Development of non-traditional radioisotopes to fill key age-dating gaps for interpreting geologic and biogeochemical cycles

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Radiotracers provide a powerful tool for understanding a suite of environmental processes but, in many cases, a combination of sample size requirements and inherent limits on dating ranges (driven by isotope half-lives) restrict radiotracer applications. Recent advances in the production of low-background marterials, however, are resulting in improved sensitivity of radioisotope measurement and are thereby enabling re-evaluation of the applicability of specific isotopes for addressing environmental quesitons. We are utilizing cutting-edge measurement approaches to both develop and expanded application of tritium (T) (in water and organic samples), ^{39}argon (^{39}Ar), and ^{32}silicon (^{32}Si) based measurements.

Environmental T concentrations have decreased from a peak of 1000-2000 TU (~1962) to current levels typically < 10 TU; resulting in large sample size and/or preparation requirements for T evaluation. We present sample preparation methods coupled to direct counting of T via ultra-low background proportional counters (ULBPCs) which, when combined, offer up to two orders of magnitude reduced sample size requirements over conventional methods and will help expand the application of T age dating to smaller samples associated with persistent environmental questions. For example, these approaches could be applied to T age dating of specific organic carbon compounds within soils to better understand carbon cycling.

We are also leveraging enhanced sensitivty measurements to enable the evaluation of ^{32}Si and ^{39}Ar for filling key geochronometer gaps in the recent sedimentary (~ 100-1000 year range) and groundwater records (~50-1000 year range). Enhanced resolution in the recent record is crucial for understanding watershed-scale changes occuring as a function of anthrogpogenic and climatic forcings. We use dating of a sediment core from Puget Sound to highlight potential applicability of the ^{32}Si system. Smilarly, the age dating range unlocked by ^{39}Ar (from waters collected near Fresno, CA) reduces the uncertainty of groundwater residence time estimates by filling the T and ^{14}C gap in age distribution modeling used to determine groundwater recharge rates.