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Dealing with heterogeneity in limestone aquifers: insights from five years of field and modelling studies at the Hydrogeological Experimental Site (HES) of Poitiers, France.

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Because of the various types and scales of heterogeneities encountered in calcareous rocks, flow and transport modelling in limestone aquifers remains one of the most challenging problems in subsurface hydrology. Important questions remain unanswered at the field scale as to what extent the concepts used in models are based on realistic descriptions of a rock volume and whether adequate data can be collected from site characterization. In order to improve the predictive capabilities of numerical models, there is a real need for modelling to study real data sets collected from a variety of hydro-geologic environments. However, there is a dearth of in-situ research facilities in bedded rocks as compared to those developed in crystalline rocks (mainly related to radioactive waste management studies). As a contribution to fill this gap, a new experimental site has been developed in Poitiers, France. The Hydrogeological Experimental Site (HES) of Poitiers covers an area of 12 hectares and includes 32 wells drilled to a depth of 120 m. The focus is on a 100m-thick confined limestone aquifer. Extensive hydrogeophysical investigations have been made at the HES since 2002 (see the recent synthesis by Audouin et al. 2008) which indicate that flowpaths in the HES aquifer are strongly constrained within (1) subhorizontal karstic structures and (2) subvertical fractures. Typically-shaped drawdown curves have been consistently monitored during pumping tests. These curves show an upward curvature when plotted versus the

logarithm of time, which makes them uninterpretable with conventional models such as the Cooper and Jacob straight-line method. A second particular feature is that most drawdown curves are merged both in time and amplitude, which may infer that each location of the HES is evenly stressed irrespective of its distance from the pumped well. Such behaviour stems from the very rapid propagation of pressure-head perturbations through preferential flowpath networks made by fractures and karstic channels, which has been proven by cross-borehole slug test analysis (Audouin and Bodin 2008). From a scientific point of view, the overall HES heterogeneity (dual nature of hydraulic flowpaths, clustering of karstic structures, limestone texture variability) and the large amount of data collected since 2002 offer a great opportunity to get new insights in the hydrogeologic modelling of limestone aquifers. Since October 2006, six modelling teams have been involved in a national research project attempting to confront different modelling approaches to the HES data (MACH-1 project: "Modelling of Heterogeneous Carbonate Aquifers – 1. Flow Dynamics"). The tested models are based on various conceptual/numerical approaches: 2D heterogeneous continuum, 2D double/triple continuum, discrete-continuum hybrid model, fractured porous media, 3D discrete fracture networks, and 3D pipe-networks. The main goal of the MACH-1 project is to analyse to which extent the variability and density of the HES data are both relevant and sufficient to confer some predictive capabilities to these models.

O. Audouin, J. Bodin, G. Porel, and B. Bourbiaux, Flowpath structure in a limestone aquifer: multi-borehole logging investigations at the Hydrogeological Experimental Site of Poitiers, France, Hydrogeol. J., in press, 2008.

O. Audouin and J. Bodin, Cross-borehole slug test analysis in a fractured limestone aquifer, J. Hydrol. 348, 2008.