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Piezometric tides are universal. How and to what extent can they be used as a low-cost hydrogeological investigation tool?

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The relative movements of the Earth, the Moon and the Sun induce variations in the gravitational field which are reflected, among other things, in ocean tidal phenomena. Similar phenomena affect groundwater.
This signal has often been studied and modelled in coastal aquifers, but there are fewer studies that focus on piezometric tides far from the sea and most of these studies focus on a few isolated wells. The first publications dealt with deep aquifers or oil fields where the piezometric tide has a significant amplitude. Some authors have deduced that piezometric tides only affect confined aquifers.
We tested this hypothesis by systematically studying the tidal signal in shallow and unconfined aquifers. Key finding: the piezometric tidal signal is universal, as are the forces that generate it. If this signal often goes unnoticed, it is simply because other phenomena with a larger amplitude hide it (rain infiltration, barometric effects, stop/go from nearby wells...).
By implementing a very sensitive measuring device (0.4 mm sensitivity) and suitable signal processing procedures (high-pass filter and low-pass filter), we were able to isolate a piezometric tidal signal in almost all the wells that were instrumented (including 7-meters deep dug wells). We were then able to carefully analyze the features of this signal (amplitude, phase shift, shape) and their change over time, with depth and from one well to another.
Signal amplitude varies greatly during the lunar month (in a ratio that ranges from 1 to 2.5). For the purpose of comparing aquifers, it is therefore always necessary to measure the maximum amplitude during a lunar month or a sidereal year and to relate it to the amplitude of earth tides at the same location.
The phase shift also varies during the lunar month, and the phase shift of the signal can only be characterized by its relationship to a specific instant in the lunar cycle (for example, when Moon and Sun are in quadrature).
The shape of the signal is more complex than a simple sinusoid, because the tidal signal integrates the effects of several different physical phenomena (gravity tide, deformation of the earth's crust, relaxation of stresses inside the rock matrix, etc.).
The measurements we have accumulated show that this signal constitutes a signature of the aquifer itself (it is homogeneous within an aquifer, but differs from one aquifer to another). More exactly, it is a signature of the productive levels that are connected to the observation wells.
The detailed analysis of the tidal signal is thus a tool for studying the intrinsic features of an aquifer and in particular its storage features, which are often uneasy to measure (porosity, storage, productive thickness). This investigation method has comparative advantages over more conventional tools such as pumping tests. These advantages are analyzed, as well as the limits of this method.