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横向各向同性地层中随钻声波测井模式波分析

李希强^{1,2}, 陈浩¹, 何晓¹, 王秀明¹, 丛健生^{1*}

1. 中国科学院声学研究所声场与声信息国家重点实验室, 北京 100190;
2. 中国科学院大学, 北京 100049

Analyses on mode waves of acoustic logging while drilling in transversely isotropic formations

LI Xi-Qiang^{1,2}, CHEN Hao¹, HE Xiao¹, WANG Xiu-Ming¹, CONG Jian-Sheng^{1*}

1. State Key Laboratory of Acoustics, Institute of Acoustics, Chinese Academy of Sciences, Beijing 100190, China;
2. University of Chinese Academy of Sciences, Beijing 100049, China

摘要

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摘要

针对横向各向同性地层随钻声波测井模型,通过模式分析的方法,考察了快速地层和慢速地层井孔内随钻单极子、偶极子和四极子声源激发的斯通利波、弯曲波和螺旋波的相速度频散和激发强度特征,计算了这些模式波对于地层弹性常数的灵敏度,并与电缆测井中的情况进行了比较.结果表明:随钻斯通利波在低频时对地层弹性常数中 c_{66} 的灵敏度较电缆测井中有了很大提高,可用于反演地层水平向横波速度;随钻偶极子最低阶弯曲波在低频时不能用于直接获取地层横波信息,但在慢速地层中频率较高(例如6 kHz)时却可以间接得到地层垂直向横波速度;随钻四极子螺旋波的特征与电缆测井中的类似,可用于获取地层垂直向横波速度.

关键词 横向各向同性, 随钻声波测井, 频散, 激发强度, 灵敏度

Abstract:

We investigated the phase-velocity dispersion and excitation intensity features of the Stoneley, flexural, and screw waves, respectively, for acoustic logging-while-drilling (LWD) in vertical wells surrounded by transversely isotropic formations. The sensitivity coefficients of those modes with respect to all elastic parameters are evaluated. And the comparisons between the LWD and conventional wireline logging are present. It is revealed that the monopole Stoneley waves at low frequencies can be applied for the inversion of the horizontal shear modulus (c_{66}) using the LWD data because that parameter governs the velocities of low-frequency Stoneley modes. The propagation velocities of flexural modes do not tend to the shear velocities in the whole frequency range in a slow formation. The flexural-wave velocities, however, have a nearly-linear relation with the shear velocities in higher frequencies (e.g., at 6 kHz). Thus we can indirectly estimate the shear velocity using a dipole sonic logging tool even in a slow formation. Similar to the wireline logging, the screw modes excited by a quadrupole can also be used for the effective measurement of shear velocity.

Keywords Transversely isotropic, Acoustic logging-while-drilling, Dispersion, Excitation intensity, Sensitivity

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About author: 李希强, 男, 在读博士生, 主要从事电缆声波测井和随钻声波测井理论研究工作. E-mail: aqlxy1984@hotmail.com

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