Mapping the Geothermal Potential of Fault Zones in the Sedimentary Basins of the Belgian and Netherlands border region

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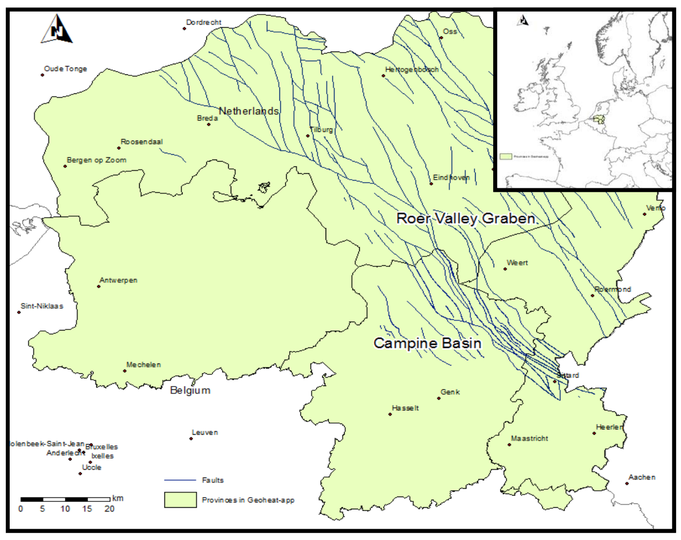
Faults can often determine the success or failure of low enthalpy geothermal projects due to their prevalence throughout the subsurface and capacity to behave as fluid flow pathways or baffles (or both simultaneously).

Here we present an assessment of the capacity of faults in the Belgium and Netherlands border region (Fig. 1) to impact geothermal potential. This work was completed as part of an EC INTERREG IVA Flanders- Netherlands funded project.

Geoheat-App project (INTERREG IV)

Four stratigraphic intervals with possible geothermal potential were identified (Fig 1). Depth, temperature and transmissivity of these intervals were mapped and geothermal potential identified

Much of the Roer Valley Graben and the Campine Basin are highly faulted. The capacity of these faults to improve geothermal potential was determined from factors known to increase or decrease permeability.



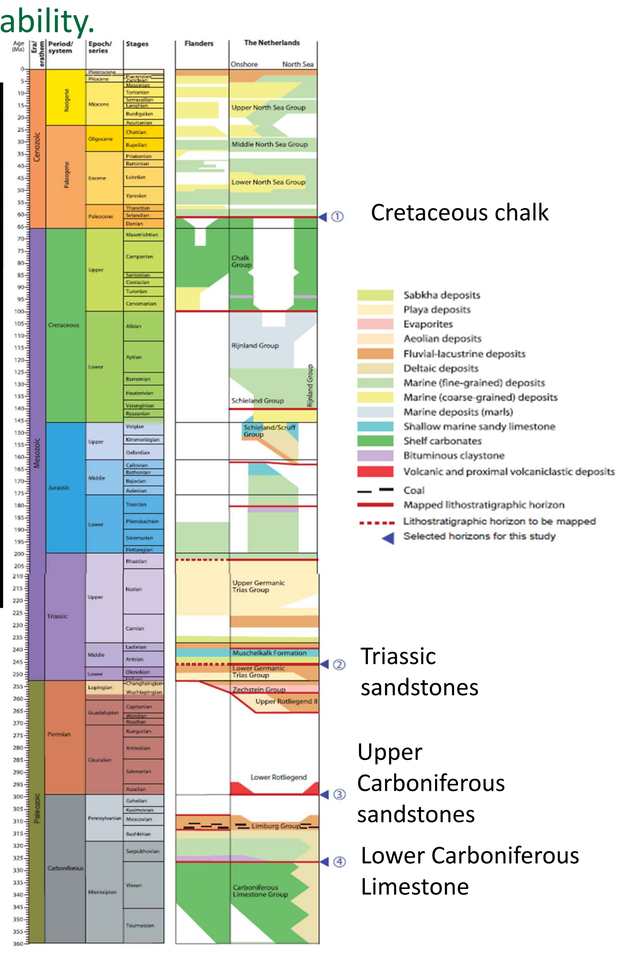


Fig 1. (Above) Flemish (Antwerpen and Limburg) and Dutch (Noord Brabant and Limburg) provinces in the Geoheat-app project. (Right) Stratigraphic column correlated across the Flemish-Dutch border with selected intervals of interest for geothermal energy.

Assessment of fault zones to improve geothermal potential

1. Lithology

Faults in carbonates cause surrounding rock to fracture, increasing bulk permeability (Fig. 2)[1]. Permeability can be further increased by dissolution processes. This is evidenced at the Venlo geothermal project, Netherlands[2]. Regions with faults cutting carbonate reservoirs (chalk and limestone, Fig.1) were considered to have the possibility of enhanced geothermal potential.

Conversely, in faults in clastic reservoirs grain-breakage (cataclasis) and clay smears are more dominant than fractures, resulting in a lower bulk permeability (Fig. 2)[1]. Regions with faults cutting clastic reservoirs (Triassic and Upper Carboniferous sandstones, Fig.1) were not considered to have enhanced geothermal potential.

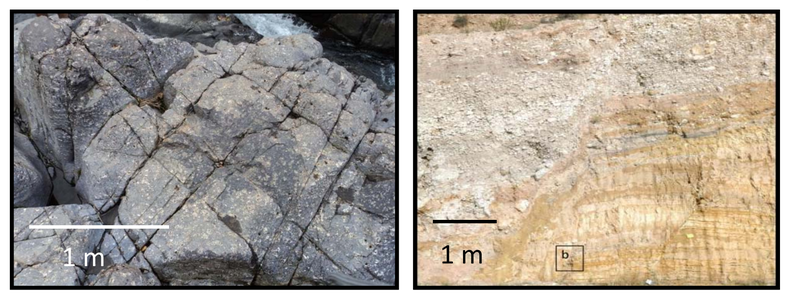


Fig 2. (Left) Open fractures can be associated with faults in carbonates but are rarely associated with faults in clastic sediments (Right).

2. Timing of fault activity.

Fluids flowing through fractures precipitate cements, effectively re-sealing them over time (Fig. 3). Each time the fault is re-activated pre-existing or new fractures can open. Therefore recently deformed faults are more likely to be permeable.

Fig 3. Fractures can become filled with cement over time.

3. Critically stressed faults

Critically stressed faults (optimally oriented to the crustal stress field) are more likely to be permeable[4]. However there is limited information about the state of stress in this region so fault activity was also used as a proxy for whether or not faults were critically stressed.

Recently active areas were identified (Fig 4):

- Seismically active areas previously identified in the Roer Valley Graben (3) - good potential.
- Areas with faults mapped cutting Quaternary intervals and from recorded earthquake locations (data from ROB and KNMI Netherlands) – good potential.
- Areas with either mapped Quaternary faults or recorded earthquakes – medium potential.

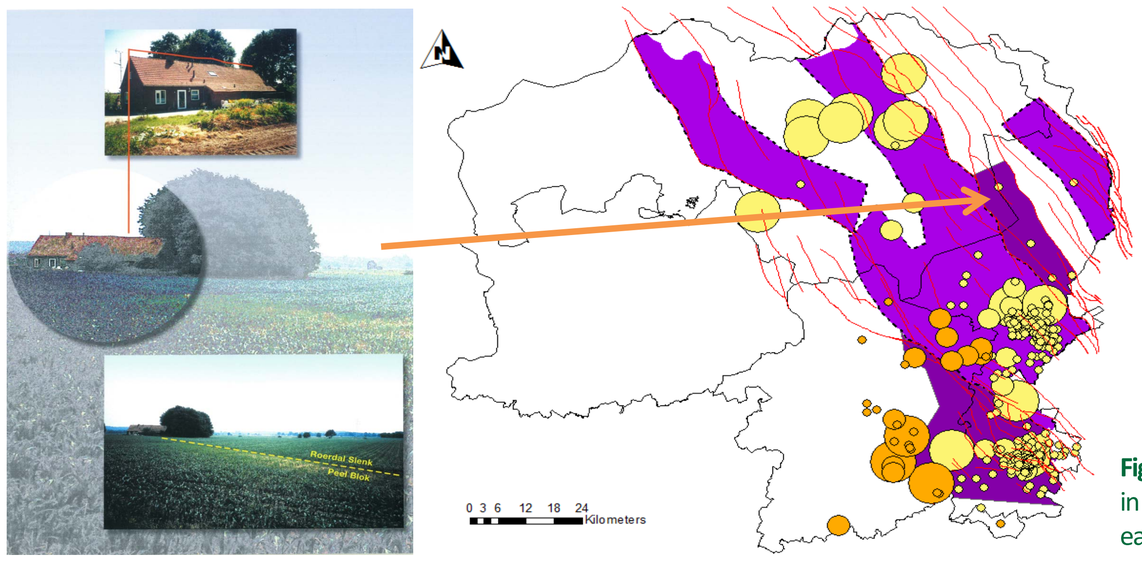
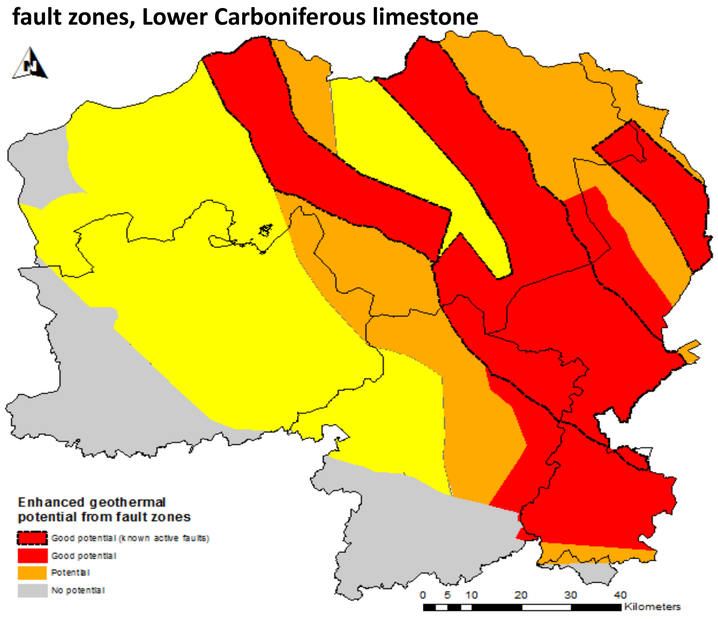


Fig 4. (Left) Photograph showing recent fault activity in the RVG. (Right) Purple areas regions in the RVG identified as active in (3) or based on recorded seismicity (circles*) and faults cutting Quaternary intervals (red lines). *Circles show location of earthquakes but the size indicates certainty of location (km) not magnitude.

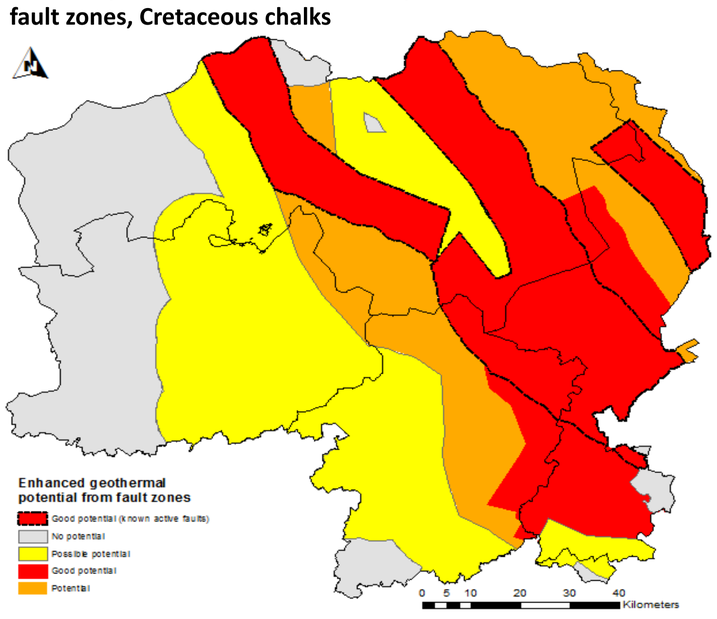
Geothermal potential maps

Regions predicted to have good enhanced geothermal potential around faults in the chalk and limestone reservoir intervals are located along the flanks of the RVG, and to the south in Dutch and Flemish Limburg Provinces. This region encompasses the Venlo geothermal site[2]. Areas with some potential flank the regions of good potential. There is a possibility of fault enhanced geothermal potential across much of the remaining area except where either the interval of interest or faults do not exist.

Possibility for enhanced geothermal potential in fault zones, Lower Carboniferous limestone



Possibility for enhanced geothermal potential in fault zones, Cretaceous chalks



Summary

The results of this study provide a provisional assessment of geothermal potential of fault zones. It suggests fault zones could enhance geothermal potential across much of the region. However detailed analyses will be required for each new geothermal project. The maps will be validated as geothermal projects develop in the region.

References: (1) Bense, V.F., T. Gleeson and S.E. Loveless., O. Bour and J. Scibek. 2013. Fault zone hydrogeology. *Earth Science Reviews*, 10.1016/j.earscirev.2013.09.008 . (2) http://www.californie.nu/ (3) Vanneste, K., Camelbeeck, T. and Verbeeck, K. 2013. A Model of Composite Seismic Sources for the Lower Rhine Graben, Northwest Europe. *Bulletin of the Seismological Society of America. 103 (2A).* 984-1007. (4) Barton, C.A., Zoback, M.D. and Moos, D. 1995. Fluid flow along potentially active faults in crystalline rock. *Geology.* 23. 683-686.

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