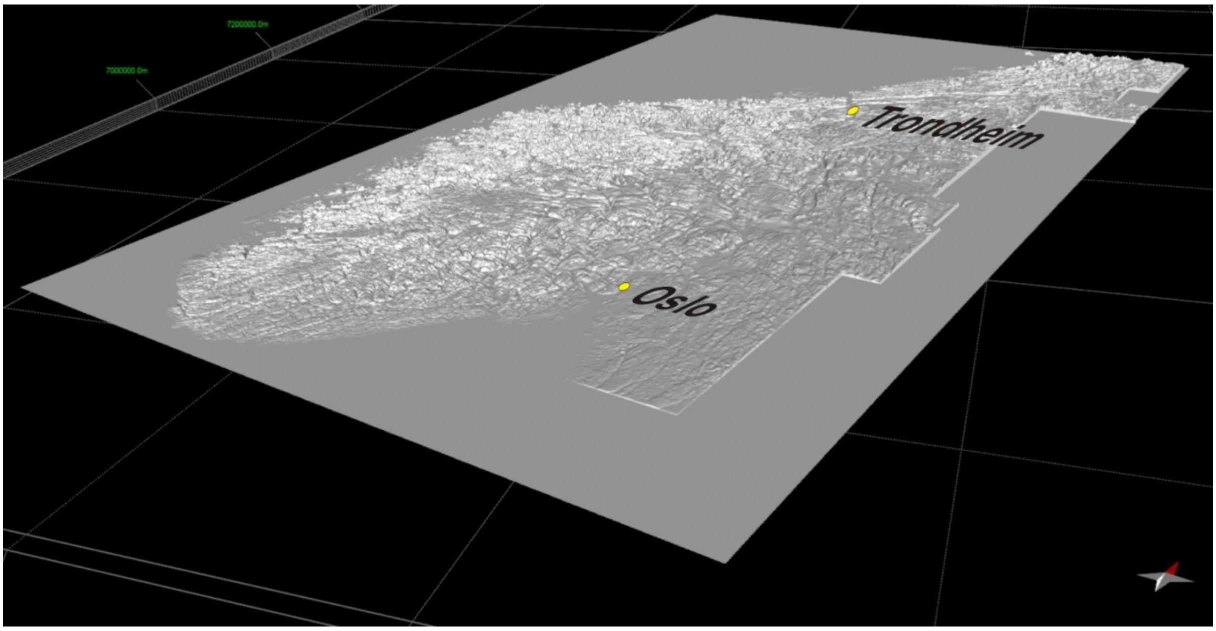



**Figure 2: Map of southern Norway showing the partial DEM from southern Norway to just north of Trondheim.**

### 2.3 Surface bedrock mapping

The nature of the bedrock mapping used is critical in the development of a 3D model. In the length of this 3D project it was decided that 1:250k national coverage was too detailed to allow a quick production of a nationwide 3D model (Figure 3). The existing 1:1M was also considered too detailed, whereas the existing 1:3M is not detailed enough. Therefore, the natural scale for the foundation for the 3D model is 1:2M.

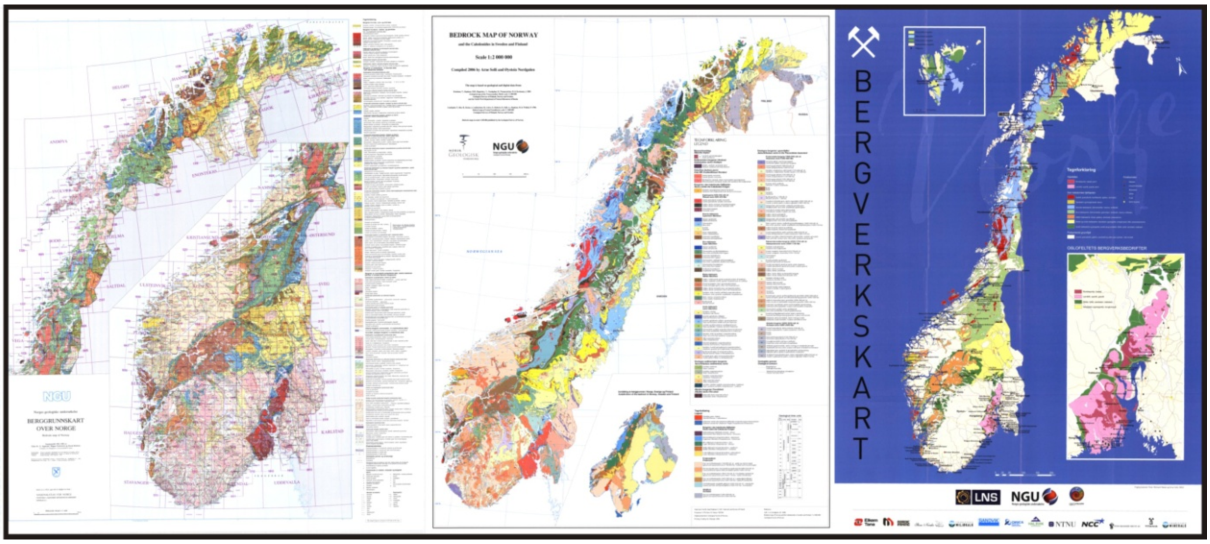



**Figure 3: The choice of which surface bedrock map to use is decisive for the project. The picture on the left is the existing 1:250K, which is far too detailed. The middle picture is a 1:2M bedrock map, which is simplified further in the picture on the right to create something manageable for the 3D model within the time constraints.**

The bedrock map above was then used to create a simplified tectonostratigraphy, as shown in Figure 4, which would form the basic units for the creation of 3D shapefiles and mesh surfaces in 3DMOVE.

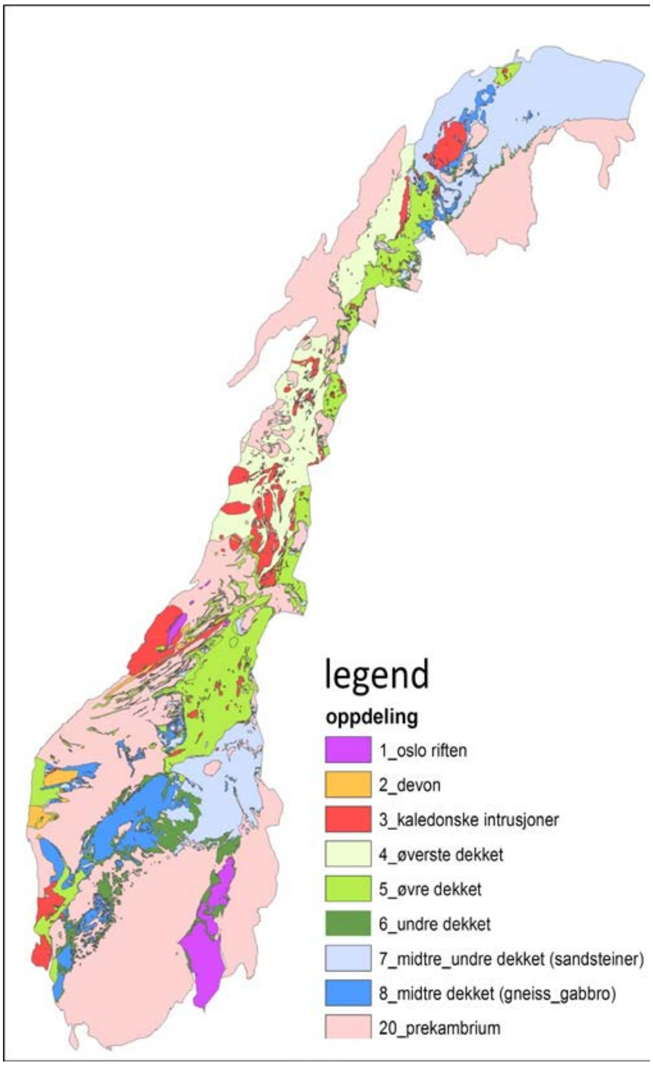



**Figure 4: Simplified 1:2M geological map showing the tectonic units that will be modelled in 3D.**

### 2.4 Geological Profiles

Geological profiles, both 50K and 250K, constructed for the inclusion in the associated map products, have been manually scanned as separate jpeg files. These have been georeferenced in 3D in 3DMOVE. At present, all 49 250K profiles are included within the 3D model and approximately 10% of the 549 50K profiles, so there is still a lot of work to do. There is a wide spectrum of quality of the profiles: the 250K profiles tend to be of high quality whereas many of the 50K profiles are poorly constructed and drawn (Figure 5). In addition, when plotted in 3D, it is noticeable, that some intersecting profiles mismatch in 3D (Figure 6).

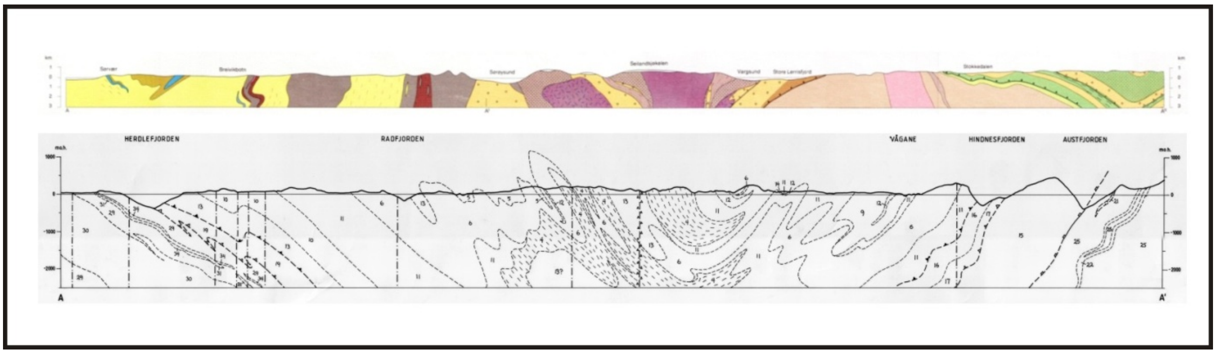


**Figure 5: Examples of 250K and 50K profiles showing the difference in quality. The digitised, coloured 250K profile is at the top and the undigitised, black and white 50K profile is a the bottom.**

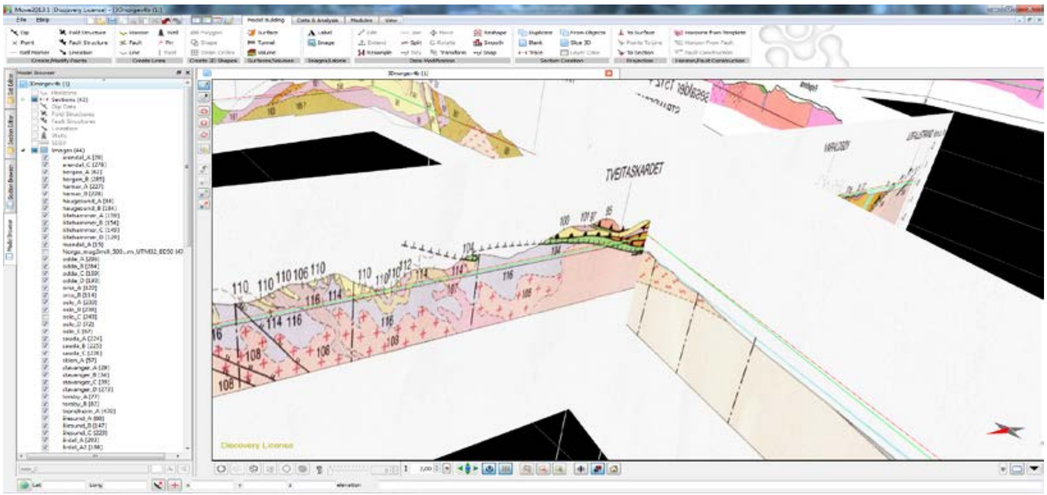


**Figure 6: Screen dump from 3DMOVE showing two intersecting 250K profiles that mismatch.**

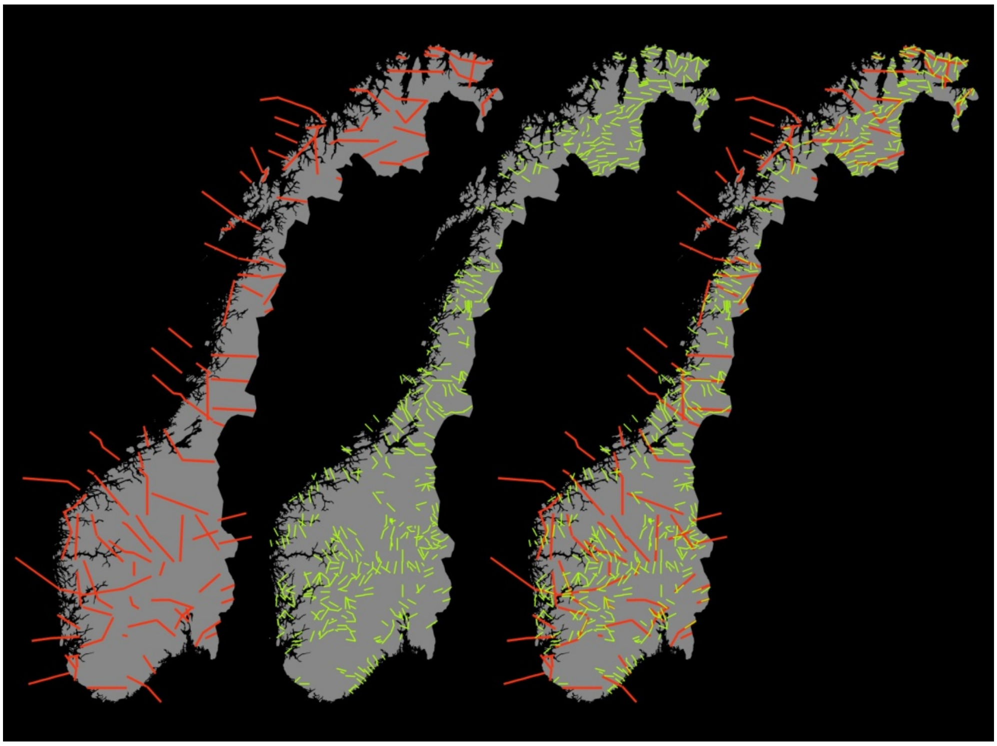


**Figure 7: Map of Norway showing the existing 1:250K geological profiles (left in red), the existing 1:50K geological profiles (middle in green) and the combined profiles on the right**

### 2.5 Nationwide dip and strike data

The Geological Survey has very recently finished compiling a database containing all dip and strike data in Norway. The database contains over 26000 points consisting of bedding, foliation, lineation, axial planes, fold axes and much more. This data can be filtered

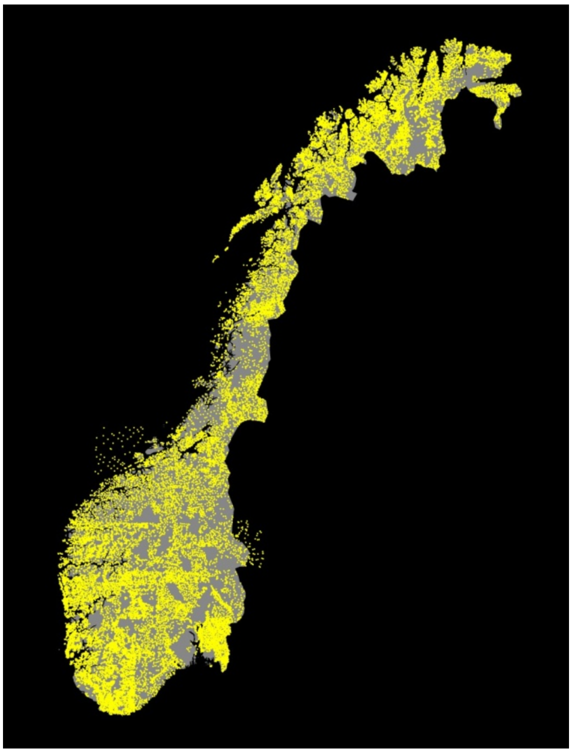


**Figure 8: Map of Norway showing the compiled dip and strike data. There are 26000 points in total with a wide array of different measurement types.**

### 2.6 Seismic profiles

Although most below surface data will be extracted from existing geological profiles, we will use existing shield scale seismic profiles. These are not yet compiled and included into the model3DMOVE.

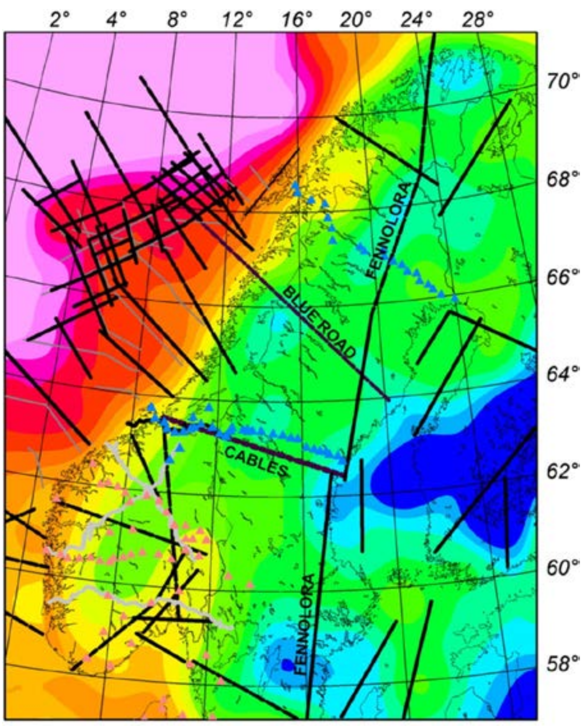



**Figure 9: Map of Fennoscandia showing the location of regional scale seismic profiles. These will be also incorporated into the 3D model.**

## 2.7 Selected Mineral deposits

This project is an initiative of the Mineral Resources Division at the Geological Survey of Norway. When the model has reached an advance stage, several key Norwegian mineral deposits will be integrated seamlessly into the 3D model. these deposits have been modelled in 3D previously in TARGET for ArcGis. It will then be possible to zoom from a national scale into these individual deposits, with their detailed geology, boreholes and ore volumes.

**Figure 10: Map of Norway showing the location of the selected mineral deposits that will be integrated into the nationwide 3D model.**

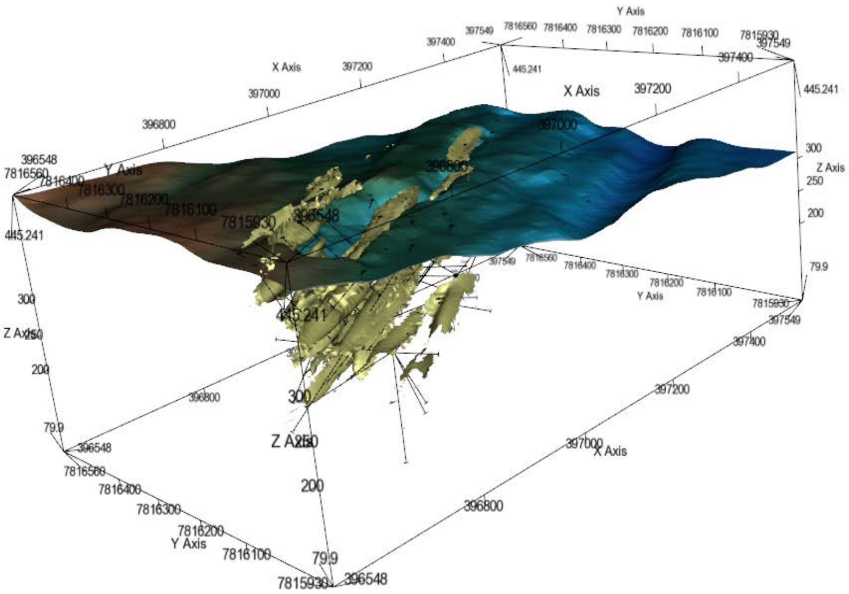



**Figure 11: Example of a 3D model from the Ulveryggen Cu deposit in northern Norway which has been modelled in detail in TARGET for ArcGis. This data, as well as nine other previously modelled deposits, will be transferred to the 3D-Norge model in 3DMOVE in the later stages of the project.**

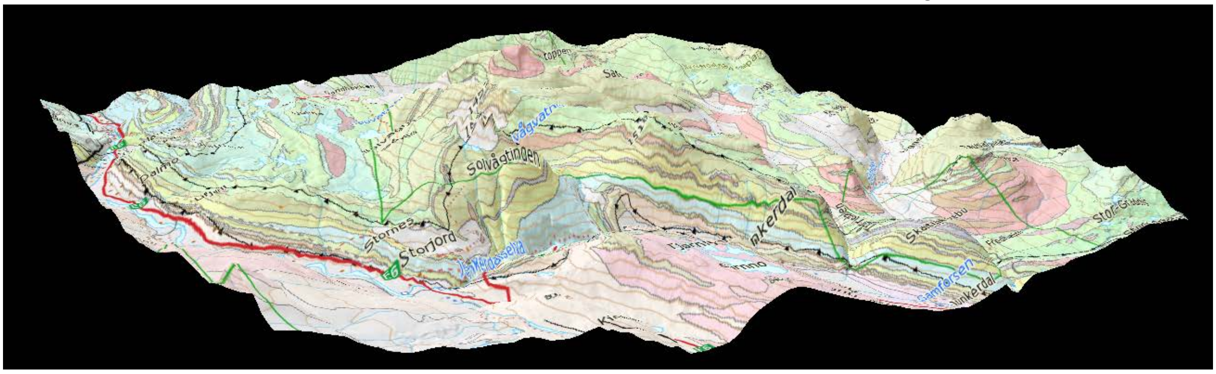
**3. DATABASE**

For the time being - the only database for the 3D-data is the DXF-files created by 3DMOVE. NGU will look into how to store 3D data for public viewing at a later stage. For the 3D online-maps, existing 2D databases exposed as Web Map Services are currently (and will continue ) being used - served using Open Source software such as PostgreSQL and PostGIS for the database and Mapserver for WMS (Web Map Service)

**4. WEB-BASED USER INTERFACE**

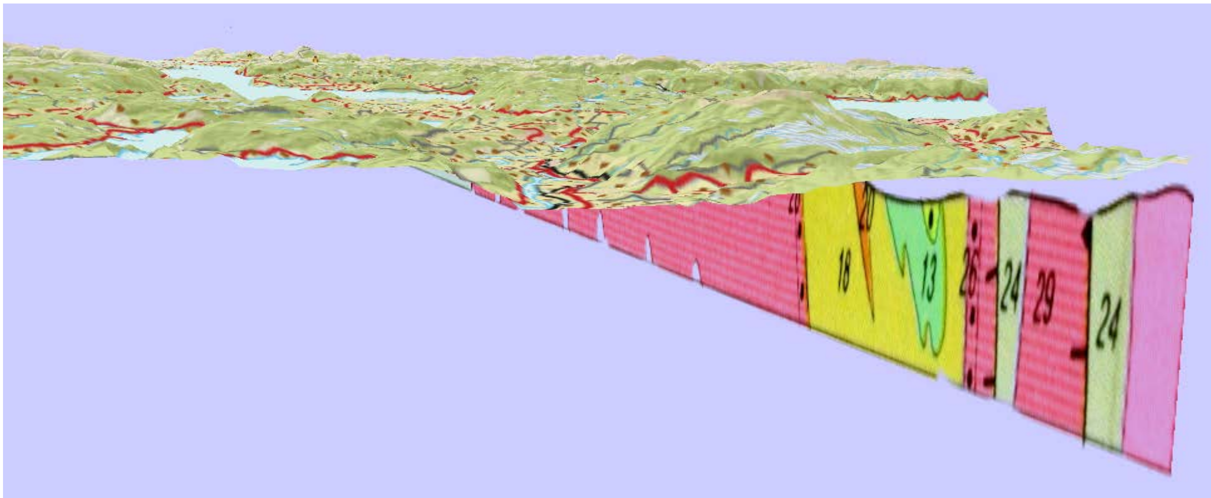
Earlier this year, a developer at the national mapping authority made some GIS-extension to a 3D javascript library named ThreeJS. This extension is called WXS.ThreeJS, is licensed as Open Source and can be found on GITHUB. One current limitation to this library to this day, is that it's limited to the UTM-zones used here in Norway. WXS.ThreeJS was also presented at the conference FOSS4G (Free and Open Source Software for GIS) in Portland, Oregon - September 2014. This client utilize the webgl-capabilities of the browser. It also works in most smartphones and tablets, but can be quite intense on the battery.

We desided to use this library to demonstrate possible use and early adoption. First step was to merge 4 different map layers (WMS) and push it onto an elevation model (Web Coverage Service, WCS). The WMS services combined data from NGU at Kartverket and the WCS is served by Kartverket as well. To be useful with ThreeJS, the WCS-service had to be extended to deliver data in XYZ-format in addition to existing formats.




[Bedrock 1:50.000 Junkerdalen)

Next we wanted to align vertical bedrock profiles in the same client. Here shown with a standard topographic map with vertical bedrock profile. The profiles are stored as transparent PNG-files and must be georeferenced in x, y and z.




Further demonstrations of use of this library will be to align multiple vertical profiles together with bedrock 2D maps. To see geological 2D-maps in 3D - integrated with NGU map portals is already developed and is currently in testing phase.

## 5. PROGRESS SO FAR

So far we have collected and compiled the basis data that we require to begin construction of the 3D model. This includes, 250k profiles (Figure 12), 50k profiles (Figure 13), 250k surface mapping, the simplified 1:2M tectonostratigraphic map and the dip and strike data. All of the basis data are entered except the 50K profiles. this is 20% finished. Once this is done then the job will start with making 3D shapefiles (line files) and subsequent 3D mesh surfaces.

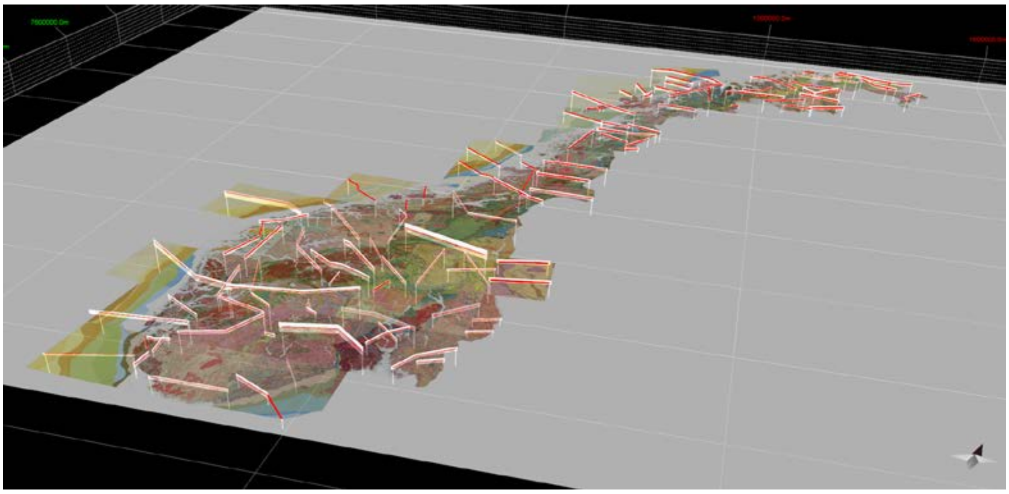


**Figure 12: Screen dump from 3DMOVE showing all of the 250K profiles georeferenced in 3D with the bedrock surface geology**

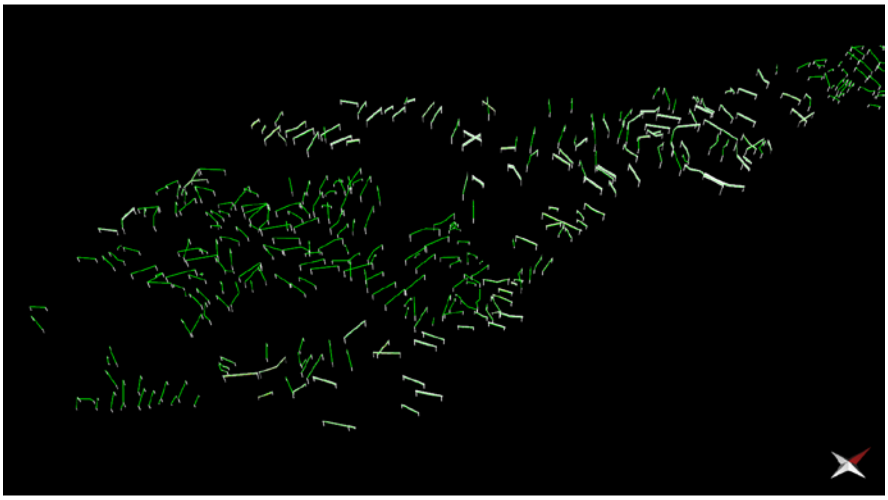


**Figure 13: Screen dump from 3DMOVE showing the georectified 3D profile traces for 50K profiles. Most of these are empty but some are filled with 'data' So far we have georectified and filled with data about 20% of the profiles.**

## 6. CONCLUSIONS

- 3D Norge is a new project at NGU which will, in the space of three years, create a full 3D model of the bedrock geology in Norway, with 3D line shapefiles and mesh surfaces
- We use existing surface bedrock geology maps, 1:250K profiles, 1:50k profiles, geophysics, seismic profiles and nationwide dip and strike data.
- At present, all of the basis data is inserted into the modelling program except the 50K profiles which are approximately 20% finished. When this is done, the work will start with creating 3D shapefiles and mesh surfaces from the basis data.

- A selection of mineral deposits which are already produced in the TARGET for ArcGis software package will be integrated into the nationwide model.

- The Geomatics division at the Geological Survey of Norway will facilitate the systemitisation and standardisation of the 3D data which will be inputted into the model and has begun to assess the possibilities for a web-based user interface.

- This project is seen as a method development project, to understand and develop the workflows and databases to allow the creation of the 3D model, organisation of the different data types and databases and a web-based interface.

- Towards the end of the project we will assess the connection to other areas of geology in Norway and at NGU, for example landslides and onshore-offshore and how this model can be extended to make more complex models for mineral deposits and specific places of interest in sub-areas.