

Molecular basis of soil carbon protection by mineral surfaces

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Soils are the largest pool of organic carbon near the Earth's surface, and they exchange carbon with the atmosphere at a rate roughly six times greater than that of anthropogenic carbon emissions. Despite the likely importance of soils to the future of Earth's carbon cycle, the fundamental controls on the carbon content of soils remain poorly understood. Here, we review the existing evidence from both field and laboratory scale studies regarding the affinity of organic molecules for mineral surfaces, its sensitivity to aqueous, mineral, and organic chemistry, and the importance of adsorption in controlling the fate of carbon in soils. We focus particularly on the affinity of dissolved organic compounds for layered silicate minerals (i.e., clay minerals). The existing database reveals a remarkably strong sensitivity of organic-clay mineral interactions to the surface charge density of the clay minerals and to the size and shape of the organic compounds. We discuss the implications of these observations with regard to the fundamental mechanisms of soil carbon recalcitrance.