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Low-temperature thermochronometry (apatite and zircon (U-Th)/He) across an active hydrothermal zone (Grimsel Pass, Swiss Alps)

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Quantification of the spatial extent and thermal impact of long-lived hydrothermal zones is challenging because radiometrically dateable hydrothermal minerals are often absent outside the main fluid pathways, while the thermal overprint can cover a significantly wider area. Understanding the heat transport and distribution in fault-bound hydrothermal systems is crucial for assessing reservoir potential in geothermal exploration. Low-temperature thermochronology could provide a useful tool allowing the quantification of hydrothermal activity and its timing for specific temperature ranges (e.g. $\sim$60-90°C for apatite). Furthermore, quantifying the effect of hydrothermal circulation on low-temperature thermochronology methods is relevant as this is a widely-applied method in areas where such hydrothermal systems have been rather common in the past and/or at present (e.g. the European Alps).

We present new apatite and zircon (U-Th)/He ages (respectively AHe and ZHe) from surface and drillhole samples collected across a hydrothermally active fault zone in the Aar massif (Grimsel Pass, Swiss Alps). Samples cover a horizontal distance of $\sim$400 m comprising fault rocks from the hydrothermally active fault core, its damage zone and the presumably unaffected country rock. Structural observations indicate that the main hydrothermal flow is restricted to a few meter wide permeable fault core, surrounded by an intensely fractured damage zone that shows variable degree of hydrothermal mineralization on fracture surfaces at up to several 10s of meters distance from the fault core. Our new thermochronometric data shows a relatively narrow thermal impact zone of <100 m for the temperature range relevant for AHe and ZHe systems. Most samples yield ages in the range of 5-6 Ma for the AHe system and 8-9 Ma for the ZHe system; which we interpret as representing the Neogene exhumation signal of the Aar massif, with little to no imprint of the recent hydrothermal heat transport. However, samples closest to the fault core show a more complex sensitivity of the (U-Th)/He systems as an effect of hydrothermal circulation. While some aliquots evidence a partial reset of the AHe system with ages as young as $\sim$1.5 Ma, others indicate ages, which are potentially older than exhumation ages. Interpretation of ZHe and AHe data should therefore be critically assessed with regard to hydrothermal alteration in the vicinity of fault zones.