An improved analytical method for determining radioactive ^{35}S in water/snow samples and its applications to snow and glacier hydrology

*Mang Lin[1], Kun Wang[2], Shichang Kang[2], Mark Thiemens[1]

1. University of California San Diego, 2. State Key Laboratory of Cryosphere Sciences, Chinese Academy of Sciences

Cosmogenic ^{35}S is useful in understanding a wide variety of chemical and physical processes in the atmosphere, the hydrosphere and the cryosphere. The 87.4-day half-life and the ubiquity of sulfur in natural environments renders it an ideal tracer of many phenomena. For example, recent ^{35}S measurements in aerosol samples provided new insights into the vertical and horizontal transport processes in the atmosphere [1-2]. However, measurements of ^{35}S in snow and water samples remained scarce as existing analytical methods required a large volume of sample (>20 L) due to their high analytical activity background and low counting efficiency [3-4]. Here, we present a new set of snow/water sample collecting and handling procedures for high-sensitivity determination of cosmogenic ^{35}S using an optimized low-level liquid scintillation spectrometer technique [5]. The counting background and efficiency of this technique were ~0.9 counts per minute and ~78%, respectively, and therefore we can easily analyze water samples as small as ~2 L, ~10 times smaller than previous methods. Laboratory experiments using diluted ^{35}S standards (with activities of <5 disintegrations per minute) showed a ^{35}S recovery percentage of ~95%, demonstrating a relatively small deviation from the true value. This new method will provide a powerful tool in studying ^{35}S in small volumes of snow and water samples, especially those from remote but climatically important regions such as the polar regions and the Tibetan Plateau and Himalayas (also known as the Third Pole). The measurements are particularly important as the radioactive sulfur provides an actual clock of glacial melting processes. With the growing rate of glacial loss, the need for measurements from remote locations becomes all the more important. Using this method, we successfully measured ^{35}S in ~1 L of fresh snow sample collected from a glacier on the Tibetan Plateau (Laohugou Glacier No.12; 39°05’-40’N, 96°07’-97°04’E; 4260–5481 m above sea level) to be 47±7 mBq/L. We point out that the precision can be easily improved by collecting relatively larger amounts of samples (e.g. ~3 L) and measuring samples as soon as possible. Based on ^{35}S activities in 9 natural samples (fresh and aged snow, ice, runoff) made in this pilot study, a first proof-of-concept approximation for age determinations and source attributions will be presented. Along with water stable isotope measurements (dD and d^{18}O), our ^{35}S measurements may assist in quantifying snow melting rates. More samples (n>100) collected from Laohugou Glacier No.12 and other three glaciers across the Tibetan Plateau and Himalayas (East Rongbuk Glacier at Mount Everest, Xiao Dongkemadi Glacier at Tanggula Range and Baishui Glacier No.1 at Mount Yulong) during 2015-2016 are being measured and will be reported. We anticipate that these results will provide deeper insight into snow/glacier melting processes over the Tibetan Plateau and Himalayas.

References:

[1] Lin, M., et al. (2016). PNAS, 113(40), 11131–11136.
[2] Priyadashi, A., et al. (2011). PNAS, 108(35), 14422–14425.
[3] Hong, Y. and G. Kim (2005). Anal. Chem., 77, 3390-3393.
[4] Uriostegui, S., et al. (2015). Anal. Chem., 87, 6064-6070.
[5] Brothers, L., et al. (2010). PNAS, 107(12), 5311-5316.

Keywords: Sulfur isotopes, Cosmogenic nuclides, Snow melt, Glacier retreat, Cryosphere, Tibetan Plateau and Himalayas