





## Seismic Response of the Rittershoffen Geothermal Reservoir to the Series of GRT-1 Stimulations

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**SUMMARY** 

**b-positive** (van der Elst)

Between April and June 2013, the GRT-1 well, located at the Rittershoffen

Phase	Templates	Final	Q <sub>Max</sub> (I/S)	<b>WHP<sub>Max</sub></b> (MPa)	Volume (m³)	<b>Duration</b> (h)	l <sub>index</sub> (l/s/bar)
Thermal (23-26 April)	146	328	25	2.8	4230	62.6	0.9
Injection test (22 June)	0	5	27	2.5	357	6.5	
Chemical (23-25 June)			5	n.a.	269	14.2	1.7
Hydraulic (27-28 June)	984	2965					
<b>Co-injection</b>	823	2473	80	3.3	4000	28.2	2.5
Post-injection	161	492					
TOTAL	1130	3298					

- geothermal site in the **Upper Rhine Graben** (France), was stimulated.
- Three distinct stimulations: 1. **thermal**, 2. **chemical** and 3. **hydraulic**.
- A local surface seismic network continuously monitored these operations, which triggered thousands of seismic events.
- The current study extends and refines the work of *Lengliné et al. (2017)*, who were considering the hydraulic stimulation of GRT-1 only, and the work of Maurer et al. (2020), who were limited in the result interpretation due to questionable absolute locations of the seismicity, especially depth.



 $1.42 \pm 0.14$  (111)  $1.15 \pm 0.04$  (885)

History of operations and seismicity

0.80 ± 0.06 (176)

## **M**ETHOD

- **Detection and picking** 
  - Template: *Maurer et al.* reference catalogue
  - Matching: Lengliné et al. method with automatic setting of detection threshold (100 sps, 10-45 Hz, 2.56 s CC window, -0.5 s before P, 1 false detection/10000 days)

## **Relative location method**

- 3D velocity model, URG scale, *Freymark et al. (2020)*
- Cross-correlation to propagate arrival times (CC > 0.5)
- GrowClust3D
- 1<sup>st</sup> event of thermal stimulation on fault crossed by GRT-1 (2201 m bsl)
- **Magnitude**: Template MIv corrected from amplitude and distance



Planes consistent with local stress field SH<sub>Max 2012</sub> (*Azzola et al. 2019*) Above 2270 m bsl.: 15°N±19° Below 2420 m bsl.: 165°N±14°



