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Towards a comprehensive understanding of a mountain glacier history with ^{39}Ar-ATTA ice and rock dating

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During the last 1000 years climate in the European Alps has been variable with warmer and colder periods affecting e.g. the extent of glaciation. In the context of investigating these dynamics, ^{39}Ar closes an important gap in radiometric ice dating between ^{3}H, ^{210}Pb and ^{14}C. The ^{39}Ar isotope with its half-life of 268 years uniquely enables dating between about 50 and 1000 years. The very low isotopic abundance of about 10^{-15} of ^{39}Ar however sets high demands on the measurement method. The quantum technological Argon Trap Trace Analysis (ArTTA) method reduces the required amount of ice to a few kilograms, hence enabling the application to alpine glaciers. The ice, however, portrays only one side of the story. Therefore, we propose an additional use case of the ^{39}Ar tracer which relies on the activation of ^{39}K by cosmic neutrons in the upper layers of soils and rocks. With the low half-life of ^{39}Ar and the property of cosmic neutrons not penetrating deeper than a few meters of glacier ice or rock, this renders a tracer which can shed light on the recent glaciation history of a region. This tracer gives access to information on the time of reglaciation (“burial dating”), as well as deglaciation (“exposure dating”) e.g. of moraines. The very low argon yield from rock (several µl from 100 g of rock) paired with the often found very high ^{39}Ar concentrations (~10^{3} R_A) set new challenges to the ArTTA method.

This work attempts to combine ^{39}Ar ice ages from vertical profiles (ice cores) as well as horizontal profiles (surface samples) along the glacier with a pilot study of rock exposure dating by ^{39}Ar along the moraines to develop a comprehensive understanding of a low lying alpine glacier system at Jamtalferner, Austria. With mostly young ice ages (<300 years) along the entire glacier and previously measured moraine ages [1] indicating a last glacial advance about 260 years b.p., this glacier constitutes a suitable setting to test the conjunctive possibilities of these two ^{39}Ar use cases.

[1] Braumann et al., *Climate of the Past* (2021): 2451-2479.