Fluid circulation recorded by low-temperature thermochronology

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Temperature is a key parameter controlling the diagenetic evolution of sedimentary rocks. Several mechanisms can be at the origin of temperature increase including, (1) deposition of sediments which will be later eroded, (2) thermal flux variation and local magmatism or (3) circulation of fluids in thermal disequilibrium with the surrounding rocks. Deciphering the respective role of these mechanisms is tricky and requires the use of complementary analytical techniques. Implications of this understanding is nevertheless fundamental as it controls - among others - the duration of heat events, the geodynamics of sedimentary basins and the spatial extent of anomalous thermal areas. We test in this study the hypothesis of fluid circulation in disequilibrium with surrounding rocks, in a geological case where evidences confirm its development. Paleotemperatures will be determined using apatite fission-track (AFT) thermochronology. Expected results are an estimate of the volume of rocks which might be affected by such circulation and the requested duration which might be recorded by AFT.

Several sites have been sampled in the north-east of the French Massif Central (Morvan) where F-Ba(-Pb-Zn) concentrations are developed. Minimal trapping temperatures measured by fluid inclusion microthermometry (Gigoux et al., 2016) are in the 100-120°C range which represents a perfect temperature window for the use of AFT thermochronology (total track fading for temperatures >100°C). Published data at the scale of the Morvan are grouped at ~200 Ma (Barbarand et al., 2013). Anomalously young AFT ages are recorded close to the Pierre-Perthuis and Courcelles-Fremoy deposits (~100-120 Ma) whereas older ages are recorded in Pontaubert and Antully (~140-160 Ma), not only close to the mineralization, but also at distance (up to ~50m). In the vicinity of the ores, AFT ages are in general in agreement with the regional trend. These ages evidence the total to partial reset of the AFT system and record temperatures in the ~80-110°C range. These results show that the thermal inprint of hot fluids might be recorded, but only at distances and in sites where the circulations have deeply modified these surrounding rocks. On one side, extrapolation of this thermal effect at the scale of sedimentary basins does not appear realistic and might be excluded. On the other side, characteristics of fluid circulation might be approached using AFT, including temperature, duration but also fluid origin.

References

Barbarand et al., (2013) Tectonophysics 608 1310 ;
Gigoux M., et al. (2016) Ore Geology Reviews 72 940