

Borehole Acoustics and Logging  
and  
Reservoir Delineation  
Consortia

Annual Report  
1996

Earth Resources Laboratory  
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We would like to express our sincere appreciation to Sue Turbak and Lori Weldon, without whose work the publication of this annual report would not be possible.

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M.I.T. Borehole Acoustics and Logging and Reservoir Delineation Consortia

This report was typeset at ERL in Computer Modern Roman using  $\TeX$ .

# BOREHOLE ACOUSTICS AND LOGGING RESEARCH

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## SUMMARY

This is the second year we have combined the work of the Logging and Reservoir Delineation groups at the Earth Resources Laboratory. In the first part of this report, we present work related to logging and petrophysics, including the ongoing work of electroseismics. This summary describes briefly the contributions of each paper in this group.

Most of our focus in logging the past year was in understanding the physics of dipole logging in an azimuthally anisotropic medium, and the processing algorithms used in characterizing such a medium. In Nolte and Cheng (Paper 2), we analyzed a cross-dipole data set in extreme detail. We found that the Alford-type rotation appears to be stable in the anisotropic region of the data. The extra degree of freedom we used by allowing the principal axes to be nonorthogonal did not affect the results significantly. Furthermore, the rotation angles are consistent for all seven independently rotated source-receiver pairs. Velocities, on the other hand, are another matter. We used both the semblance method and the homomorphic method to estimate the fast and slow shear wave velocities from the rotated traces, and compared our results with those provided by the contractor. We also obtained estimates of velocity anisotropy from cross-correlation of the principal traces after the rotation. Although all of the processing shows similar variations in the velocities over our interval of interest, the actual velocities varied more than 10 percent. This is probably the result of the large dispersion of the flexural waves. More analysis is necessary to determine the most robust method of obtaining the shear wave velocities.

Paper 3 (Zhu *et al.*) deals with laboratory dipole logging measurements in a rock sample with both fast and slow shear wave velocities higher than the acoustic velocity of water. The authors show evidence of a Stoneley wave that may be coupled to the flexural waves. Since we really do not have a well-understood theory for such a condition, more

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work needs to be done to see if any new information can be obtained from this “flexural Stoneley” mode.

In an area where we have a better understanding of the underlying theory, Tao and Cheng (Paper 4) investigated the effects of gas-saturation, lithology, and borehole environment in the determination of permeability from Stoneley waves. This work combined the previous work in our group of Xiao-Ming Tang, Xiaomin Zhao, and Kazuhiko Tezuka, among others. The results indicated that small amounts of gas can significantly affect Stoneley wave dispersion and attenuation. Moreover, in a gas-saturated reservoir, the Stoneley wave sensitivity to permeability is increased significantly, so that permeability as low as a few millidarcies can be detected effectively. The vertical extent of the permeable zone (as opposed to a fracture) needs to be around 0.5 meters for effective detection.

Tadeu *et al.* (Paper 5) deals with the numerical modeling of full waveform and dipole logs using mode summation techniques. Their method is capable of modeling tool ex-centering and other geometrical effects.

The next series of papers (Zhu and Toksöz, Paper 6; Mikhailov *et al.*, Paper 7; and Haartsen and Toksöz, Paper 8), investigate the electroseismic phenomenon in detail, using theory, numerical modeling, laboratory scale modeling, and field experiments. The results demonstrate that the electroseismic effect is indeed real and observable in the field. This topic is still in the initial stages of development and we will continue the development of the electroseismic technique as a practical tool for detecting fluid flow.