Chemical character and burial of sediment Phosphorus in the Gulf of Finland (Baltic Sea)

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Gulf of Finland (NE Baltic Sea) is highly eutrophied and suffers from intensive blooms of blue green algae despite anthropogenic loading of phosphorus (P) has decreased. One reason for this may be release of P from bottom sediments. Iron (Fe) bound P is released from sediments in anoxic conditions [1] and anoxia is common in the Gulf because of water column stratification and bottom morphometry. However, sediment P may be released also in oxic conditions [2]. Release of sediment P depends on its chemical character.

We studied chemical character of sediment P by fractionation, in order to evaluate its potential mobility and burial in shallow estuaries, coastal areas, and open sea areas with poor oxygen conditions. The method [3] separates six sedimentary P forms: 1) pore water and loosely bound P, 2) P bound to oxides of reducible metals (Fe), 3) transformable organic P, 4) P bound to oxides of aluminum, 5) apatite-P, and 6) residual organic P. In addition, we determined several parameters from sediments and pore waters.

Estuary sediments with fast sedimentation accumulated high concentrations of river transported P. P was mainly in inorganic form and, in addition to oxic sediment surfaces, Fe-bound P was also present in deep layers. This may result from incomplete Fe reduction [4] and dissolution of Fe not reducible in natural conditions. Coastal and open sea sediments were high in organic P and its concentration increased towards the inner bay (i.e. eastwards) and highest P load. Most of organic P was buried with sediment, though part of it seemed to be released in the long run. This may be one reason for the slow response of the Gulf of Finland to decreased anthropogenic P loading. Sediments in the western part of the open Gulf and in the northern Baltic Proper were high in apatite-P and most of deposited P was buried. On the contrary, burial efficiency of deposited P was lowest in coastal sediments high in organic P.

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Temperature gradient driven magma differentiation and isotopic fractionation

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The existing database of igneous rocks shows a clear increase in δ^{56}Fe at high SiO_2 raising basic questions about how magma differentiation occurs. Answers require integrating relevant experiments with observations from igneous rocks in a local geological context.

While the equilibrium isotopic fractionation factors between phases at high T appear small based on theory and experiment, the isotopic fractionation by thermal diffusion is large [1-3]. Our measurements of both thermal migration and Soret experiments show positive covariations in δ^{56}Fe, δ^{30}Si and δ^{26}Mg (with δ^{26}Mg offsets of up to 1.7% for ΔT of 260°C [3]). Wet andesite placed in a 950-350°C temperature gradient evolves to a granitic bulk composition at the low temperature end. Compositions with position form a calc-alkaline trend identical to convergent margin rocks. Temperature gradient driven differentiation is plausible if magmatic time scales are long, as observations in silicic igneous rocks suggest. If magma underplating occurs, long duration thermal migration could be a relevant differentiation mechanism.

We suggest this process may explain δ^{56}Fe data from two igneous bodies in the Duluth Complex (MN). The Sonju Lake Intrusion (SLI) is a small layered mafic intrusion lying below the normally zoned Finland Granite (FG) of the same age. While mineralogy, phase compositions, and trace elements smoothly grade between the two bodies, the 1:1 volume relationship and Sr isotopes rule out a straightforward genetic relationship. The average and standard deviation for $\delta^{56}Fe_{IRMM14}$ in 8 SLI samples is 0.09±0.04 (1s), while the core Finland granite has a $\delta^{56}Fe_{RMM14}$=0.27(04). Notably, the outer Finland monzodiorite has δ^{56}Fe=0.09(03). This latter observation suggests the heavy δ^{56}Fe of the granite is not a source effect but rather process related—the heavy δ^{56}Fe of the granite is consistent with a model of differentiation to granite by sustained thermal migration. Planned analyses of δ^{30}Si and δ^{26}Mg will help to further test this model.

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