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Depth-dependence of the production rate of in-situ 14-C in quartz

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Terrestrial cosmogenic nuclides provide a means to document and quantify the rates of changes of the landscape at the Earth's surface and have therefore received an increasing attention over the past decade. The short lived in-situ produced 14-C has recently emerged as a complement to other longer lived cosmogenic nuclides such as 10-Be or 26-Al. The short half-life (5730 yr) of 14-C makes it suitable to investigate surface processes such as denudation rates or sediment residence times on ka scales.
The wide application of in-situ 14-C for quantitative studies is however bound to the proper calibration of its production mechanisms and rates. As other cosmogenic nuclides, 14-C is produced at the Earth's surface by nuclear reactions with incoming neutrons and muons. The production rate of 14-C has been determined for quartz exposed at the surface where neutrons dominate the overall production [1]. At depth, however, the muon production pathway starts to dominate, because the mean attenuation length of muons is considerably longer than that of neutrons. So far, the muon derived in-situ 14-C production rate is solely based on theoretical and experimental work [2] that has not been tested on natural objects.
We measured the 14-C concentration in quartz along the Leymon High core (42.065 N, 7.014 E - alt: 1277 m; Northwestern Spain) using the ETH 14-C extraction line [3] and the MICADAS gas source AMS [4]. This core has been drilled down to 20 m in a quartz dyke and has already been used to refine the depth-dependent production rate of 10-Be and 26-Al [5]. Our results on 14 samples of this core spanning a depth range from 1 to 1545 cm allow us to estimate the muogenic contribution to the overall 14-C concentrations measured along the core. This data set yields a local surface muon production rate of 3.9 (+3.1, -0.6) at.g-1.yr-1, which translates into a surface Sea Level High Latitude muon production rate of 2.2 (+1.8, -0.4) at.g-1.yr-1. This is ca. 17 % of the SLHL neutron production rate, which is lower than the previous estimates [2]. Further measurements on other cores should be carried out to ascertain these estimates.

[1] Lifton et al., 2001 – GCA 65-12, pp.1953-1969
[2] Heisinger et al., 2002 – EPSL 200, pp.345-355
[3] Hippe et al., 2013 – NIMPR – B 294, pp. 81-86
[4] Synal et al., 2007 – NIMPR – B 259, pp.7-13
[5] Braucher et al., 2013 – NIMPR – B 294, pp.484-490