How significantly are we disturbing near-surface element cycles?

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The cycles of all elements on earth have been disturbed to various extents by anthropogenic activities. An accounting of natural versus anthropogenic mass transfer fluxes involving reservoirs that are connected to the earth's surface (i.e. discounting deep earth mass transfer processes) shows that cycles of platinum group metals, helium, gold and many base metals are now dominated by anthropogenic processes [1, 2]. In contrast, cycles of many elements that are abundant, soluble in natural waters, or biologically utilized (e.g. Cl, Br, Na, N, C, P, K, Mg, Ca) are still dominated by natural transfer processes. Major uncertainties in the accounting of fluxes are associated with difficulties in quantifying anthropogenic affects on soil erosion [2]. The position of elements along the gradient of anthropogenically vs. naturally dominated transfer processes is also a strong function of element utilization in modern industrial processes. For instance, "critical elements" such as Co and Li have moved from naturally dominated cycles to more strongly anthropogenically-influenced cycles within the last decades. In contrast, known elemental toxins such as Pb show signs of decreasing anthropogenic influence, partly at the expense of metals - such as the platinum group elements - that are utilized in technological replacements (e.g. catalytic converters) to major prior uses of Pb (e.g. tetraethyl lead in gasoline) that have caused severe environmental pollution.

Careful analyses of "sedimentary archives" such as snow, ice, peat and sediment cores illustrate the temporal (and spatial) evolution of anthropogenic impacts on elemental cycles. For instance, peat records from Spain reaching back several thousands of years demonstrate that platinum group metal contamination first occurred through mining on the Iberian Peninsular during the Roman Empire, and only recently greatly intensified through the combined effects of catalytic converter utilization, fossil fuel burning and increased erosion [3]. In contrast, many sedimentary archives - but also long-term tracing of seawater contamination - show that anthropogenic lead is being transferred from fast cycling into more slowly cycling geochemical reservoirs [4].

[1] Klee & Graedel (2004) *Annu Rev Environ Resour* **29**, 69ff. [2] Sen & Peucker-Ehrenbrink (2012) *Environ Sci Technol* **46**, 8601ff. [3] Rauch *et al*. (2010) *Environ Sci Technol* **44**, 881ff. [4] Kelly *et al*. (2009) *Earth Planet Sci Lett* **283**, 93ff.