



## Thermal water in the northern Outre-Forêt

What initially started as exploration for hydrocarbons in the early 20<sup>th</sup> century, resulted in the discovery of thermal and mineral-rich water in the northern Outre-Forêt. Today, multiple Enhanced Geothermal System (EGS) or Hot Dry Rock (HDR) geothermal projects exist in the area.

### Anomalies

In the northern part of the Outre-Forêt, delineated by the cities Haguenau, Landau and Bruchsal, positive thermal anomalies are abundantly observed in deep geothermal wells. When taking into account a geothermal gradient of 10 + 30 °C/km, the anomalies range from +6 °C in Niederbronn-les-Bains up to +85 °C in Rittershofen.

Merkwiller-Pechelbronn and Soultz-sous-Forêts are situated in a consecutive graben-horst system in the central part of the Upper Rhine Graben, the “basin de Pechelbronn” and “horst de Soultz”, respectively. Rittershofen is located just east of this graben-horst system, and Niederbronn-les-Bains and Morsbronn-les-Bains just west of it. The granitic socle gradually becomes shallower and eventually crops out due to a dome structure to the west. This whole region is heavily fractured. In the eastern part, also called the “Champ pétrolifère de Pechelbronn et zone géothermique de Soultz”, west-dipping faults dominate, while in the western part, also called the “Champ de fractures de Saverne” faults dip to the east, e.g. the Faille Rhénane in Morsbronn-les-Bains and the Faille Vosgienne in Niederbronn-les-Bains. These faults, especially the Faille Rhénane, provide the pathway for vertical circulation of thermal water from the underlying granitic socle and Permo-Triassic sandstones. The Faille Vosgienne is also known to bring up mineral-rich water (Feuchter, n.d.).

All these geomanifestations, also those in Landau and Insheim more northeastwards, are situated in the central part of the Upper Rhine Graben, an active rift with a high geothermal potential. Topography-driven fluid flow takes place from both graben shoulders to the rift center, where upflow of hot fluids occurs along deep-seated faults (Freymark et al., 2019). The most favorable conditions are met where preferential discharge of deep fluid circulation occurs along a V-shaped intersection of faults, such as at Soultz-sous-Forêts (Les Landes et al., 2019), but free convection along major faults is also deduced in the area of Landau (Bächler et al., 2003). Hydrothermal convection along faults may explain up to 85% of all temperature anomalies in the Upper Rhine Graben (Baillieux et al., 2013). In addition to the fault geometry, crustal thinning and mantle upwelling take place in the central part of the Upper Rhine Graben. Therefore, a generally increased geothermal gradient is observed in Outre-Forêt compared to its surroundings. These factors combined give rise to the maturation of hydrocarbon-rich sediments and thermal water production (Feuchter, n.d.).





## Data

ID	Coordinates	T °C	Depth m	TDS° g/l	Cl mg/l	Na mg/l	SO <sub>4</sub> mg/l	Free CO <sub>2</sub> mg/l	He ppmv	<sup>3</sup> He/ <sup>4</sup> He	Analysis year	References
Gt La-1, Landau in der Pfalz	49°11'11" North 08'07"19" East	160	3300								<2021	GTN (n.d.)
				106								<2018
GTI-1 Insheim	49°09'35" North 08'09"37" East	165	3600	107							<2018	Vidal and Genter (2018)
GRT-1, Rittershofen	48°53'50" North 07'56"17" East	170	2500								2020	Maurer et al. (2020)
		160	2580	101							<2018	Vidal and Genter (2018)
GPK-2, Soultz-sous-Forêts	48°55'52" North 07'52"05" East	203	5080	100							<2021	Feuchter (n.d.)
		200	5060								<2018	Vidal and Genter (2018)
Héliions I, Merkwiller-Pechelbronn	48°56'32" North 07'49"23" East	43	544								1904	S.I.M.E. (2021)
Héliions II, Merkwiller-Pechelbronn		70 – 76.3	906 – 1146	20.8							~1971	Feuchter (n.d.)
Source romaine, Niederbronn-les-Bains	48°34'14" North 07'30"20" East	11	18	5.15							<2021	Feuchter (n.d.)
Forage I, Morsbronn-les-Bains	Exact location not known											S.I.M.E. (2021)
		44	593								1904	Feuchter (n.d.)
Forage Arbogast, Morsbronn-les-Bains	48°54'25" North 07'44"53" East	41 – 42	680	3.4 – 4.84							<2021	Feuchter (n.d.)

° TDS = Total Dissolved Solids

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