Charcterization of the rate of phospholipid hydrolysis under abiotic conditions in bentonite

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Membrane phospholipids (PLs), analyzed as intact polar lipids (IPLs) or phospholipid fatty acids (PLFA) are used as biomarkers of the identity, abundances and metabolic activities of extant microbial communities in a wide range of environmental systems. A key factor in the interpretation of PL concentrations is assessment of the timeframe over which the data are applicable. While it is generally accepted that PLs degrade within days to weeks after cell death due to biological activity in surface systems, little is known about their persistence of in low biomass environments such as the deep subsurface. If biological activity is sufficiently low, the degradation of PLs may become controlled by the abiotic hydrolysis rate of the ester bonds. The Materials Corrosion Test (MaCoTe) study being undertaken in the Grimsel underground laboratory in Switzerland represents a unique opportunity to investigate the degradation of PL in a low biomass system. Modules containing bentonite packed to densities previously indicated to prevent microbial growth have been installed in boreholes within the granite massif. Here we report the characterization of PLFA concentrations within the bentonite modules over a 3 year period. PLFA concentrations decreased in all interior samples with a pseudo first order rate constant of 3.0×10^{-8} s^{-1} equivalent to a half-life of 0.73 years. This rate is comparable to the rate reported previously for phospholipid hydrolysis at 40 C in laboratory studies implying that abiotic hydrolysis is the mechanism of phospholipid removal. These observations imply that detectable phospholipids would be expected to persist a maximum of 3 to 4 years (4 to 6 half-lives) in environmental samples due to abiotic hydrolysis processes.