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Improved Bouguer gravity anomaly mapping in the EMR Region

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1. Introduction

The Einstein Telescope (ET) is a proposed 3rd-generation gravitational-wave observatory focused on improving wave resolution in the low-frequency range (1-10 Hz). Due to anthropogenic noise and stability requirements, it is expected to be built at a depth of about 300 m. The Euregio Meuse-Rhine (EMR) is a potential site. As part of the E-TEST project, the University of Liège hired FREMEN GEO to conduct a gravity survey to understand local geology and estimate rock densities, critical for Newtonian Noise estimation for the interferometer.

2. Existing data

The most recent major work in the area is the Bouguer anomaly map by Everaerts and De Vos (2012) at the Belgian scale, based on previous campaigns with a density of about 1 point per km² (see Figure 1).

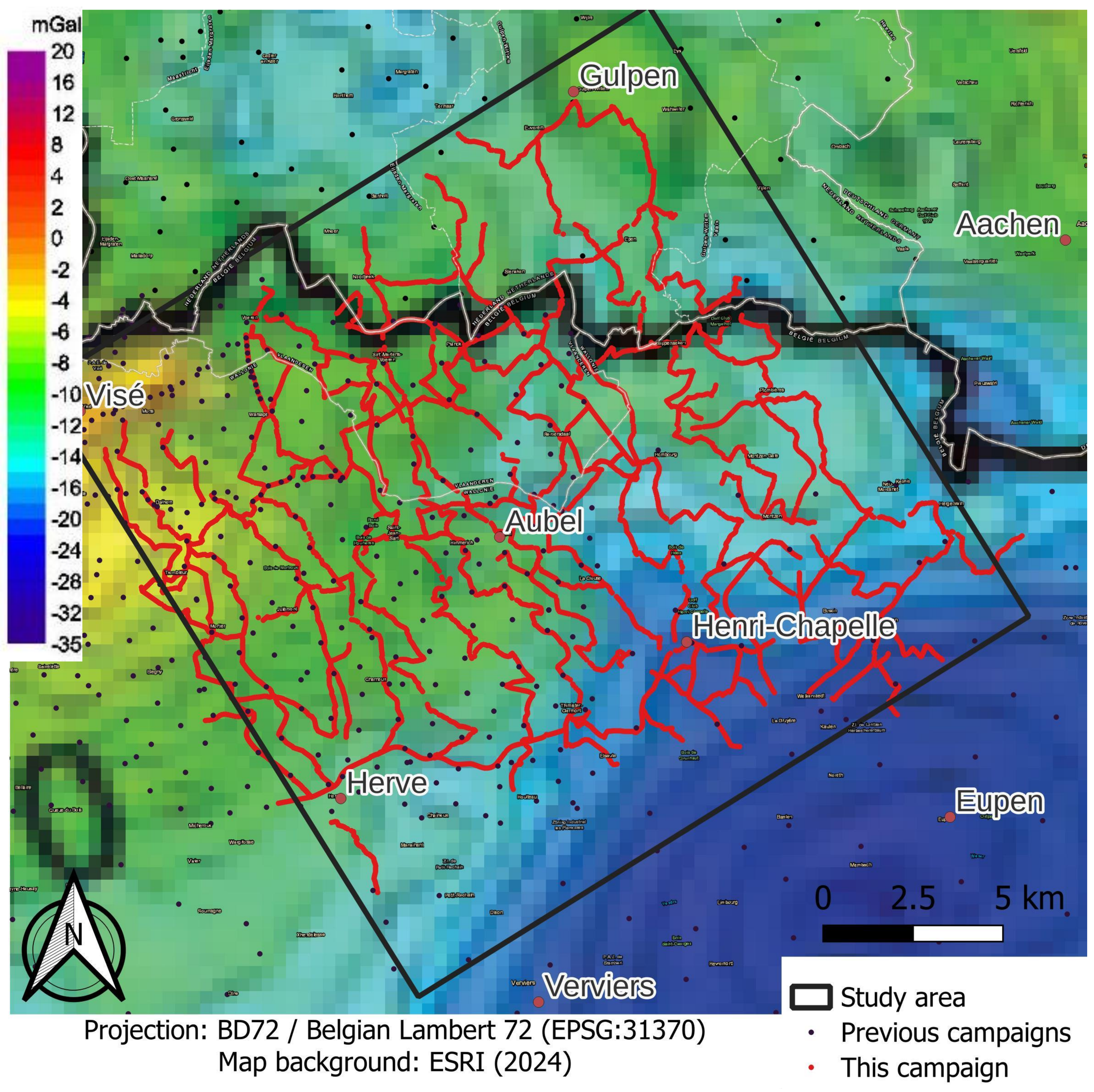

Figure 1: Previous gravity campaigns in the study area (modified from Everaerts & De Vos, 2012). The new study consists of profiles with 50 meters between points.

3. New campaign

FREMEN GEO collected 9000 points across an 18 x 18 km area in Belgium and the Netherlands in late 2023/early 2024. This is a substantial increase in data density compared to earlier studies.

The points, measured along SE-NW and SW-NE profiles, span small roads and paths, with 5% repeated for quality control (see Figure 2).

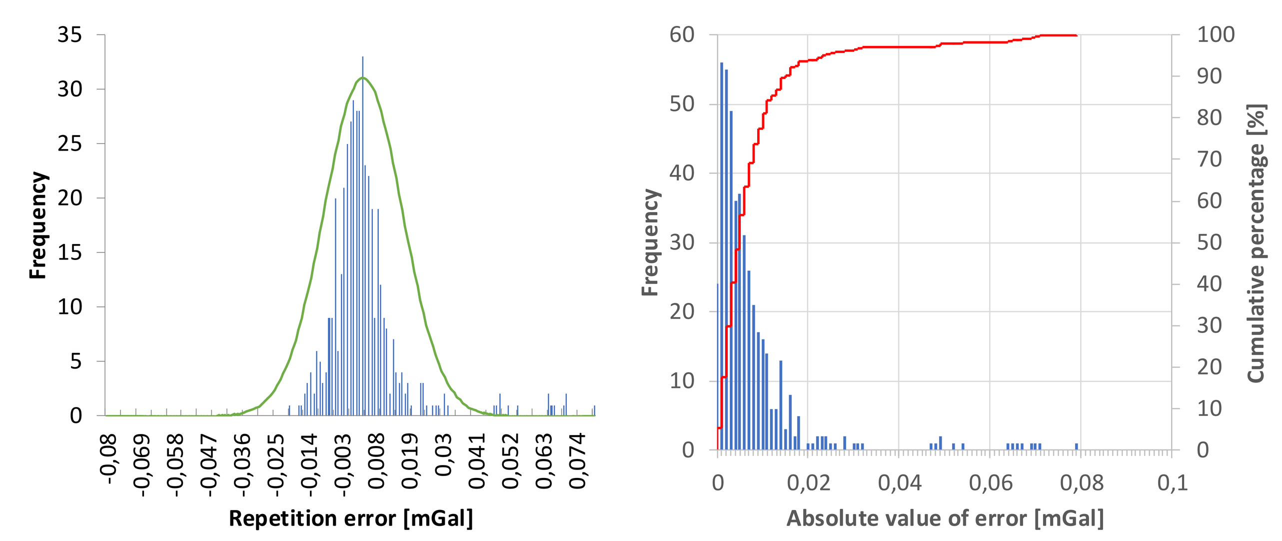

Figure 2: Data quality assessment on the new dataset. The mean study error, based on repetitions, is estimated to +/- 0.007 mGal.

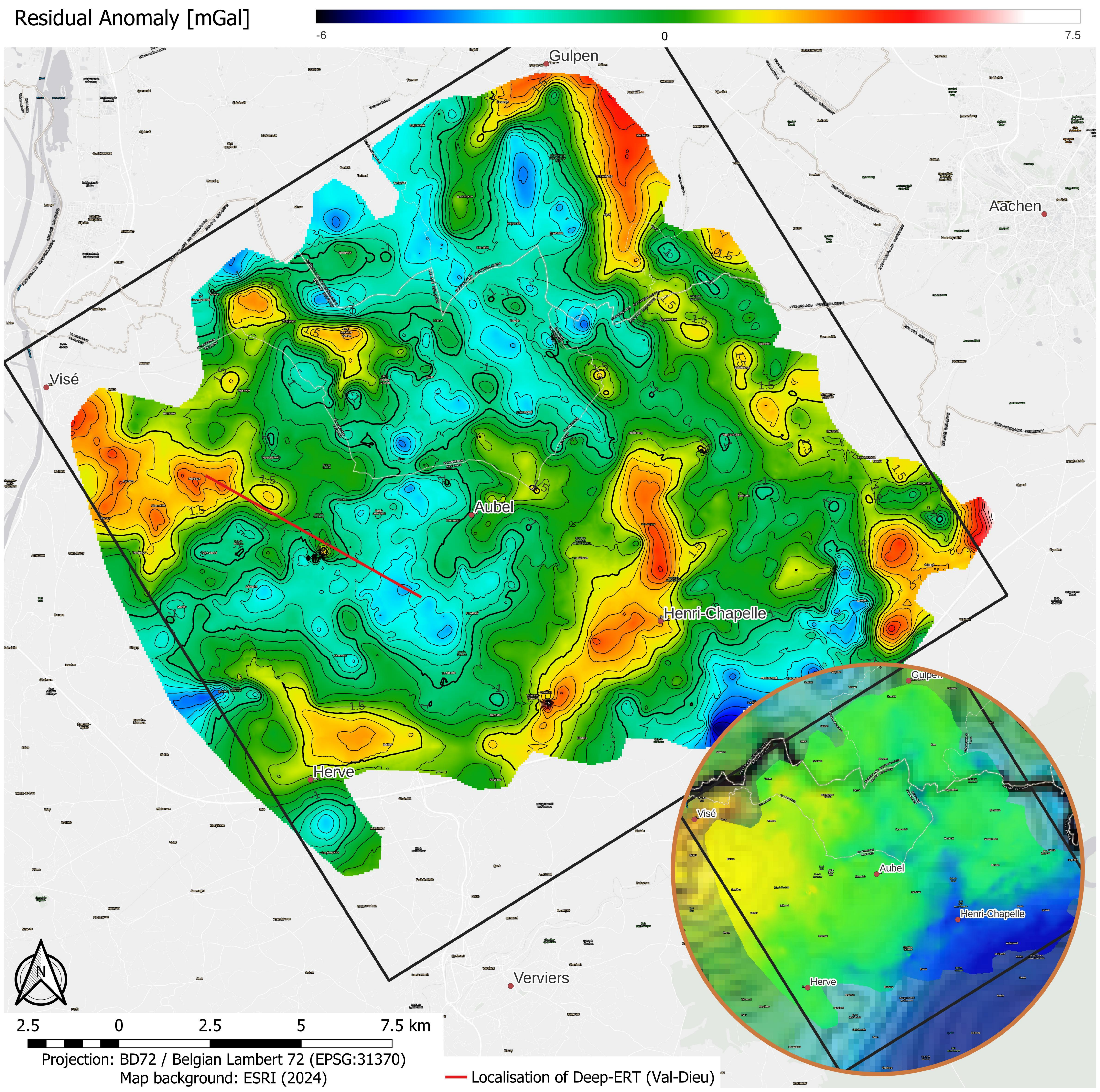

Figure 3: Residual anomaly after linear regional de-trending. The reduction density has been set to 2.2 g/cm³ as this seem to lower the correlation with the topography the most. The regional trend has been removed to only present the residuals. The insert shows the simple Bouguer Anomaly in agreement with previous studies.

4. Results interpretation

The geology is complex, with numerous faults and folds under Cretaceous cover, making interpretation of the new data (Figure 3) challenging. Other geophysical methods, like Deep-ERT, have provided useful insights.

A comparison between the residual Bouguer anomaly and the Val-Dieu Deep-ERT results is shown in Figure 4.

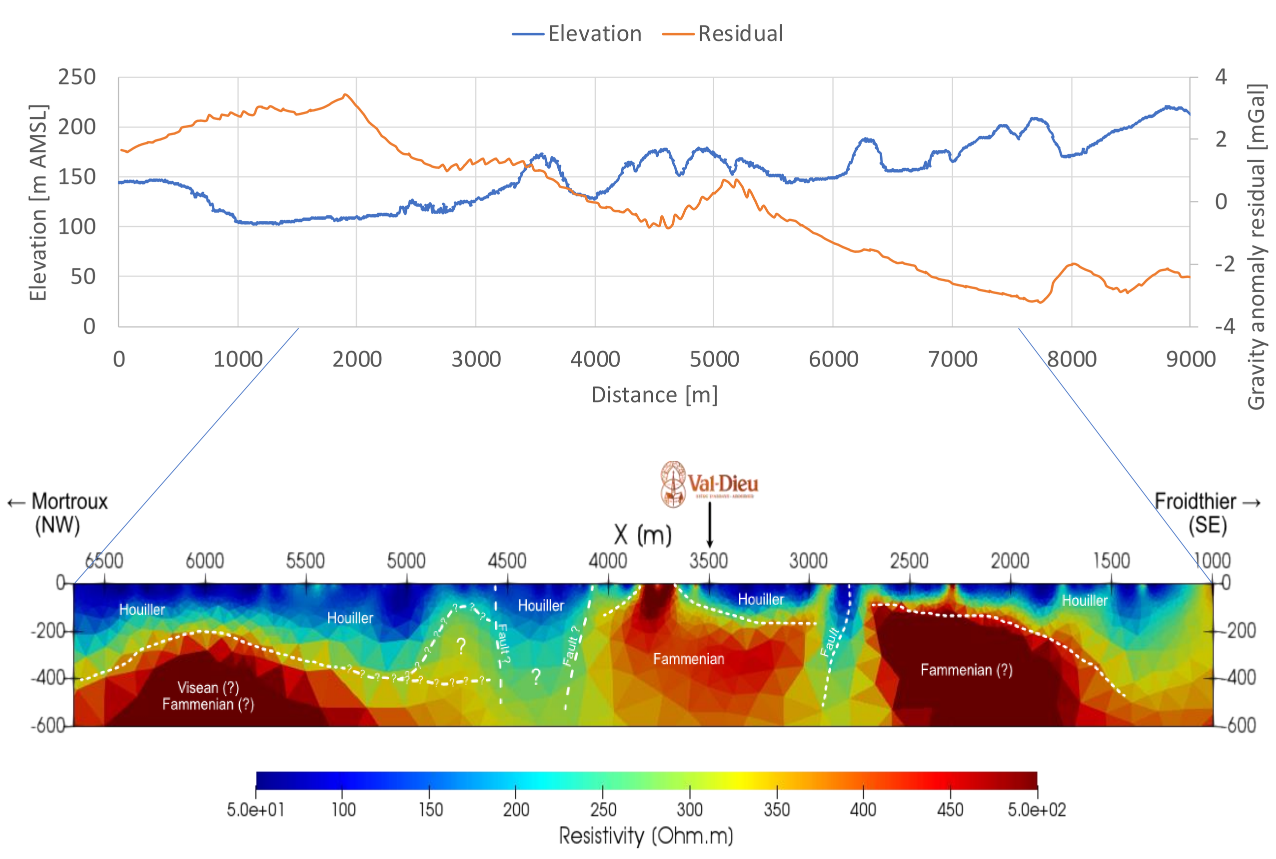

Figure 4: Comparison between the Deep-ERT inversion and a Bouguer anomaly profile. The results are counterintuitive at first, but are likely linked to the fracture density.

5. Future works

The current hypothesis is that higher anomalies correspond to lower fracturing, consistent with borehole data from the E-TEST project. Ongoing geological modeling, using stochastic forward modeling of gravitational anomalies, may provide further clarity.

References:

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- Everaerts, M., & de Vos, W. (2012). Gravity acquisition in Belgium and the resulting Bouguer anomaly map. Memoirs Of The Geological Survey Of Belgium, 58.

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