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Mineralogical controls on organic carbon stabilisation and persistence

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The interconnected processes of organic carbon production, transformation and storage are strongly controlled by soil and sediment minerals, whose ubiquity and reactivity govern organic carbon stability and persistence in terrestrial and marine environments. Mineral-carbon interactions include adsorption, coprecipitation, aggregation and polymerisation, that together act to pump carbon from less stable forms that are more easily mineralised to more stable forms that survive microbial attack. In natural systems mineral-carbon interactions modulate atmospheric carbon dioxide and oxygen and play a critical role in the global carbon and oxygen cycles. In engineered contexts mineral-carbon interactions could be central to carbon capture and storage technologies, where minerals such as iron oxyhydroxides might be harnessed to lock carbon away from the atmosphere. Recent advances in spectroscopy, microscopy and computational modelling provide exciting insights into the mechanisms of carbon uptake and release at mineral interfaces, that can be used to investigate the role of mineral-carbon interactions in the Earth system. Here we will explore the mechanisms, products and impacts of mineral-carbon interactions for carbon storage over past, present and future timescales. We will identify key knowledge gaps at the nexus of mineralogical and microbiological controls on carbon transformation and storage, and highlight emerging frontiers for research that could improve our ability to predict carbon cycling in natural and engineered environments.