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Antarctic Science Bursary Report

Radon as a proxy for subglacial and groundwater input into Taylor Valley lakes, Antarctica

Introduction:

In Taylor Valley, the three large lakes that lie along the valley floor are unique in that they are all in direct contact with glacial faces. Lake Hoare and Lake Fryxell are separated by the Canada Glacier, and Lake Bonney is abutted by Taylor Glacier, an extension of the East Antarctic Ice Sheet. The overarching hypothesis of the McMurdo Long Term Ecological Research site (LTER) is that climate change will increase connectivity throughout the landscape. Owing to a long history of research in the valleys, certain aspects of the physical hydrology of the region are well documented: such as, glacial mass balance, river discharge, lake levels and ablation, and meteorology; but due to the inherent difficulty in measuring direct glacial input into the lakes, the quantity of subglacial discharge and its contribution to the overall water balance are unknown.

We hypothesize that levels of radon (Rn-222) in lake water can act as a proxy for subglacial and groundwater input into Taylor Valley lakes. Radon is an inert gas, with a half-life of 3.8 days that is produced during the radioactive decay of radium. As radium is present in all rock material, it will enter aqueous solution during water–rock interactions, and lead to high concentrations in groundwater. The difference in radon concentrations between surface water and groundwater allow radon to act as an indirect tracer of water routing (Burnett et al., 2003). We hypothesize that subglacial water routed over till and bedrock should lead to high concentration of unsupported radon.

Methods:

I received a grant from Antarctic Science to purchase a Durridge RAD7 radon detector (www.durridge.com). The RAD7 is a portable alpha spectrometer than can analyze samples directly in the field, and provides a lower detection limit of 40 Bq/m^3 (Durridge, 2011). Samples are collected into 2.5 L sample bottles and measured within hours of collection. This experimental research will build on recent literature employing radon measurements in lacustrine settings (Kluge et al., 2007; Dugan et al., 2011; Schmidt et al., 2009).

In December 2012, preliminary sampling was carried out on the western lobe of Lake Bonney (Figure 1). At this time, river inflow had commenced only days previously, and seepage and glacial input was expected to be low. Samples were collected from four areas:

- Deep lake water adjacent to the glacier face
- In the deepest portion of the lake
- Directly below the ice cover in the middle of the lakes
- In a stream that feeds into the lake

Preliminary Results:

There were two results from this initial sampling. First, river inflow and all epilimnion water had insignificant amounts of radon (< 50 Bq m^{-3} is considered insignificant). Secondly, West Lake Bonney bottom water had high levels of supported radon, at ~200 Bq m^{-3} (derived *in situ* from Ra-226, half life = 1600 years), but very low concentrations of unsupported radon. This was tested by reanalyzing two samples 2-4 days after initial measurement. From this limited sampling, the source of Ra-226 is impossible to distinguish. Further sampling through spring melt and into summer is necessary to confirm the occurrence of seepage.

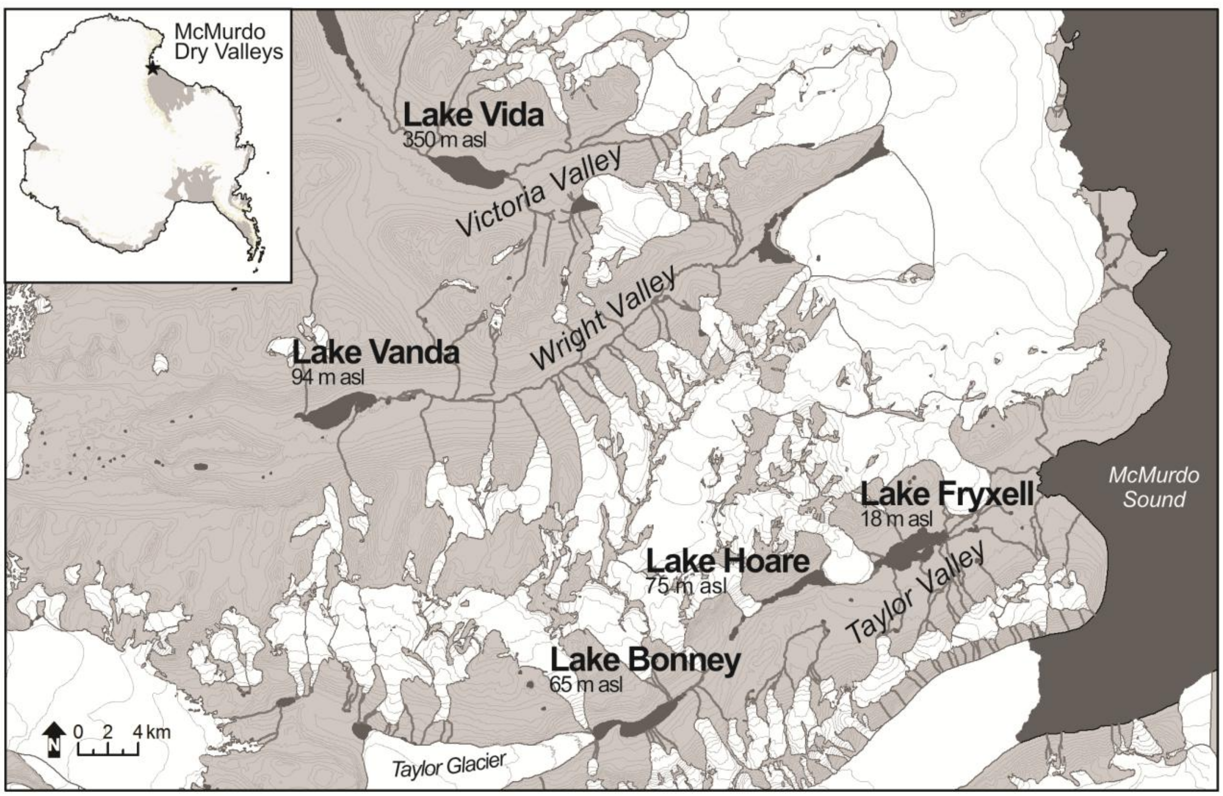

Figure 1. The major lakes in the McMurdo Dry Valleys, Antarctica

Upcoming Work:

In the November and December of 2013, I plan to continue sampling on Lake Bonney and expand sampling to Lake Hoare (Figure 1). Sampling both hypersaline Lake Bonney and freshwater Lake Hoare will capture a range of lacustrine conditions in Taylor Valley. Lake Hoare is also a much younger lake than the western lobe of Lake Bonney, and it is expected that background radium levels will be much lower.

In 2012, sampling finished in mid-December. In 2013, sampling will be extended further into the melt season with the goal of measuring seepage initiated by subsurface flow during the austral summer. If subglacial discharge and groundwater seepage into the lakes can be detected we may be able to quantify the remaining unknown hydrologic variables in Taylor Valley, and ultimately understand the climatic drivers of the water cycle.

References:

Burnett, W.C., Cable, J.E., and Corbett, D.R., 2003, Radon tracing of submarine groundwater discharge in coastal environments, *in* Taniguchi, M. and Gamo, T. eds., Land and Marine Hydrogeology, Elsevier, Amsterdam, p. 25–44.

Dugan, H.A., Gleeson, T., Lamoureux, S.F., and Novakowski, K., 2011, Tracing groundwater discharge in a High Arctic lake using radon-222: Environmental Earth Sciences, p. 1–8, doi: 10.1007/s12665-011-1348-6.

Kluge, T., Ilmberger, J., VonRohden, C., and Aeschbach-Hertig, W., 2007, Tracing and quantifying groundwater inflow into lakes using radon-222: Hydrology and Earth System Sciences, v. 11, p. 1621–1631.

Schmidt, A., Stringer, C.E., Haferkorn, U., and Schubert, M., 2009, Quantification of groundwater discharge into lakes using radon-222 as naturally occurring tracer: Environmental Geology, v. 56, p. 855–863.