



**HAL**  
open science

## On the geothermal potential of crustal fault zones: a case study from the Pontgibaud fault zone (French Massif Central, France)

Hugo Duwiquet, Laurent Guillou-Frottier, Laurent Arbaret, Mathieu Bellanger, Michael Heap

### ► To cite this version:

Hugo Duwiquet, Laurent Guillou-Frottier, Laurent Arbaret, Mathieu Bellanger, Michael Heap. On the geothermal potential of crustal fault zones: a case study from the Pontgibaud fault zone (French Massif Central, France). EGU General Assembly 2019, Apr 2019, Vienne, Austria. pp.2019 - 8894. hal-02096045

HAL Id: hal-02096045

<https://brgm.hal.science/hal-02096045v1>

Submitted on 11 Apr 2019

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



## **On the geothermal potential of crustal fault zones: a case study from the Pontgibaud fault zone (French Massif Central, France)**

Hugo Duwiquet (1), Laurent Guillou-Frottier (1,3), Laurent Arbaret (1), Mathieu Bellanger (2), and Michael Heap (4)

(1) ISTO, UMR 7327, Université d'Orléans, CNRS, BRGM, F-45071 Orléans, France (hugo.duwiquet@gmail.com), (2) TLS-Geothermics, Toulouse, France (mathieu.bellanger@tls-geothermics.fr), (3) BRGM, F-45060, Orléans, France (l.guillou-frottier@brgm.fr), (4) IPGS, Université de Strasbourg, EOST, CNRS UMR 7516, Strasbourg, France (heap@unistra.fr)

By considering a multidisciplinary approach, the present study aims to understand the potential of a new and novel type of geothermal system for high temperature and electricity production: Crustal Fault Zones (CFZ). Numerous recent studies indicate that crustal-scale fault zones represent efficient conduits for meteoric fluids to flow down to mid-crustal depths (Haines et al., 2016), in particular near the brittle-ductile transition where temperatures may exceed 400°C (Violay et al., 2017). One such example, the Pontgibaud fault zone (French Massif Central), is a 30 km-long and 3 km-wide fault zone. Current fluid circulation is attested by the presence of CO<sub>2</sub>-rich thermomineral springs. The local heat flow value of 110 mW.m<sup>-2</sup> was estimated from a measured temperature gradient of 41°C.km<sup>-1</sup>. The Pontgibaud fault zone has been well studied in the last few years (Bellanger et al., 2017). In particular, vertical resistivity profiles show anomalously low resistivity zones at 3 km depth, which seems to be connected to the other large-scale low resistivity zone at 15 km depth (Ars et al., 2017). With the available geophysical database and additional geological field measurements, a numerical approach dedicated to the understanding of Pontgibaud hydrothermal system will be relevant, as demonstrated by 2D numerical models of Soultz-sous-Forêts geothermal system (Alsace, France) (Guillou-Frottier et al., 2013). There, the numerical models led to the prediction of two additional thermal anomalies, one of them (Rittershoffen, Alsace, France) being currently under exploitation since 2014. The present study aims at investigating the possibility for the Pontgibaud crustal-scale fault zone to host an active hydrothermal system. This multi-disciplinary approach allowed us to formulate a numerical model based on the geological knowledge of the Pontgibaud area. Two main unknown variables play a key role on possible fluid circulation: fault zone geometry (dip) and permeability ratio “R” between the fault zone and its host rocks, which varies from 1 to 300. For a sufficiently permeable fault zone (greater than 4x10<sup>-15</sup> m<sup>2</sup>), buoyancy-driven flow creates a positive thermal anomaly at a depth of 2-5 km. Benchmark simulations indicate that vertical structures promote largest thermal anomalies at shallow depths. Moreover, for a vertical fault zone, the thermal anomaly is larger for high R values. Fluid circulation patterns are described in a regime diagram parameterized by the fault dip, the thermal anomaly and the R ratio. Finally, numerical models of the geologically-constrained Pontgibaud fault zone show that a temperature of 150°C at a depth of 2500 m can be obtained for a fault network permeability of 9x10<sup>-15</sup> m<sup>2</sup>. The resulting thermal regime down to 15 km depth appears consistent with previously obtained resistivity profiles. Using this analytical multi-disciplinary and numerical approach, this work established a potential predictive tool for future high-temperature geothermal operations in a basement context.