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► **To cite this version:**

Audrey Taillefer, Roger Soliva, Laurent Guillou-Frottier, Elisabeth Le Goff, Guillaume Martin. Fault-related controls on hydrothermal flows in Eastern Pyrénées (France). EGU 2017, Apr 2017, Vienne, Austria. 19, pp.2017 - 4996. <hal-01491096>

HAL Id: hal-01491096

<https://hal-brgm.archives-ouvertes.fr/hal-01491096>

Submitted on 16 Mar 2017

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Fault-related controls on hydrothermal flows in Eastern Pyrénées (France)

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The way faults control upward fluid flow in extensive hydrothermal systems without an abnormal heat source such as volcanic or plutonic activity is still unclear. In the Eastern Pyrénées, an alignment of 29 hot springs (from 29°C to 73°C) along the Têt normal Fault offers the opportunity to study this process. Using an integrated multi-scale geological approach including mapping, remote sensing, macro and microscopic analyses of fault zones, we show that hot springs locate close to high topographic reliefs related to fault throw and segmentation. Emergences are always in crystalline rocks at gneiss-metasediments contacts, mostly in the Têt Fault footwall. In more details, they localize either (1) in brittle fault damage zones at the intersection between the Têt Fault and subsidiary faults, and (2) into hercynian ductile faults where dissolution cavities run along shear zones. Using these observations and 2D preliminary numerical simulations, we propose a hydrogeological model of upward hydrothermal flow. Meteoric fluids infiltrate at high altitude in the fault footwall relief where they acquire temperature because of the geothermal gradient. Hydraulic gradient and buoyancy forces allow them to upflow along fault-related permeability anisotropies. The identification and prioritization of the features controlling this kind of system have important implications for geothermal exploration and for the understanding of fluid-flow into the brittle Earth's crust in general.