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Geostatistical description of lithofacies distribution in the aquifer system of Cremona, Italy.

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We develop two alternative conceptual models to describe the heterogeneous spatial distribution of geomaterials within the groundwater system in the proximity of the city of Cremona, Italy. The key hydrogeologic feature of the region is the occurrence of the *Springs Belt* which develops across the entire Lombardia region and provides a major source of fresh water for agricultural needs. During recent years the natural springs of the Cremona aquifer have been increasingly threatened by over-abstraction and contamination by agricultural fertilizers. The area investigated includes the main natural springs in the region, and is located between the Adda and the Serio rivers, covering a surface of approximately 785 km^2. The groundwater system is constituted by two main productive aquifers, which are separated by a locally discontinuous aquitard. The vertical variability of geomaterials distribution inferred from available well logs suggests that the system is relatively heterogeneous on the given observation scale. Lithofacies distribution within each identified aquifer is estimated upon considering two alternative conceptual models: (a) a composite medium scheme, and (b) a multiple-continua approach. In the former scenario, the system is conceptualized as composed by disjoint blocks of different materials, the boundaries of which can be uncertain. The latter approach assumes that the porous medium is composed by a set of overlapping continua, whose relative fraction at a given location can be uncertain. We start by classifying available sedimentological information and group the various identified lithotypes into five separate clusters. An extension of the indicator-based approach of *Guadagnini et al*. [2004] is then developed in order to provide a geostatistical chracterization of lithotypes distribution when the system is described as a composite medium. A multi-continua description is achieved by means of multiple indicator Kriging techniques. With the aid of formal model selection criteria we associate different tested indicator variogram models (and associated parameters) with a weight, or posterior probability, representing their relative degrees of likelihood. Interestingly, we noted that some of the weights are not small enough to justify adopting one variogram model at the exclusion of all the others. This suggests that predicting the aquifer behavior to future forcings and assessing the corresponding predictive uncertainty may best be accomplished using a multimodel approach such as maximum likelihood Bayesian model averaging (MLBMA).

References

Guadagnini, L., A. Guadagnini, and D.M. Tartakovsky (2004), Probabilistic Reconstruction of geologic facies, *J. of Hydrol.*, 294, 57-67.