Geostatistical analysis for estimating the spatial variability of hydrogeological and soil parameters for the regional simulation of land subsidence in Shanghai City, China

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Study on the spatial distribution of hydrogeological and soil parameters has great importance on improving the simulation precision for land subsidence caused by excessive withdrawal of groundwater. In a regional field investigation, only a small fraction of *in situ* data such as hydraulic conductivity can be analyzed, owing to time and cost constraints. The sparse measured data contain a considerable degree of uncertainty, especially for the parameters describing the soil properties, such as porosity, compress index and rebound index in deep aquifers. The absence of the parameter information is one of the obstacles for the precise prediction.

The objective of this study is to determine hydrogeological and soil parameter distributions of the aquifer system as inputs in numerical model for land subsidence in Shanghai City, using Kriging methods and sequential Gaussian simulations. The spatial structure analyses by GSLIB software revealed that the log of hydraulic conductivity has strongly anisotropic variability and the anisotropic of topography in such area is controlled by its hydrogeology factor while aquifer was forming. Although the stochastic field of the hydraulic conductivity is fairly well presented by using ordinary Kriging and conditional simulation method, ordinary Kriging provides the bad estimation of soil parameters at unsampled sites because of sparse measured data. On the other hand, fairly good correlations are found between the compress index and rebound index, between the porosity and hydraulic conductivity, and between the porosity and compress index. As a result, the cross-variograms were modeled and used for Cokriging method. Results showed that Cokriging is efficient for deriving the soil parameters such as compress index, rebound index and porosity combing with the hydraulic conductivity, which is more easily obtained.

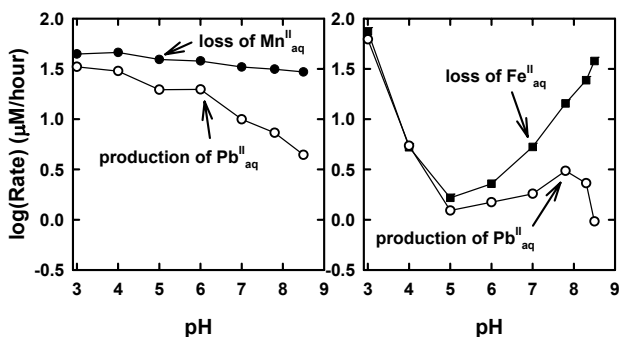# (Physico)chemical controls on rates of reductive dissolution

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Subsurface interstitial waters contain a complex mixture of inorganic and organic constituents, each with distinctive (physico)chemical properties. Overall reductive dissolution rates reflect the combined effects of these constituents.

Water infiltration is accompanied by the successive loss of surface-active natural organic matter (NOM) via adsorption. To simulate this effect, ferric chloride and aluminum sulfate coagulants were added to NOM-rich water, then filtered. Coagulation/filtration decreased the dissolved organic carbon concentration (in mgC/L), yet increased subsequent rates of $Pb^{IV}O_2$(plattnerite) reductive dissolution. Our hypotheses are that (1) Coagulation/filtration removes a NOM sub-fraction that is surface-active, yet deficient in reductant groups; (2) The portion of NOM that remains is rich in reductant groups. and (3) The surface-active fraction blocks PbO_2 surface sites from attack by the reductant-rich fraction. A series of substituted hydroquinones was added to untreated NOM-rich water and to coagulation/filtration treated water. Hydroquinones bearing anionic, hydrophilic groups experienced the greatest inhibitory effect from the surface-active sub-fraction. Those bearing cationic, hydrophilic groups experienced the least inhibitory effect.

PbO_2 is subject to reductive dissolution by Fe^{2+} and Mn^{2+}. Initial rates for reaction of 20 μM PbO_2 with 20 μM $MnCl_2$ or 40 μM $FeCl_2$ are shown below:

PbO_2 surfaces become buried and Pb^{II} becomes adsorbed or incorporated by the oxyhydroxides generated from Mn^{II} and Fe^{II} oxidation. Hence, evolving features of the suspended particles govern forward reaction rates.