Using Variscan Metasediments as an EGS Reservoir on a European Scale – Preliminary Stages of Outcrop Analogue Characterization

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Introduction

As the world's need for renewable energy resources increases, more and more industries are looking at the possibilities for geothermal exploitation. Despite having huge potential in Europe, there are only a few commercial geothermal plants using EGS (Enhanced Geothermal Systems), in crystalline metamorphic rocks. One of the aims of the EU-Horizon-2020-MEET-project (**M**ultidisciplinary and multi-context demonstration of **EGS** exploration and **E**xploitation **T**echniques and potentials) is to explore and bring about this potential in Variscan crystalline and metasedimentary reservoirs *(Trullenque et al, 2018).*

What is EGS

An Enhanced Geothermal System doesn't rely on natural convective hydrothermal resources to generate electricity and therefore can be theoretically used anywhere in the world. When the natural permeability of the proposed reservoir rock doesn't meet economic standards for flow rates, the systems are "enhanced" by pumping high pressure cold water into the naturally fractured rock or through chemical or mechanical stimulation, generating shearing events to increase the permeability of the reservoir. As long as this pressure of fluid is maintained the reservoir rock doesn't need a high matrix perme-ability.

Why Harz?

The Western Harz Mountains *(seen in Fig.1)*, which is well known by the Department of Structural Geology and Geodynamics and has been chosen as the analogue for this project. It is regularly used for teaching field trips as the outcrop situation is reasonable. As well as this, Göttingen is situated between the Western Harz and the Rhenish Massif along the Variscan strike. Therefore, similar structures are expected to be exposed *(such as in Fig. 2.)*. The boundary that separates the autochthonous and par-autochthonous zones *(seen in Fig. 1)* from the allochthonous can be seen in the Rhenish Massif in the SW and the Harz in the NE, therefore through interpolation, Göttingen is expected to sit across this.

Fieldwork

Due to the relatively low outcrop situation in the Western Harz, outcrop analogues are mostly limited due to accessibility and quality. However, shore areas of water reservoirs are prominent in the Harz as well as road cut walls, providing reasonable quality outcrops. The initial field campaign involved identifying some of the outcrops*(as seen in Figs 3, 4 and 5)* which would become analogues. Structural data was then taken using, digital and manual methods, including photogrammetry. The data is currently being analysed to create a simplified structural model of the faults and folds across the area of the outcrops *(as seen in figs 3, 4, 5 and 6)* .Once this has been completed, a model of the fracture network will be added to the model, using orientation, length, distribution and displacement data. Fracture families, density and distribution can be analysed and any changes compared to the fold structures realised *(e.g. Stephen et al. 2016, Watkins et al. 2018)*.

Representative Outcrops of the Fold-and-Thrust Belt Structures in the Western Harz

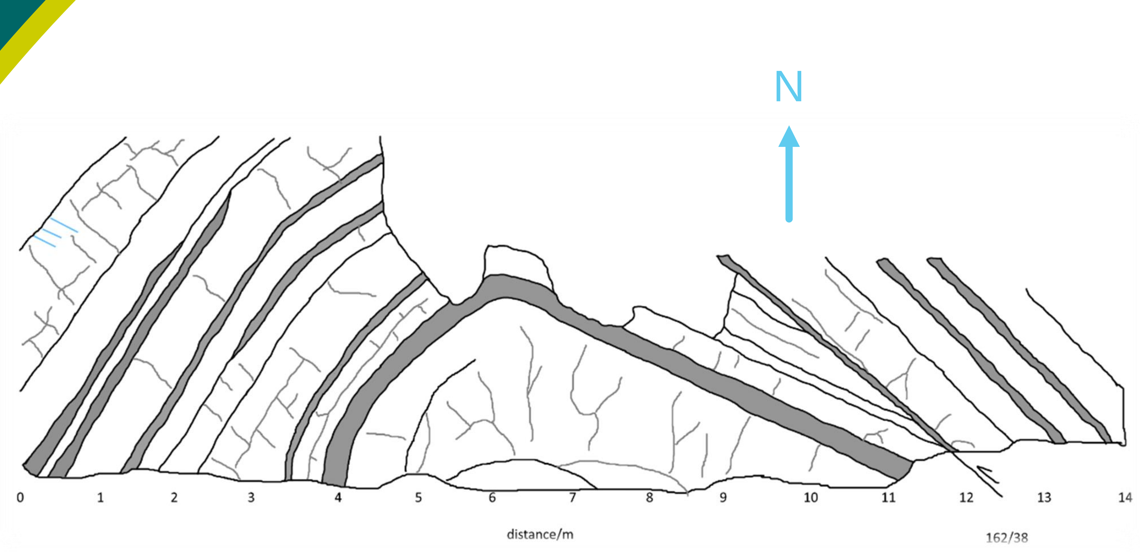

Fig.3 – digitised field sketch of Wildemann fold hinge. NW verging Variscan fold.

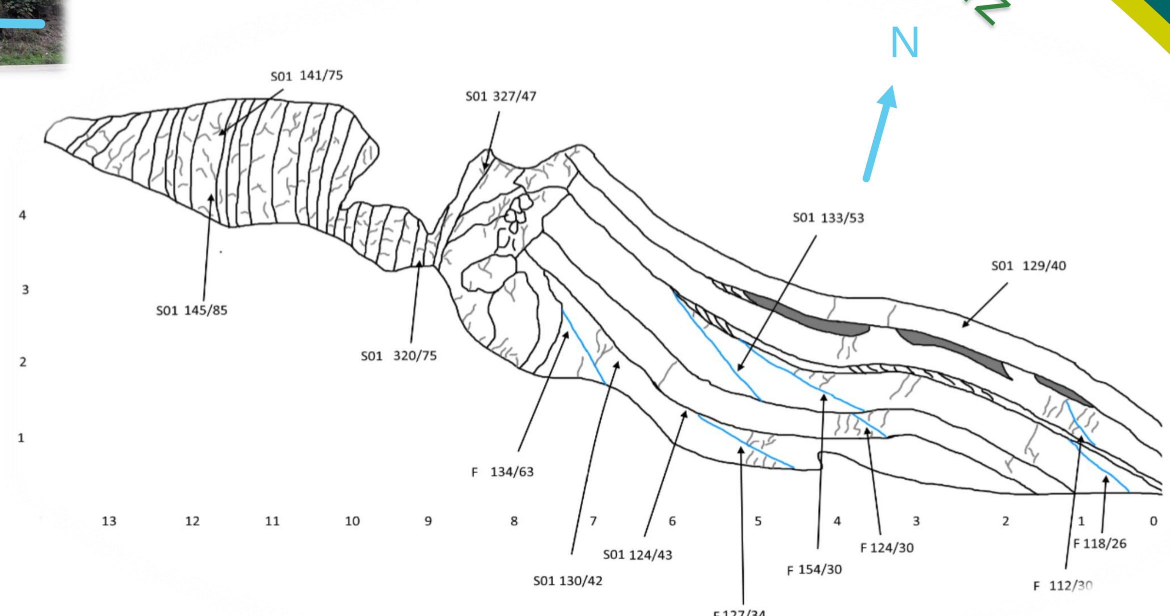

Fig.4 – image (right) and digitised field sketch (above) of Variscan fold and thrust interactions, no visible hinge but hinge can be implied. High level of deformation in the overturned limb.

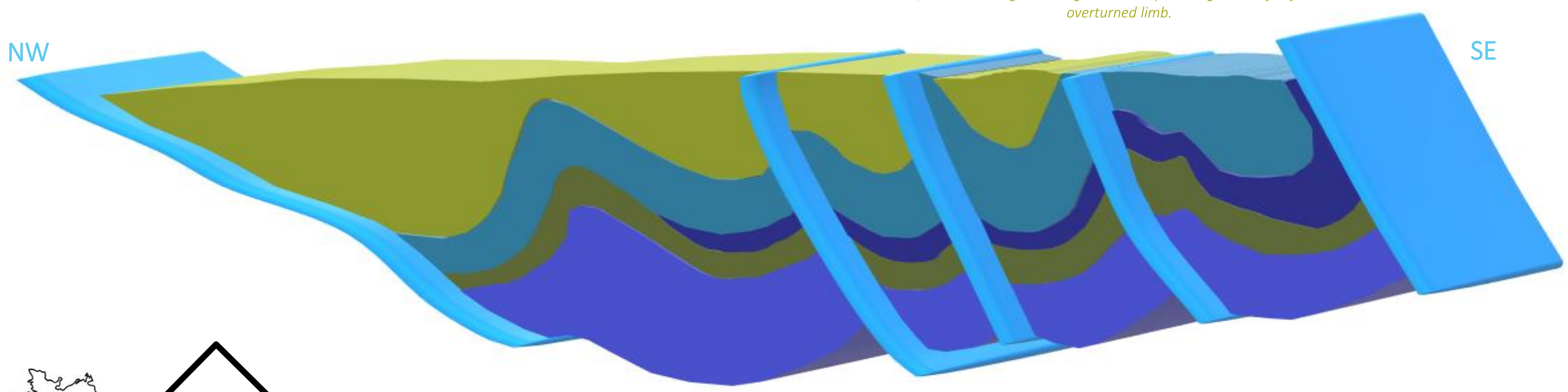

Fig.2 – Simplified conceptual 3D diagram of Variscan fold-and-thrust belt, as exhibited in the Western Harz Mountains.

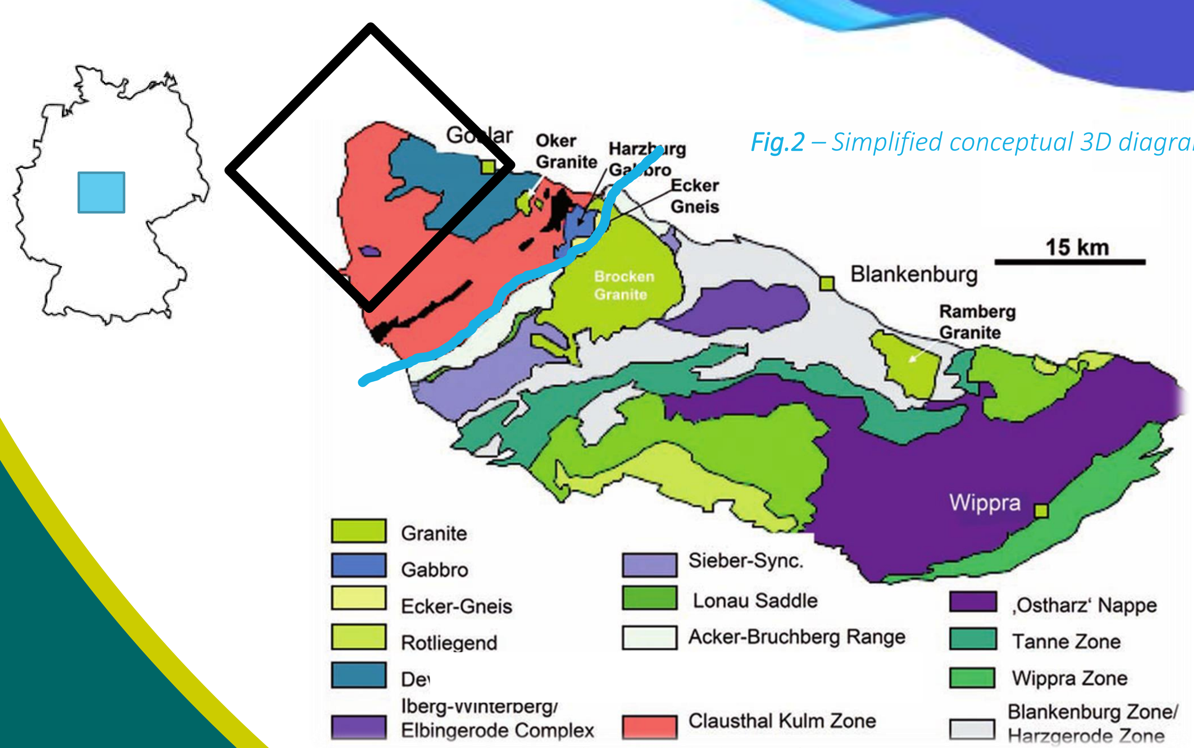

Fig.1 – Simplified geological map of the Harz Mountains. Area of focus in black box. Blue line indicates the boundary between the allochthonous and par-autochthonous zones. Map after Brink (2011).

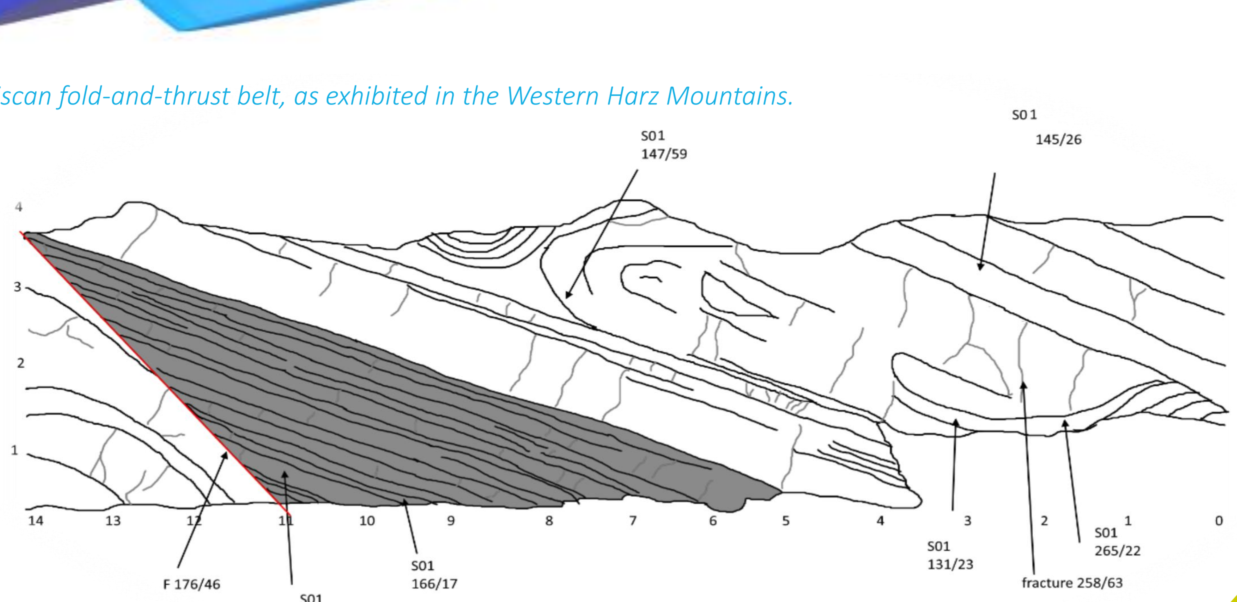

Fig.5 – digitised field sketch of classic Variscan thrust and NW verging fold interaction. Possibly internal folding.

Fig.6 – key for digitised field sketches.

Göttingen Campus Project

The University of Göttingen operates its own natural gas power plant that generates both heating and electricity around the campus. However, it is currently investigating the potential for the district heating of the campus via geothermal power. After two seismic surveys recently undertaken, the target horizon has been identified. The Jurassic sedimentary cover continues to a depth of 1500 m, with the Variscan basement beneath. It is thought that the basement comprises of Variscan metasediments (meta-greywackes, slates and quartzites) with the seismic survey indicating a very high anisotropy. These have then been over printed by younger tectonics related to the Lienetal Graben system. The aim of this research project will be to create a conceptual 3D-structural model of the subsurface of Göttingen campus, collecting data from various outcrop analogues in similar structural settings. Parallel to this, an exploration drilling programme will take place, drilling to 2000 m depth to characterise the basement rock and detect the most appropriate horizon for EGS. This will be the first drilling project that extends into the Variscan basement of Göttingen.

Conclusions

This study is in the preliminary stages, with the first of many field campaigns completed. samples have been collected for lab characterisation of the rock physical properties and mechanical testing. The main areas of interest have been established and the main parameters for the conceptual model have been chosen. Work is underway to create a 3D-structural model of the first chosen outcrop area. The next step is to create more detailed models, using the same parameters at different outcrops and eventually identify the changes in structures from the micro scale, outcrop scale, and reservoir scale, across the Variscan fold and thrust belt to allow, in combination with the results of the planned drilling campaign to finally develop a reservoir model.

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