Uranium Isotopes in Fine-grained Clastic Sediments: A New Perspective on Erosion and Sedimentation

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High precision uranium isotope measurements may provide a means of determining the timescale associated with the transformation of bedrock to sediment, which includes the time required to mechanically break down rock into transportable fragments, the residence time of sediment particles in soils, streambeds, floodplains, dunes, and moraines, and their transport by wind, rivers and ocean currents to the site of final deposition on the seafloor or in lakes. The interpretation of variations in the 234U/238U ratios in sediments is based on a model for the disruption of the 238U decay series due to the loss of the decay product 234Th by recoil associated with the alpha decay of 238U. This paper presents the results of a study of 234U/238U ratios, as well as O, Nd and Sr isotopes, in fine-grained deep sea sediments, 0 to about 400 ky in age, cored in the North Atlantic Ocean at Ocean Drilling Program Site 984A. The sediments are largely siliciclastic, but have a significant carbonate component that varies between a few and 30 per cent by volume. The O isotope data obtained on separated foraminifera clearly show the last several glacial cycles, and thus provide a detailed temporal framework for the sediments. The Nd and Sr isotopic data show that the provenance of the sediment has oscillated, roughly but not exactly, in concert with the extent of continental ice volume, between a local source - probably volcanic rocks from Iceland - and a continental source. An unexpected finding is that the 234U/238U ratios of the siliciclastic portion of the sediment, isolated by leaching, show large and systematic variations that are correlated with glacial cycles and to some degree with sediment provenance. The U isotope variations are inferred to reflect differences in the transport time of the sediment - the time elapsed between the generation of the small sediment particles on Iceland and the continental source areas, and the time of deposition on the seafloor in the North Atlantic Ocean. The calculated transport times vary from less than 10 kyr to about 400 kyr. The long transport times for deposition during glacial times are inferred to be due to storage either as loess deposits or on continental shelves. During interglacials the far-traveled detritus is heavily diluted with sediment derived from Iceland and transported to the site of deposition within 10 kyr.