Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.26979

Detrital rutile geochemistry indicates regional Proterozoic cold subduction

MONA LUEDER[1], JÖRG HERMANN[1], INÊS PEREIRA, PHD[2], JAN SCHÖNIG[3], RENÉE TAMBLYN[1], BRUNO DHUIME[4], PROF. DANIELA RUBATTO[1], LAURA STUTENBECKER[5] AND DANIELA KRIEG[6]

[1]University of Bern
[2]Universidade de Coimbra, Centro de Geociências
[3]Georg-August-Universität Göttingen
[4]CNRS-UMR5243, Géosciences Montpellier, Université de Montpellier
[5]University of Muenster, Institute of Geology and Paleontology
[6]technical University of Darmstadt, Institute of Applied Geosciences

Low-temperature high-pressure metamorphic rocks (low T/P), which are indicative of modern-style subduction zone metamorphism, are largely absent from the Precambrian geological record. Consequently, the onset and evolution of subduction during the Precambrian remains a widely debated topic in geosciences. Signatures of eroded Precambrian low T/P rocks might be preserved in form of detrital single grains in clastic sedimentary rocks. To trace subduction conditions in the detrital record, peak metamorphic pressure and temperature, time of metamorphism, and source lithologies need to be determined on detrital single grains. Rutile is a prime candidate to be used as a tool to trace subduction conditions through time. It is a common accessory mineral in high-grade metamorphic rocks, a widely used petrogenetic indicator mineral, and is chemically and mechanically stable during sedimentary processes.

Here we apply a novel approach, combining H_2O contents and trace elements in rutile to identify rutile formed at modern-style cold subduction conditions. Modern fluvial detrital rutile from rivers draining exposed eclogites in the Internal Western Alps shows a distinct signature with high H_2O/Zr (>4) and low total Nb+W+Sn contents (<1250 µg/g). This signature is typical for rutile from oceanic crust metamorphosed at low T/P conditions, demonstrating the use of detrital rutile as a viable tracer of modern-style cold subduction.

We applied this discrimination tool to detrital rutile in an arkose from the Hebridean Terrane, NW Scotland (1.0–1.8 Ga), and modern fluvial detrital rutile from the Carnarvon Basin, Western Australia (0.5–2.5 Ga), to evaluate the presence of modern-style cold subduction signatures prior to the late Neoproterozoic. In both cases, trace element signatures and high Zr-in-rutile temperatures indicate a dominant input from felsic protoliths of amphibolite- to granulite facies conditions. However, ~5–10 % of the analysed grains show high H_2O/Zr and low Nb+W+Sn signatures, which are indicative of modern-style cold subduction, operating in the late Paleo- to early Mesoproterozoic in East Laurentia and in the early Neoproterozoic in East Gondwana.

This opens new opportunities to track low T/P rocks, that were lost to erosion, in the sedimentary record, making it of particular interest for understanding Earth's geodynamic evolution in the Precambrian.