Trace metals are essential for life and the concentration of trace metals in the surface oceans regulates photosynthetic activity, which in turn regulates the drawdown of atmospheric carbon dioxide and ultimately climate. The processes governing the concentration of trace metals in the oceans are complex but in most cases the ocean sediments provide an important sink for these bio-essential elements, locking up trace metals with sediment minerals. This talk will introduce the importance of trace metals in the ocean system, the importance and peculiarities of marine sediment minerals, the processes by which trace metals are scavenged by these intriguing phases, and what happens to trace metals as these phases change during sediment diagenesis. We will see that the global scale cycling of trace metals in the oceans is governed by molecular scale interactions between trace metals and minerals.