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Rapid Clay Authigenesis in Large River Delta: Evidence from Porewater Geochemistry of Ganga Sediments

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The formation of authigenic clay mineral in the marine realm through reverse weathering consumes seawater (SW) alkalinity and releases CO_2 to the ocean-atmosphere reservoir; thus, playing a critical role in modulating the global carbon cycle, and ocean chemistry. Direct evidence of natural reverse weathering in coastal environment is limited to single study from Amazon Delta[1–3]. Thus, the scale and importance of reverse weathering in modulating seawater chemistry and global climate remains enigmatic.

We provide direct evidence of authigenic clay mineral formation in the lower delta region of the Ganga River based on shallow porewater (PW) profiles of alkali and alkaline earth elements from high salinity regions (17–26‰). We observe that in presence of biogenic silica, there is rapid consumption of alkali elements in sediments, associated with an excess of dissolved Si. The depth dependent fluid phase chemistry of the porewaters demonstrate significant removal of K (8.0 to 4.5 mmol/L) and Li (15.1 to 5.6 µmol/L), amounting to an uptake of ~27% and ~58% for these two elements (salinity normalized). This is accompanied by up to ~59-fold increase in dissolved Si concentration in porewater within the upper 50 cm of sediment compared to overlying estuarine water (~9 µmol/L). The depth profiles of porewater lithium isotopes demonstrate a classical signature of lighter isotope (^{6}Li) incorporation into authigenic clay. This is evident from significant rise in d^7Li_{PW} to ~39–40‰ at depths of ~10 cm w.r.t modern d^7Li_{SW} (31‰). This preferential incorporation of light Li confirms structural incorporation in subsurface sediment of Ganga Delta, with a fractionation factor of 0.9842±0.0008. High resolution SEM imaging of the solid phase, corroborated by the elemental mapping (EDS), further reveals the presence of diagenetically altered biogenic silica. Our revised calculations will probe the net CO_2 addition to the ocean-atmosphere system through reverse weathering by expanding the presently observed reaction rates to global scenario.

References: [1] P. Michalopoulos, R. C. Aller and R. J. Reeder, Geology, 2000, 28, 1095–1098. [2] P. Michalopoulos and R. C. Aller, Geochim Cosmochim Acta, 2004, 68, 1061–1085. [3] P. Michalopoulos and R. C. Aller, Science (1979), 1995, 270, 614–617.

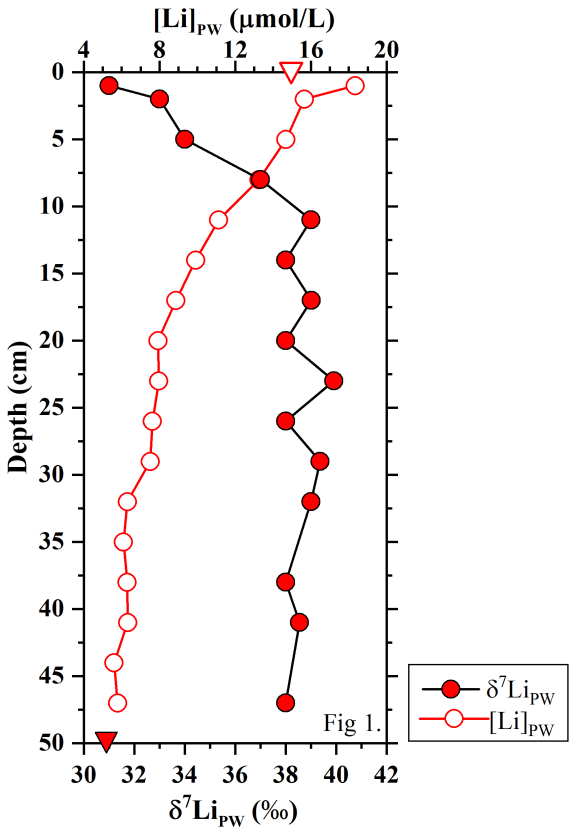

Fig 1.

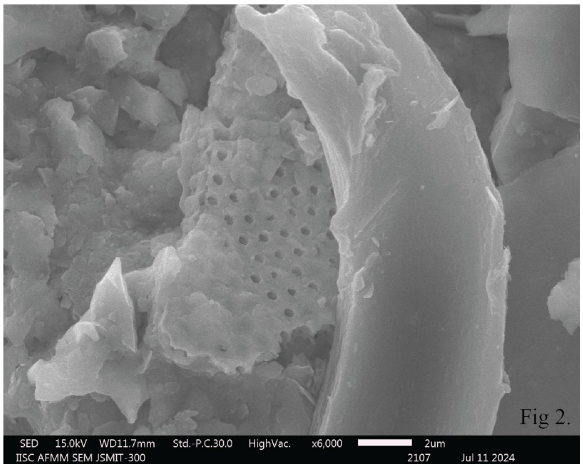

Fig 2.