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 materials, however, are resulting in improved sensitivity of radioisotope measurement and are thereby enabling re-evaluation of the applicability of specific isotopes for addressing environmental questions. We are utilizing cutting-edge measurement approaches to both develop and expanded application of tritium (T) (in water and organic samples), 39argon (39Ar), and 32silicon (32Si) 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 sensitivity measurements to enable the evaluation of 32Si and 39Ar 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 occurring as a function of anthropogenic and climatic forcings. We use dating of a sediment core from Puget Sound to highlight potential applicability of the 32Si system. Similarly, the age dating range unlocked by 39Ar (from waters collected near Fresno, CA) reduces the uncertainty of groundwater residence time estimates by filling the T and 14C gap in age distribution modeling used to determine groundwater recharge rates.