The polarization azimuth of the fast split shear-wave may give information about the orientation of in-situ stresses. However, this polarization azimuth may vary both laterally with structural locations and vertically with depth. This paper investigates the possibility to determine changes of polarizations with depth from multicomponent shear-wave reflection data recorded on the surface. Approximate reflection coefficients for split shear-waves are derived for a planar interface separating two anisotropic media with a polarization change across the interface. These equations are then used to formulate a two-stage procedure of singular value decomposition (SVD) to recover the background polarization azimuth $\alpha$ and its changes with depth $\Delta \alpha$, the average time delay $\Delta t$ and the principal shear-wave reflectivity. Although the reflection data matrix from surface surveys are often less accurate than the transmission data matrix from VSPs, it is still possible to recover changes of polarizations provided the anisotropy is significant, or independent information about the background anisotropy is available.

Approximate tensor reflectivity equations
Consider a simple model: a planar interface separating two anisotropic media with different $\alpha S I$ polarizations. Use $\alpha$ as the background polarization azimuth in the upper medium, and $\Delta \alpha$ as the polarization change in the lower medium. For sub-vertical propagation of shear-waves in orthorhombic media, I obtained approximate equations for different variations of $\Delta \alpha$. [For exact, or generalized solutions see Li and Crampin (1993), or Schoenberg and Protazio (1992)].

For small $\Delta \alpha$, the shear-wave tensor reflectivity matrix can be approximated as:

$$ R \approx C(\Delta \alpha) R_{\alpha}^1 C^T(\Delta \alpha) = C(\alpha) \begin{bmatrix} R_{11}^1 & 0 \\ 0 & R_{22}^1 \end{bmatrix} C^T(\Delta \alpha); $$

for large $\Delta \alpha$ ($|\Delta \alpha - \pi/2|$ is small), it can be approximated as:

$$ R \approx C(\Delta \alpha) R_{\alpha}^2 C^T(\Delta \alpha) = C(\alpha) \begin{bmatrix} R_{11}^2 & 0 \\ 0 & R_{22}^2 \end{bmatrix} C^T(\Delta \alpha). $$

where, $C$ is a rotation matrix; $R_{\alpha}^1$ and $R_{\alpha}^2$ are the principal tensor reflectivities at, respectively, $\Delta \alpha = 0^\circ$ (no polarization change) and $\Delta \alpha = 90^\circ$, following Thomsen (1988). After numerical comparison with the exact solution, I find that equation (1) is good for $\Delta \alpha < 30^\circ$, and that equation (2) is good for $\Delta \alpha > 50^\circ$.

Inverting for polarization change
Consider the inversion for small $\Delta \alpha$. Following the convolution model and the reflectivity method, the multicomponent reflection data matrix can be written as:

$$ D(\omega) = S(\omega) C^T(\alpha) \Delta_{\alpha}(\omega) C(\Delta \alpha) R_{\alpha}^1 C^T(\Delta \alpha) \Delta_{\alpha}(\omega) C(\alpha) G(\omega), $$

(3)
where $S_o$ and $G(w)$ are source and geophone response; $A_u(o)$ and $A_d(o)$ are up- and down-going propagator, and are equal with the reciprocity assumption. After proper compensation for the source and geophone response, equation (3) can be solved by a two-stage procedure of singular value decomposition (SVD), which allows the determination of the polarization azimuth $a$, its changes with depth $\Delta a$, the average time delay $A_{\tau}$, and the principal shear-wave reflectivity. Initial application to full wave synthetics calculated by the reflectivity method (Taylor 1991) reveals the potential of this technique (Figures 1 & 2).

**Acknowledgements**
I thank Colin MacBeth for helpful discussion during the work. This work was supported by the Edinburgh Anisotropy Project and the Natural Environment Research Council.

**References**

**Figure 1.** Schematic Earth model in south Texas containing a region with 10% shear-wave anisotropy in Layer 3 simulating a fractured reservoir with different fracture strike from the surrounding medium. Number $nn\%$ indicates percentage anisotropy, and $XnnY$ indicates fracture strike $nn^\circ$ from $X$-axis (inline direction) to $Y$-axis (crossline direction). The model is adapted from Yardley, Graham and Crampin (1991).

**Figure 2.** (a) The synthetic data matrix for normal incident shear-waves calculated using ANISEIS (Taylor 1991) from the model in Figure 1. The strong coherent off-diagonal energy indicates shear-wave splitting.
(b) The data matrix after the first SVD which corrects the overburden anisotropy and determines the background anisotropy parameters. The off-diagonal energy in (a) is largely minimize, there is only some residual energy in the off-diagonals, which is caused by the polarization change.
(c) The principal data matrix, representing the principal reflectivity $R_{ij}$, after the second SVD which determines changes of anisotropy parameters. Note that the residual energy in the off-diagonals in (b) is almost fully eliminated.