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Performance of the new in-situ cosmogenic 14C extraction system at ETH Zürich

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In-situ produced cosmogenic 14C has become a versatile tool in Earth surface sciences that is increasingly used to unravel complex glacier chronologies, investigate landscape transience, and study the dynamics of sedimentary and soil systems. The widespread use of 14C has long been hampered by the limited amount of routinely operating extraction systems due to technically demanding and time-consuming analytical procedures. The main challenge is to quantitatively extract the small amounts of 14C present in terrestrial rocks (quartz) and at the same time effectively separate the in-situ component from the much more abundant atmospheric 14C. Over the past few years, an increasing number of laboratories have developed new extraction systems and improved analytical techniques.

Here, we present the characteristics and performance of the newly developed 14C extraction system at ETH Zürich. It was built upon the experience gained with the previous system at ETHZ, which has been in operation since 2008 [1]. The new system has been significantly modified to facilitate analytical procedures, reduce attendance time and system maintenance, and improve the analytical reproducibility. The key aspects are:

- Extraction of 14C by high-T diffusion (1670°C) is performed in a sapphire tube placed in a commercially available resistance furnace that has proven highly reliable during daily operation at high temperatures.
- The extraction sequence and most of the gas cleaning steps are computer-controlled and run fully automated without the need of any operator attendance.
- The final gas purification is performed manually but was simplified by removing unnecessary cold traps and reaction surfaces and by shortening the gas flow path.
- 14C-free CO_2 carrier gas is added before extraction to provide larger gas quantities in the system and reduce the impact of potential losses of small gas amounts through adsorption.
- Most of the system is maintained under low vacuum and is regularly flushed with Helium gas, which serves for system cleaning and fast gas transport.

This analytical setup has substantially reduced the time and effort for 14C extraction and has greatly improved the reproducibility of the analytical procedures. This is clearly reflected in considerably increased data reproducibility. The long-term blank level of the new system is ca. 27,000 14C atoms (n=26) with a coefficient of variation (CoV) of 38%. The blank level was found to remain most stable and low when the extraction line is in continuous operation. Measurements of the CRONUS-A and CRONUS-N reference materials yielded mean 14C concentrations of about 730,000 at/g qtz (n=7) and 14,000 at/g qtz (n=4), respectively, and are in agreement with concentrations measured previously at ETHZ and other laboratories [2, 3]. Measurements of the CRONUS-A quartz show excellent reproducibility with a CoV of only 0.5%.

[1] Hippe et al., 2013 – Nucl Instrum Meth B 294: 81-86
[2] Lupker et al., 2015 – Quat Geochronol 28: 80-87
[3] Jull et al., 2015 Quat – Geochronol 26: 3-10