Evolution of the Alpine Orogen revealed by (U-Th)/He hematite and U-Pb calcite geochronology. Potential standard for U-Pb Iron Oxides dating by LA-ICP-MS.

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Résumé

Alpine orogenic models have significantly evolved over time. In the 1990s, the discovery of mainly extensional tectonics in the inner part of the Western Alps, recorded by seismicity and normal faults with kilometer-scale offsets reactivating the Pennic Front, was interpreted first as gravitational collapse, then as isostatic rebound, or vertical of a rigid mantle indenter. The recent development of geochronology and geochemical characterization methods now brings new constraints to these geodynamic models.

Our dataset, comprising 33 U-Pb calcite ages coupled with 59 (U-Th)/He hematite ages, reveals a synchronous yet contrasting stress regime: compressive deformation in the subalpine foreland (15.4 to 2.1 Ma) and extensional deformation in the western Alpine orogenic wedge (13.3 to < 0.8 Ma). These results indicate a syn-orogenic phase linked to the exhumation of the External Crystalline Massifs, in which the vertical relative motion is accommodated by both compression at their front and extension at their back. The orogen thus does not behave as a single coherent block under a uniform stress field but rather as an assemblage of smaller tectonic blocks in interaction, with deformation localized along pre-existing

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lithospheric structures. This highlights the major role of inherited structures in controlling differential stress distribution and mountain belt evolution.

Alongside the development of the (U-Th)/He method, LA-ICP-MS detection limits have improved significantly over the past 15 years-from 0.01–1 ppm to below 0.001 ppm. This has expanded the range of datable minerals using the U-Pb method, including calcite, garnet, and other phases, emphasizing the critical importance of matrix-matched standards to reduce analytical uncertainties.
We present here results from 15 iron oxide samples (mainly hematite) studied for their potential use as reference materials for U-Pb geochronology by LA-ICP-MS. The aim is to ultimately enable faster, more accurate, and cost-effective analysis, unlocking diverse applications: paleoclimate reconstruction through lateritic weathering profiles, understanding ore deposit formation and mineralization processes, tracking ocean oxygenation events via banded iron formations, and dating deformation phases across various geological contexts.

Mots-Clés: U Pb calcite, Hematite dating, Alpine Orogen