Measurement of slow formation shear slowness using a monopole acoustic logging-while-drilling tool

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Acoustic logging-while-drilling (LWD) is a technology that is used to measure the formation elastic properties during drilling. When the formation shear slowness is smaller than the borehole fluid slowness (i.e., fast formation), monopole logging can be used to obtain both formation compressional and shear slownesses by measuring the corresponding refracted waves. In a slow formation where the shear slowness is larger than the borehole fluid slowness, other logging methods, such as quadrupole LWD, is used instead for shear slowness measurement due to the missing of fully refracted shear wave. Through modeling analysis, we find that the transmitted shear wave generated by a monopole LWD tool in a slow formation can be detected and used to measure the formation shear slowness. This phenomenon can be explained by Huygens' Principle, which states that every point on a wave front can be considered as a secondary source that induces particle motion. It is hard to discern the transmitted shear wave in monopole wireline data because it strongly interferes with the Stoneley mode in wireline logging. However, the transmitted shear wave decouples from the Stoneley in the LWD environment because the drill collar slows down the low frequency part of the Stoneley mode. The non-dispersive nature of the transmitted shear wave makes it suitable for shear slowness extraction using time semblance analysis, but sophisticated signal pre-processing might be needed as this wave is generally weak compared to the Stoneley wave. Moreover, this study helps better understand how the Stoneley mode behaves and interferes with other modes in a slow formation under the LWD conditions.

Keywords: Borehole acoustics, Slow formation, shear slowness, logging while drilling