Scaling of sulfur geochemical processes in prairie pothole wetlands

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The Prairie Pothole Region (PPR) extends from Alberta, CAN to Iowa, USA and hosts millions of wetlands that provide rich habitat for migratory waterfowl. Alteration of the underlying FeS_2-bearing glacial till controls the chemistry of PPR wetland water which evolves to SO_4^{2-} dominance. Our data from a 92 ha site near Jamestown ND, USA, document an upper zone of oxidized glacial till (iron oxide-rich, FeS_2 depleted, and $CaSO_4 \bullet 2H_20$-bearing) that has a mean thickness of 6.1 m and overlies unoxidized FeS_2-bearing till. Detailed petrographic studies and similar $\delta^{34}S$ values of till-hosted FeS_2 (mean;-19‰) and $CaSO_4 \bullet 2H_20$ (mean;-17‰) confirm that FeS_2 is the source of SO_4^{2-}. $\delta^{34}S$ values of dissolved sulfate are more positive in groundwater (mean;-11‰) and wetland water (mean;-6‰) as a result of microbial sulfate reduction.

Oxidation of pyritic till is widespread in the region. Data from nearly 500 well logs in a 10^3 km^2 area surrounding the ND study site document oxidation to an average depth 7.8 m. We studied geochemistry of ~180 wetlands from this same area together with 77 wetlands from throughout the USA PPR. The $\delta^{34}S_{SO4}$ range;-23 to +22‰, is large for terrestrial surface waters. Wetland size and $\delta^{34}S$ values are positively correlated The larger wetlands overlie outwash glacial outwash sands and have enhanced groundwater connectivity. We attribute this correlation to both a larger ratio of bottom sediment area to water volume (resulting in more efficient removal of isotopically light reduced S to sediments) and to input of microbially modified $SO_4^{2-}$from groundwater in better connected wetlands. Thus, sulfur geochemical processes scale consistently from local to regional in the ecologically important PPR.