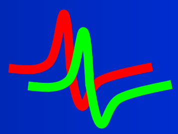
Twin Wavefield (Pump-Probe) Exploration*



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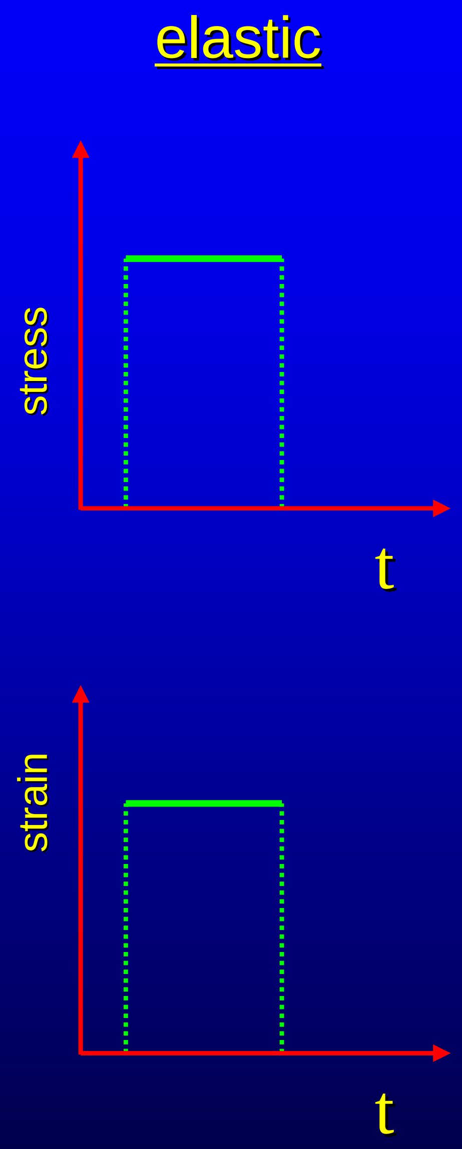
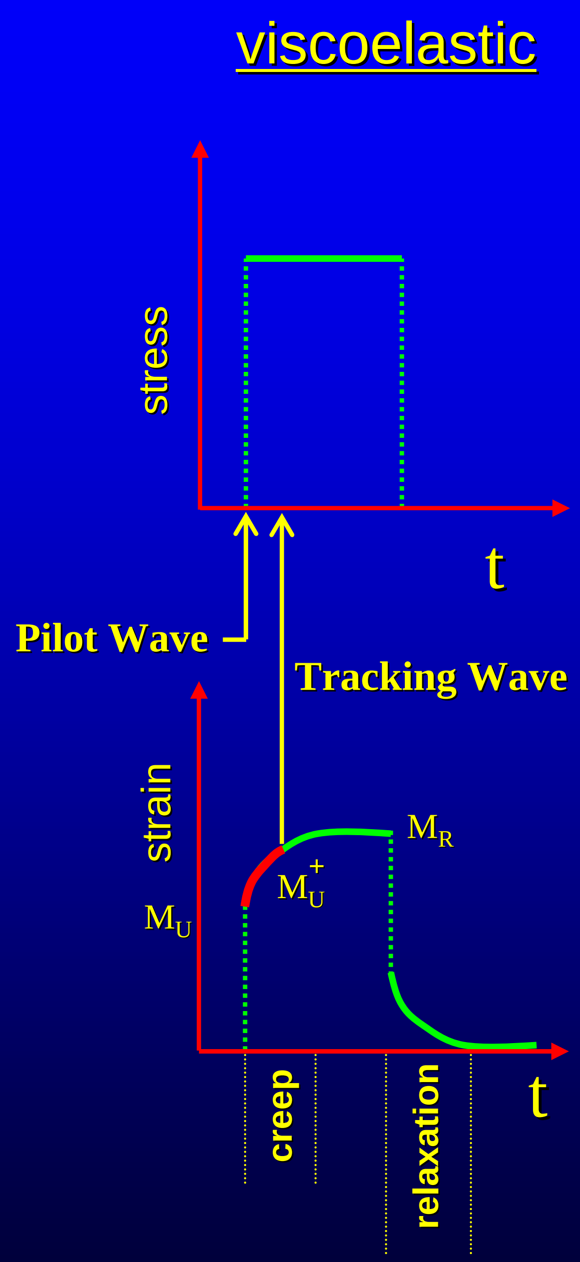
*formerly IMP, Mexico, *from Ursenbach & Stewart, 2004

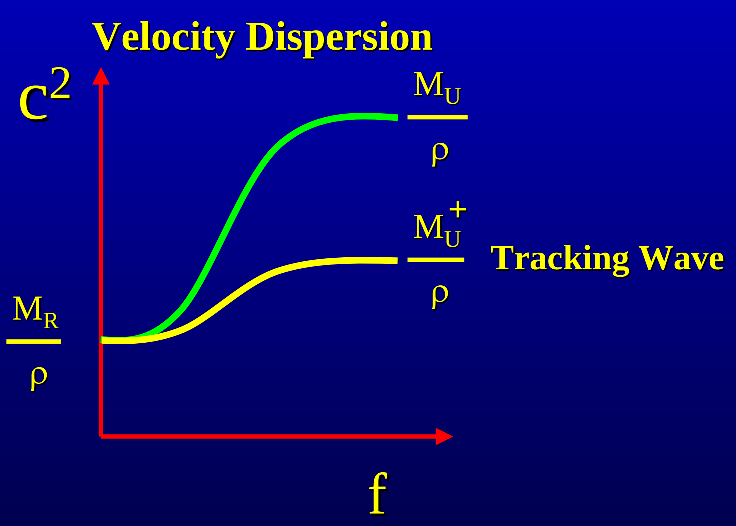
The basic idea

- In viscoelasticity, the material properties change with strain
- Material properties are attached to fluid content
- Can we use two different waves (strain sizes) to determine fluid-related properties?

TRANSIENT MECHANICAL BEHAVIOUR







2D P-SV Biot poroelastic theory (1956, 1962)

$$\partial_t v_x^s = R_{22}\,[\partial_x \sigma_{xx} + \partial_y \sigma_{xy}] - R_{12}\,\partial_x \sigma + B_2\,[v_x^f - v_x^s], \ldots. \quad (1)$$

$$\partial_t v_y^s = R_{22}\,[\partial_x \sigma_{xy} + \partial_y \sigma_{yy}] - R_{12}\,\partial_y \sigma + B_2\,[v_y^f - v_y^s], \ldots. \quad (2)$$

$$\partial_t v_x^f = -R_{12}\,[\partial_x \sigma_{xx} + \partial_y \sigma_{xy}] + R_{11}\,\partial_x \sigma + B_1\,[v_x^f - v_x^s], \ldots. \quad (3)$$

$$\partial_t v_y^f = -R_{12}\,[\partial_x \sigma_{xy} + \partial_y \sigma_{yy}] + R_{11}\,\partial_y \sigma + B_1\,[v_y^f - v_y^s], \ldots. \quad (4)$$

$$\partial_t \sigma_{xx} = (P + Q)\,\nabla \bullet v_s - 2N\,\partial_y v_y^s + Q/\eta_o\,\nabla \bullet [\eta_o (v^f - v^s)] \quad (5)$$

$$\partial_t \sigma_{yy} = (P + Q)\,\nabla \bullet v_s - 2N\,\partial_x v_x^s + Q/\eta_o\,\nabla \bullet [\eta_o (v^f - v^s)] \quad (6)$$

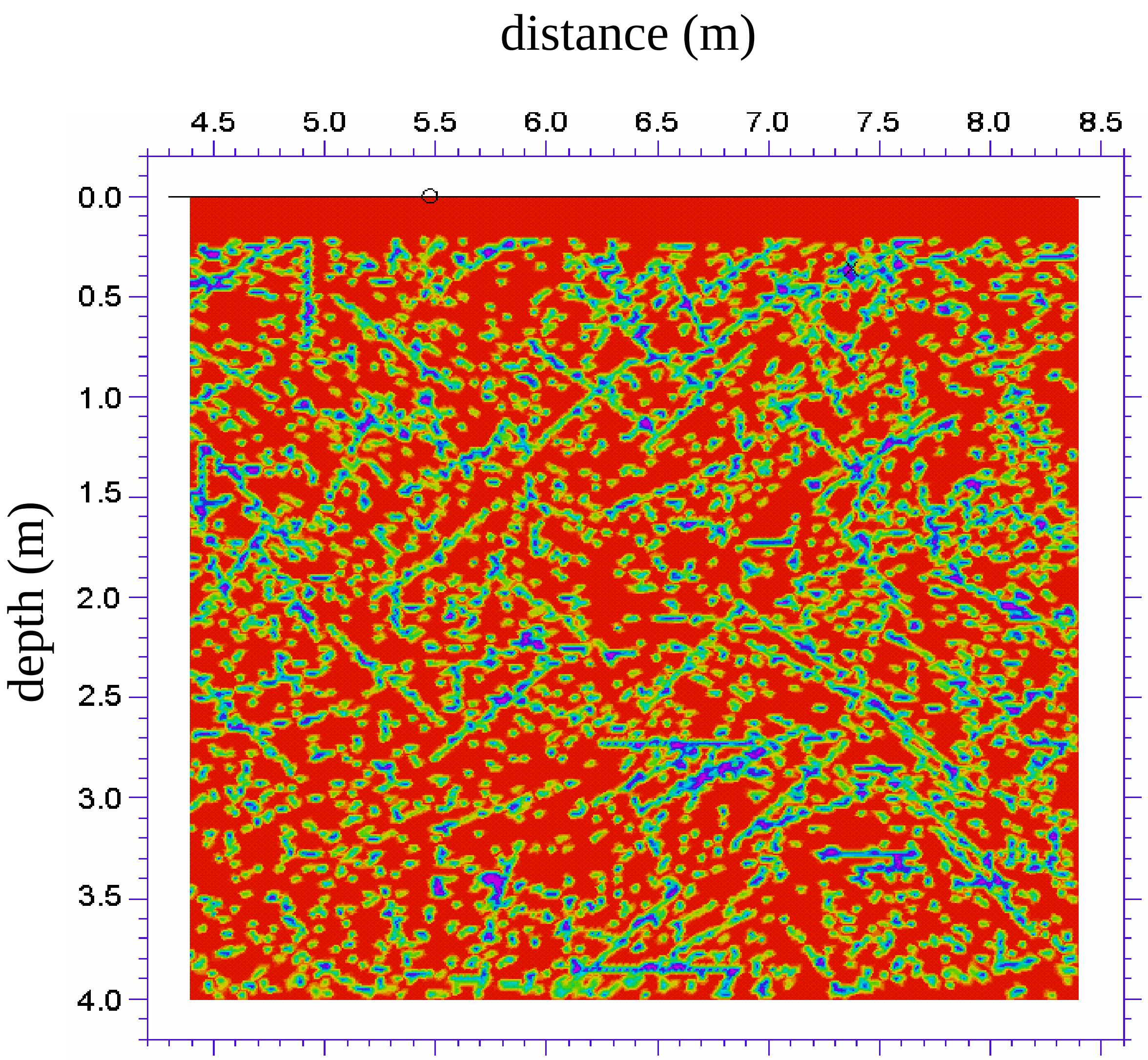
$$\partial_t \sigma_{xy} = N\,(\partial_x v_y^s + \partial_y v_x^s) \;, \ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

$$\partial_t \sigma = (Q + R)\,\nabla \bullet v_s + R/\eta_o\,\nabla \bullet [\eta_o (v^f - v^s)] \ldots\ldots\ldots \quad (8)$$

$$R_{ij} = \rho_{ij} / (\rho_{11}\rho_{22} - \rho_{12}^2), \qquad i, j = 1,2$$

$$B_1 = \frac{\eta_o^2\ \mu_f}{\kappa}(R_{11} + R_{12}) \qquad\qquad B_2 = \frac{\eta_o^2\ \mu_f}{\kappa}(R_{12} + R_{22})$$

TEST MODEL: geology



homogeneous porous background

$\eta_o = 0.05$ K = 10 mD

pseudo-fractured porous media

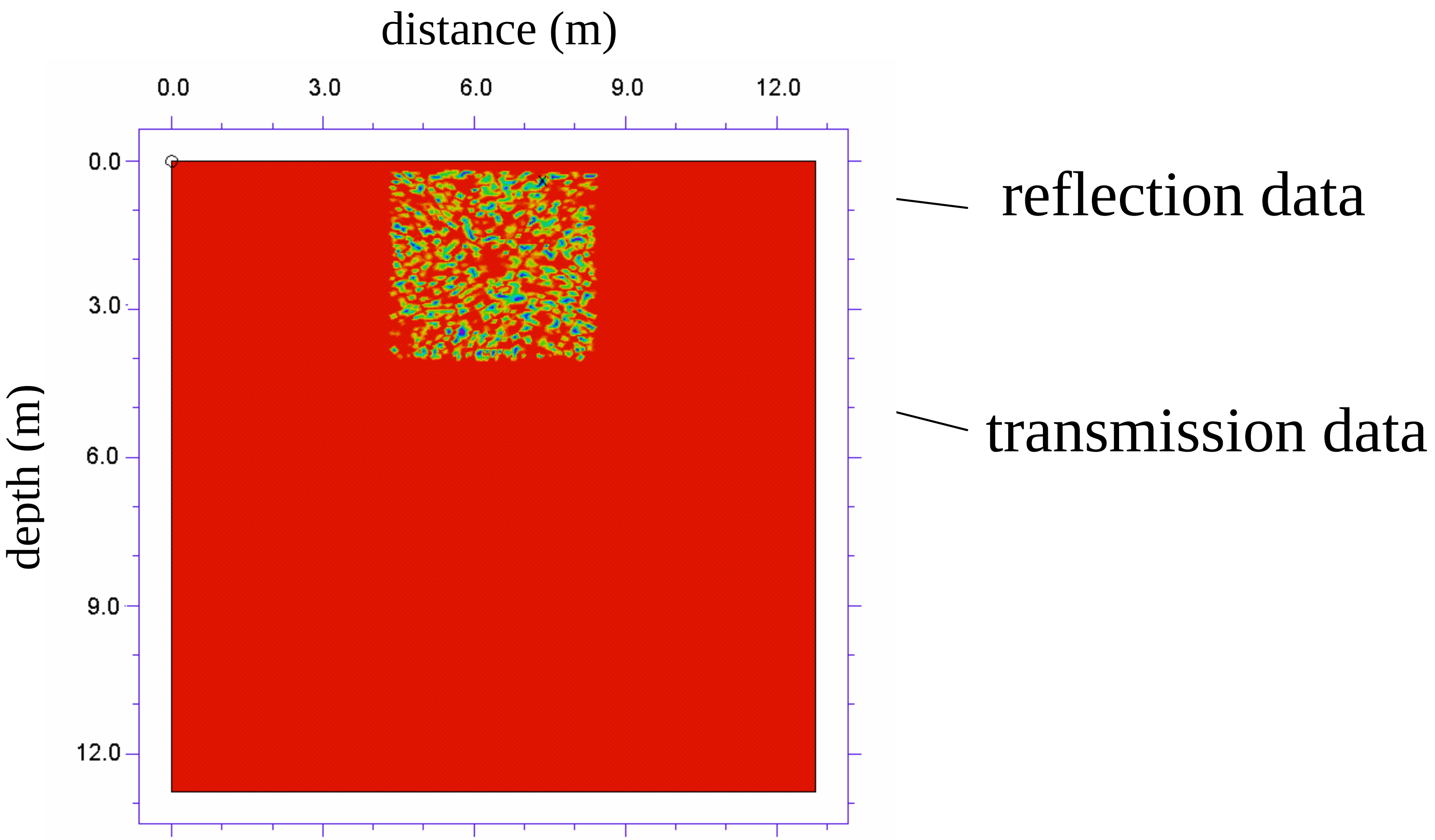
$\eta_o = 0.60$ K = 10 D

Whole model is saturated with water except within the ellipse, which is permeated with

gas.

TEST MODEL: geometry

512 X 512 square cells (Δh = 0.025 m)



Center of mass velocity

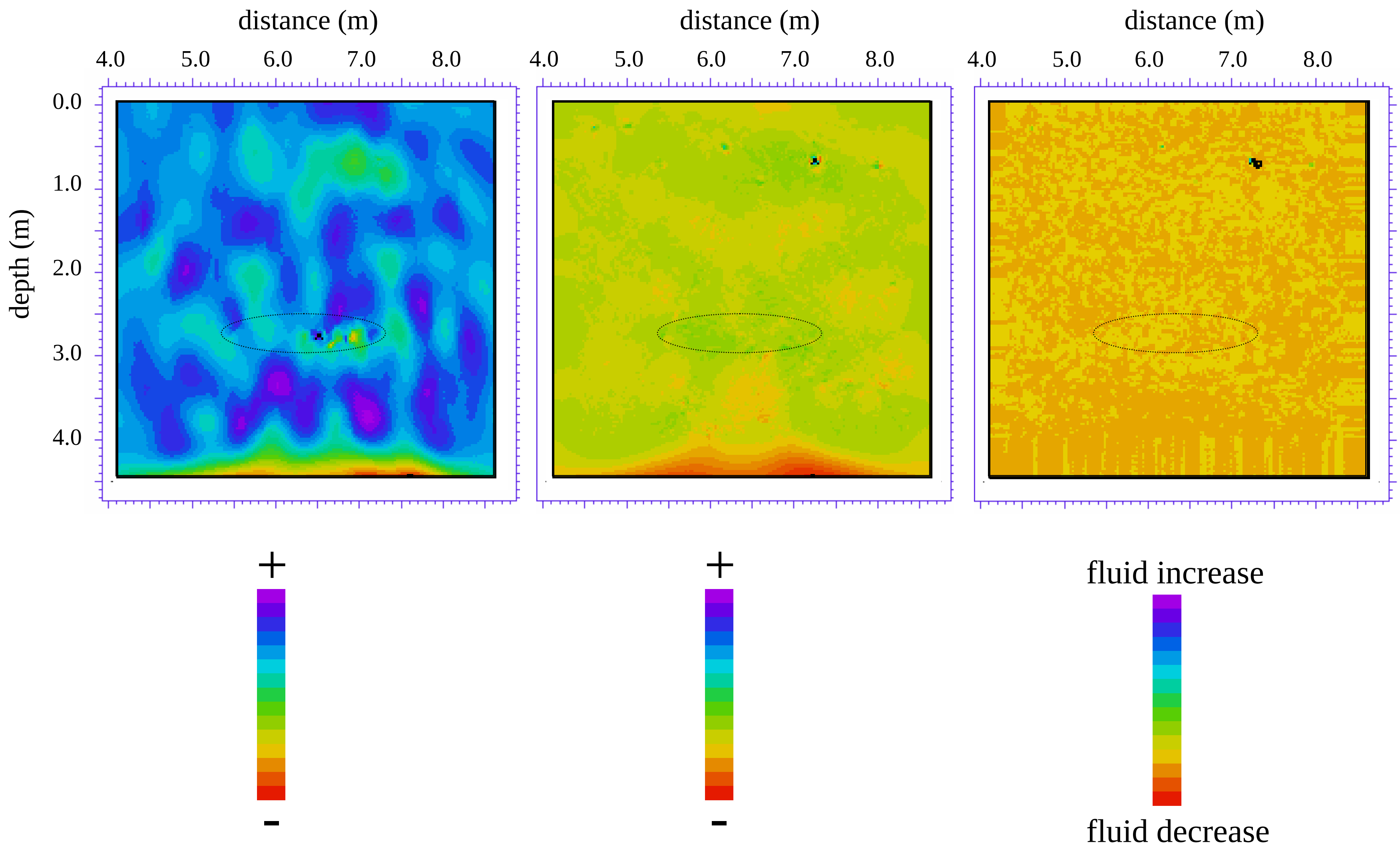
$$v_y = \frac{\eta_o \rho_{f_o} v_y^f + (1 - \eta_o) \rho_{s_o} v_y^s}{\rho}$$

Pore fluid pressure

$$p_f = - \frac{\sigma}{\eta_o}$$

Fluid content

$$\xi = -\nabla \bullet [\eta_o (\mathbf{v}^f - \mathbf{v}^s)]$$



CREWES Collaboration

- Viscoelastic modeling to have *a priori knowledge* of Q attenuation
- Analytical solution considering *twin waves* in a homogeneous and in a heterogeneous viscoelastic medium
- Investigate exactly how to implement
- Analyze converted waves