Reactive transport modeling of Sr-90 sorption in reactive sandpacks

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Granular clinoptilolite was shown to be an effective material to treat groundwater contaminated with the radionuclide Sr-90, as proven in a permeable reactive barrier (PRB) at the Chalk River site, Ontario, Canada [1]. A large number of pore volumes can be treated, because clinoptilolite is characterized by a high sorption potential with effective distribution coefficients (K_d) exceeding 6900 cm^3/g [2]. Recently, an alternative treatment technology has been proposed, using the same reactive material as an in-situ reactive sandpack to reduce contaminant levels in extracted groundwater. Reactive sandpacks can be installed around the well during construction and contaminated water is treated in the direct vicinity of the extraction well [2].

A proof-of-concept study was initiated by conducting a series of in-well column experiments to test adsorption behaviour for Sr-90 and contaminant treatment for flow conditions representative to those near a well screen [2]. Fitted distribution coefficients were strongly correlated to flow rates, indicating that Sr-90 adsorption cannot be described by an equilibrium sorption model [2]. In addition, a reduction in flow rates was observed over time, which was attributed to iron oxide precipitation in the treatment material [2], potentially also causing a reduction in clinoptilolite reactivity.

To further interpret the observed data, the reactive transport model MIN3P was used to simulate the experimental results in an attempt to better understand the sorption mechanisms. Transient boundary conditions were accounted for by varying flow rates and aqueous Sr-90 concentrations. Preliminary results confirm that the distribution coefficient (K_d) varies as a function of flow rates and breakthrough occurs earlier than predicted based on the equilibrium model. Therefore, in addition to transient boundary conditions, a kinetically-controlled linear adsorption model is used to reproduce observation data.

In addition, we evaluate whether a cation exchange model coupled with multi-rate mass transfer processes provides a more adequate description of Sr-90 attenuation. Building on the work of Jeen et al. [3], a formulation that simultaneously considers the reduction of hydraulic conductivity and decrease of reactivity as a function of mineral precipitation will be presented. This new formulation will allow to carry out long-term simulations constrained by experimental data, accounting for iron oxide precipitation as observed in the sectioned solid samples.

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[3] Jeen *et al.* (2007) *Environ. Sci. Technol*. **41,** 1432-1438.

Multi-episodic modification of the lower crust beneath the North China block: responses to the Phanerozoic decratonization

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It has been generally accepted that the North China craton has considerably lost its continental lithospheric root in the Phanerozoic on the basis of multidisciplinary studies on the lithosphric evolution over the past decade. The formerly existed thick, cold Archean lithospheric mantle has been severely thinned, destructed and replaced by relatively hot and young mantle with oceanic affinity. It is worth noting, however, that the previous investigations regarding to the lithospheric evolution were mainly focued on the mantle lithosphere, how does the lower crust, namely, the other part of the lithosphere respond to such tremendous change in lithospheric structure is another important issue to be addressed.

With the outcrops of crustal materials as old as 3.8 Ga, the North China craton is one of the oldest cratons in the world. The widely distributed 2.5 Ga basement, on the one hand confirmed the existence of ancient lower crust, and on the other hand suggested that the North China was cratonized at that time. Our latest geochronological and geochemical studies on a suite of lower crustal granulite xenoliths entrapped in the Mesozoic volcanic rocks, along with the results of granulite and pyroxenite xeoliths from the other localities on the craton have shed light on the evolution of the lower crust. Zircon U-Pb age analyses revealed that, besides the ubiquitous Archean age population (predominantly 2.5 Ga), there are also Phanerozoic age populations ranging from Permian to Paleogene, varying from different localities. The Archean age population implies the existence of the ancient lower crust throughout the North China craton, while the Phanerozoic age populations imply that the ancient lower crust has been modified, most possibly through multi-episodic magmatic underplating. Zircons of different age populations also show varied Hf isotopic compositions, suggesting that the underplating magmas were from different sources. In addition to the compositional modification, the depth that the lower crust extended at different time was also changed remarkably, similar to the thinning mantle lithosphere during the Phanerozoic, the thickness of lower crust has also been thinned since the early Mesozoic.

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