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承压井水位观测系统对体应变的响应机制分析

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Response analysis of the well-water-level system in confined aquifer

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摘要 本文基于弹性力学与流体静力学原理对承压含水层这种弹性孔隙介质在作用力激励下所作出的体应变响应的力学机制进行了较清晰深入的阐述与理论推导，得到了井水位系统的动力学方程，该方程表明井水位系统为一个零阶的放大环节，其传递函数为一常数，从而给出了在含水层孔隙度分别等于零和等于1情况下的井水位系统所允许的理论格值范围.鉴于井水位系统为一个天然体应变计，其维尼迪柯夫调和分析所得到的振幅比（或潮汐因子）即为该水井的传递函数（灵敏度）.由于半日波为水位观测资料的主项，而M2波又为半日波的主项，因此以M2波灵敏度的倒数作为该井水位系统的格值是较为可取的.在取得格值的基础上，本文利用福建5口水井2008年5月份的井水位分钟值对发生在5月12日的四川汶川地震所引起的同震阶变进行计算，四川汶川大地震所引起的这5口水井的水震波幅度与体应变潮汐波幅度约为10^{-7}~10^{-8}.

关键词 井水位观测系统, 体积模量, 孔隙度, 力学机制, 格值, 水震波

Abstract: Based on principles of viscoelastic mechanics and hydrostatics, this paper expounds the dynamic mechanism of cubic strain response to excitation force in the confined aquifer and derives its theoretical formula. The result shows that the dynamics equation of well water-level system is an amplifying link of zero-order. It also shows that its transfer function is a constant. According to these results, the allowable bounds of theoretical calibration value η of water-level system were determined when the porosity of the confined aquifer is zero or one. Whereas the well-water-level system is a natural cubic strain gauge, the amplitude ratio (tide factor) computed by Venidikov′ s harmonic analysis method is the transfer function (sensitivity) of the system. Because wave M2 is the main component of the semidiurnal wave which is the main component of the observation data of ground water level, the paper takes the reciprocal of the amplitude ratio (sensitivity) of wave M2 as the theoretical value η of well water-level system. With this theoretical calibration value η, the water-level seismic wave excited by Wenchuan earthquake is calculated through the minute values of observation of well water level of five wells in May, 2008. The calculated result shows that the amplitude of seismic water-level wave is the same as the cubic strain wave of the planet Earth at approximately the order of magnitude 10^{-7}~10^{-8}.

Keywords Well-level system, Modulus of volume elasticity, The porosity of aquifer, Dynamic mechanism, Theoretical calibration value, Water-level seismic wave

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