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A field experiment to monitor the gravimetric and geodetic changes during a large-scale pumping test in a crystalline aquifer

O. Bour (1), T. Jacob (2), F. Boudin (3), F. Moreau (1), R. Bayer (2), M. Maia (4), J-P. Caudal (1), P. Davy (1), S. Durand (6), O. Dauteuil (1), N. Le Moigne (2), MF Esnoult (3), J. Hinderer (5), B. Luck (5), M-F Lalancette (7), C. Batany (7), L.Morel (6), A. Ferrand (6), P. Gavrilenko (1), N. Florsch (8)

(1) Géosciences Rennes, UMR 6118 CNRS, Université Rennes 1, Campus Beaulieu, 35042 Rennes cedex, France

(2) ISTEEM, UMR 5573 CNRS, Université Montpellier 2, Montpellier, France

(3) UMR 7580 Simogénèse, CNRS, Institut de Physique du Globe de Paris, Paris, France

(4) UMR 6538 Domaines Océaniques, CNRS, Université de Bretagne Occidentale, Brest, France

(5) EOST, UMR 7516, Institut de Physique du Globe de Strasbourg, Strasbourg, France

(6) Laboratoire de Géodésie et Géomatique, ESGT-CNAM, Le Mans, France

(7) Laboratoire de Géophysique, SHOM, Brest, France

(8) UMR 7619 Sisyphe CNRS, Université Pierre et Marie Curie, Paris, France

To image the hydraulic and mechanical properties of a highly fractured aquifer, we conduct a gravimetric and geodetic monitoring during a large-scale pumping test at Ploemeur (French Brittany). The objective of the gravimetric monitoring was to quantify the possible variations of mass within the aquifer during the experiment. Once related with the variations of piezometric levels, such measurements should allow quantifying the porosity of the upper unconfined aquifer. Simultaneously, possible deformation of the ground surface was expected due to the change of mass within the upper unconfined aquifer and because of the variations with time of the water pressure within the lower confined aquifer.

In this abstract, we mainly describe the design of this large-scale experiment and present some preliminary results. The crystalline aquifer of Ploemeur (French Brittany) is characterized by a complex geometry with highly heterogeneous properties. The aquifer is mainly confined, the unconfined part of the aquifer being limited to the upper part of the aquifer within weathered rocks. The deeper confined aquifer is used for water supply at a pumping rate of about 120 m^3. During the experiment, all the water abstraction was stopped for about 39 hours. The variations of the piezometric levels were continuously monitored at various depths, from 25 to 120 meters, in about 20 piezometers around the pumping wells. The variations of the piezometric levels were about 10-12 meters close to the pumping wells to about 1-2 meters 500 meters away from the abtractions wells. During the experiment, 2 absolute gravimeters and five relative gravimeters have been used to record gravimetric changes. The vertical deformation of the ground surface was monitored through a network of 2 long-base tiltmeters, 2 Blum tiltmeters, 7 GPS receivers (5 bifrequency and 2 monofrequency) and the differential levelling of a zone of about 1 km^2.

The gravimetric measurements does not reveal significant variations during the hydrologic experiment showing that the variations of mass remain very low despite high water level changes. Thus, it implies either a very low value of the porosity of the upper unconfined aquifer or very few water exchanges between the deeper and upper aquifer. The observed vertical deformation of the ground surface is smaller than a centimetre, a value to low to imply a significant variation of the absolute gravity, but significant to be recorded with the various methods used to monitor the deformation. Among the different techniques, tiltmeters appears very sentive to water level fluctuations. In particular, these tools are very efficient to record the deformation simultaneously to fast water level changes. The others methods provide also very useful informations about the spatial distribution of the vertical deformation of the ground surface. Thus, the achievement of gravimetric and geodetic monitoring during large-scale experiments allows to provide very useful and complementary data about the properties of heterogeneous aquifers.