

## The adsorption of Th and Pa on different particle types in dependence of the provenance of natural seawater

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We performed experiments in order to investigate the adsorption of Th and Pa on different particles in recently sampled seawater. Water from three different locations was 0.2 µm filtered. Then, four different particle types were added to the respective seawater samples at a concentration of 0.5 mg/l, and neutralized Th and Pa spikes were added. Additionally, one sample was run without particles added. Th and Pa distribution was monitored in increasing time intervals for several days.

Spike recoveries ranged from 40 to 100 % for Th and from 50 to 100 % for Pa (depending on particle type). Our recoveries are higher than previously observed in experiments with artificial seawater. The low losses to the container walls allowed the determination of distribution coefficients ( $K_d$ ) for different particle types. Th on MnO<sub>2</sub> was found to have a  $K_d$  of  $>3 \cdot 10^7$  in all water types, Pa on the same particle type  $>2 \cdot 10^7$ . On smectite,  $K_d$ Th was found to range between 4 and  $10 \cdot 10^6$  towards the end of the experiments.  $K_d$ Pa in the same samples was 1.2 to  $1.8 \cdot 10^6$ . On biogenic opal particles,  $K_d$ Th was about  $1 \cdot 10^6$  in two of three samples. In the water sample from the Subtropical Gyre (Argentine Basin), its  $K_d$  was found to be twice as high ( $2 \cdot 10^6$ ) at the start of the experiment, and up to  $8 \cdot 10^6$  at the end. For Pa on opal,  $K_d$ s of  $0.5 \cdot 10^6$  resulted in general, with two somewhat higher exceptions ( $1 \cdot 10^6$ ) towards the end of the experiments. The experiment with CaCO<sub>3</sub> (non-biogenic) resulted in very variable  $K_d$ s depending on the water type used for both Th and Pa.

One of the most interesting results was the large percentage of Th and Pa found in the particulate fraction when no particles were added. This must be attributed to the spontaneous formation of particles from the colloidal phase  $<0.2$  µm, like described by Chin et al. (1998). Consequently, the temporal pattern of Th and Pa adsorption in our experiments is considered to reflect the process of colloid aggregation. A very similar pattern of aggregation in all three samples without particles added was observed, although on a different level. A strong relationship between the adsorption pattern on smectite and the aggregation pattern without particles points to a potential role of clay minerals for the uptake of dissolved organic matter (DOM) in aquatic systems, like it has been extensively described for soils.

### References

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## Combining control volume finite element methods with realistic fluid properties for high-resolution simulations of multiphase flow in magmatic-hydrothermal systems

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Realistic modelling of multi-phase fluid flow in magmatic-hydrothermal systems is very challenging because hydrological properties of fluids and rocks vary over many orders of magnitude. The governing equations for the hydrodynamics and thermodynamics in magmatic hydrothermal systems are highly non-linear and strongly coupled. Essential requirements of a numerical formulation for such a system are: (1) a treatment of the hydrodynamics that can accurately resolve complex geological structures and represent the highly variable fluid velocities herein, (2) a realistic thermodynamic representation of the fluid properties including the wide P-T-X range of liquid+vapour coexistence for the highly saline fluids, and (3) an accurate handling of the highly contrasting transport properties of the two fluids.

Recently, control volume finite element methods (CVFEM) have been successfully applied to model multiphase flow and energy transport (e.g., Forsyth 1994). CVFEM combine the best features of finite volume and finite element methods. CVFEM are mass and shock preserving, yield great geometric flexibility in 2D and 3D. Furthermore, efficient matrix solvers can be employed to model fluid flow in geologically realistic structures (e.g., Matthäi & Roberts, 1996).

We chose the system water-NaCl as a realistic proxy for natural fluids occurring in magmatic-hydrothermal systems. An in-depth evaluation of the available experimental and theoretical data led to a consistent and accurate set of formulations for the PVTXH relations that are valid from 0 to 800°C, 0 to 500 MPa, and 0 to 1  $X_{\text{NaCl}}$ . The accuracy of the representation is probably sufficient to derive thermochemical properties of the NaCl and H<sub>2</sub>O components for future incorporation of reactive transport schemes. Dynamic viscosities are currently approximated by the approach of Palliser & McKibbin (1998).

### References

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