# Determining the early incision history of the Colorado Plateau using an innovative dating method

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Terrestrial Cosmogenic Nuclide (TCN) exposure and burial dating techniques have been limited to depths of <30 m. Improvements in TCN target chemistry and Accelerator Mass Spectrometry have provided an opportunity to expand this depth in an effort to address previously intractable questions regarding large-scale landscape evolution such as the timing and origin of canyons. The primary objective of this honours thesis is to test the validity and reproducibility of measuring a long-lived TCN ($^{10}$Be, $t_{½}$ = 1.39 Ma) in quartz-dominated sediments using muonproduced nuclides at great depths. The secondary objective of this thesis involves evaluating the timing of early incision history of the northern Colorado Plateau, a topic which remains highly debated.

We have devised a strategy to test the limits of muogenic TCN production at depths >130 m and to estimate the rate and timing of initial incision of a large valley near the Book Cliffs, Utah. High energy cosmic ray primaries (mostly protons) produce secondary particles (such as fast and negative muons) when they interact with nuclei of atoms in the atmosphere or exposed minerals. Muons are 209 times the mass of an electron, and because of their small mass they interact weakly with matter. Thus, muons can penetrate deeply into the subsurface, and cause further interactions to produce rare TCN such as $^{10}$Be.

Samples of graphite-bearing quartzite were collected >130 m below the valley bottom along a mine stope that stretches from bank to bank approximately perpendicular to the valley axis above. The concentration of muogenic $^{10}$Be produced from oxygen and silicon in the quartz will be proportionate to the flux of cosmic radiation received, which has not varied more than 10%, over the past 8 Ma. We hypothesize that the sub-surface $^{10}$Be concentrations will have a spatial pattern that reflects the cosmic ray shielding by the overlying topography. If the incision occurred recently, the 10Be concentrations will be greatest under the deepest portion of the valley. Older or slower incision histories will generate other spatial distributions. Currently seven $^{10}$BeO targets and one process blank are being prepared at Dalhousie University and will be tested at the Center for AMS at Lawrence Livermore National Laboratory. With this project, we hope to first and foremost determine the viability of detecting muogenic isotopes for future applications of the dating method, and to apply the innovation to help constrain the incision history of the Colorado Plateau.

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