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Heavy mineral content of dredged sediment, its resource potential and its relationship to elevated REE concentrations in groundwater around a dredged material placement facility, Upper Chesapeake Bay, Maryland (USA)

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Sediments dredged to maintain navigational channels and stored in the Pearce Creek dredged material placement facility on the shore of the Chesapeake Bay were sampled to investigate potential links to elevated rare earth element (REE) concentrations in groundwater surrounding the facility. The heavy mineral fraction, generally less than 3 weight percent, is dominated by magnetite, ilmenite, and rutile, followed by dense silicate minerals such as aluminosilicate, staurolite, garnet, and zircon. Accessory REE hosts include apatite, monazite, xenotime, and allanite. Gold is also present in trace amounts. Groundwater shows considerable range in pH (3.5 – 7.8), pe (-3.9 – 11.1), and dissolved (< 0.45 um) concentrations of notably sodium (Na, 6.0 – 490 mg/L), chloride (Cl, 4.3 – 765 mg/L), alkalinity (0 – 554 mg/L $CaCO_3$ equivalent), sulfate (2.1 – 2,770 mg/L), iron (Fe, 0.02 – 428 mg/L), and (SREE (0.0001 – 3.37 mg/L). Sulfate, Fe and REE concentrations increase with decreasing pH. Maximum REE concentrations are roughly an order of magnitude higher than maximum values reported for coal mine drainage [1] (Stewart et al., 2017). Geochemical modeling (PHREEQC) indicates that the groundwater is in equilibrium with poorly crystalline $Fe(OH)_3$, and that REEs predominantly occur as carbonate/bicarbonate and phosphate complexes at neutral pH, but transition to sulfate complexes and the free ion at lower pH. Modeling also indicates that REE phosphates are saturated or supersaturated at neutral pH, but become increasingly undersaturated at lower pH. Heavy REEs are more undersaturated at lower pH than light REEs. These results are consistent with NASC-normalized REE patterns. The correlation of dissolved REEs with Fe, sulfate, and decreasing pH suggest that acid generation from oxidation of sedimentary iron sulfide was critical in mobilizing REEs from REE-bearing phosphate minerals, which is consistent with a previous study [2]. The heavy mineral fraction of dredged sediments warrants further evaluation as potential resources for Ti, Zr, Hf, and REEs, in addition to Au.

[1] Stewart et al. (2017), *International Journal of Coal Geology* 169, 28–39

[2] Goodman et al. (2023), *Science of the Total Environment* 884, 163725