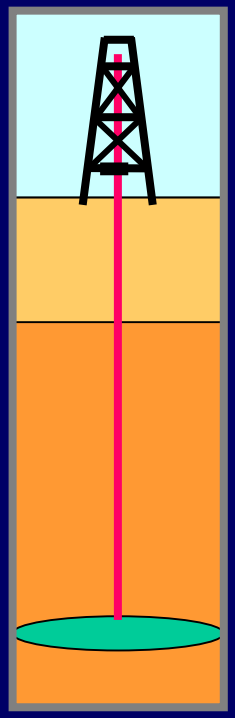
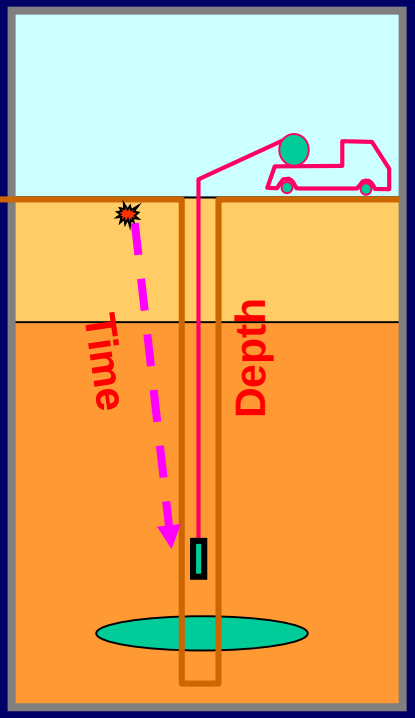
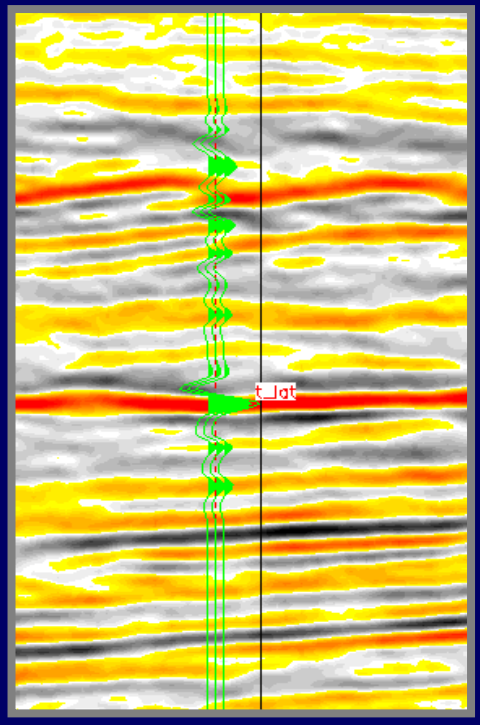
# Well-Seismic Ties






Synthetic Trace

Time (ms)



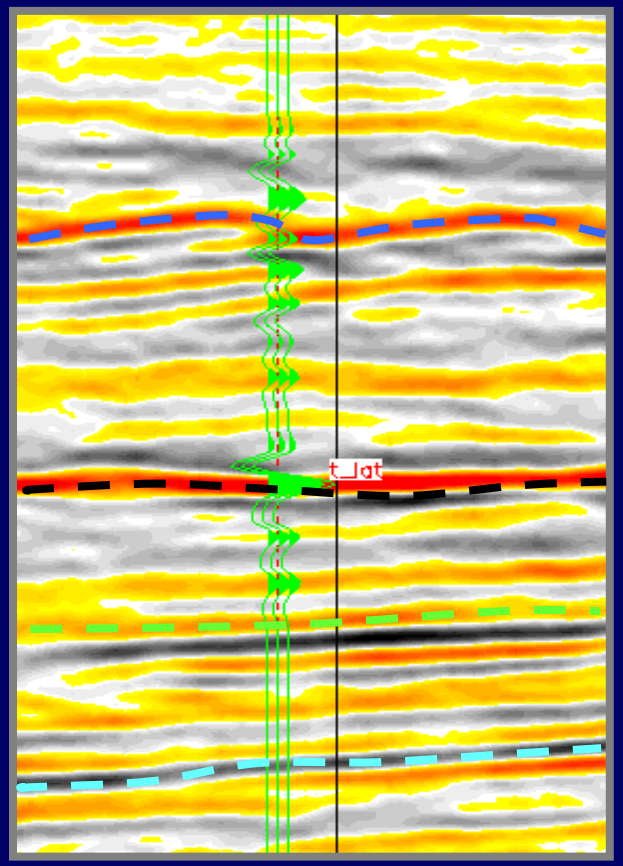
# Outline

- Objectives of the seismic - well tie
- What is a good well-seismic tie?
- Comparing well with seismic data
- Preparing well data
- Preparing seismic data
- How to tie synthetics to seismic data.
- Pitfalls

# Objectives of Well-Seismic Ties

- Well-seismic ties allow well data, measured in units of depth, to be compared to seismic data, measured in units of time
- This allows us to relate horizon tops identified in a well with specific reflections on the seismic section
- We use sonic and density well logs to generate a synthetic seismic trace
- The synthetic trace is compared to the real seismic data collected near the well location

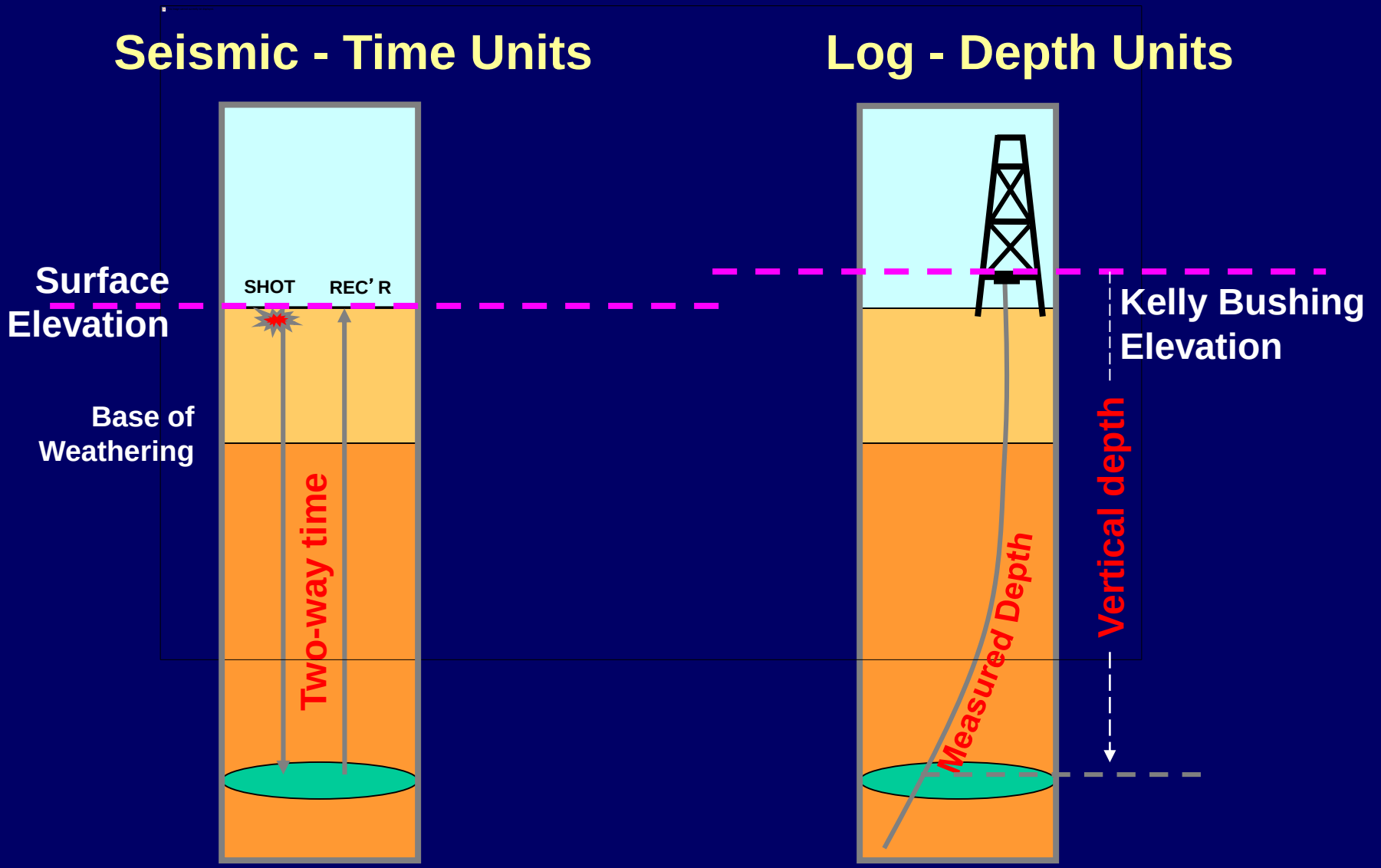
**Synthetic Trace**



# Purposes for Well-Seismic Ties & Quality

| Business Stage | Accuracy Required | Seismic Quality Required | Example Application |
|---|---|---|---|
| Regional Mapping | Within a few cycles | Poor/fair | • Mapping and tying a regional flooding surface across a basin |
| Exploration | Within ~½ cycle | Good | • Comparing a lead to nearby wells |
| Exploitation | Wavelet character match | Very good | • Seismic attribute analysis<br>• Inversion |

# Measurements In Time and In Depth



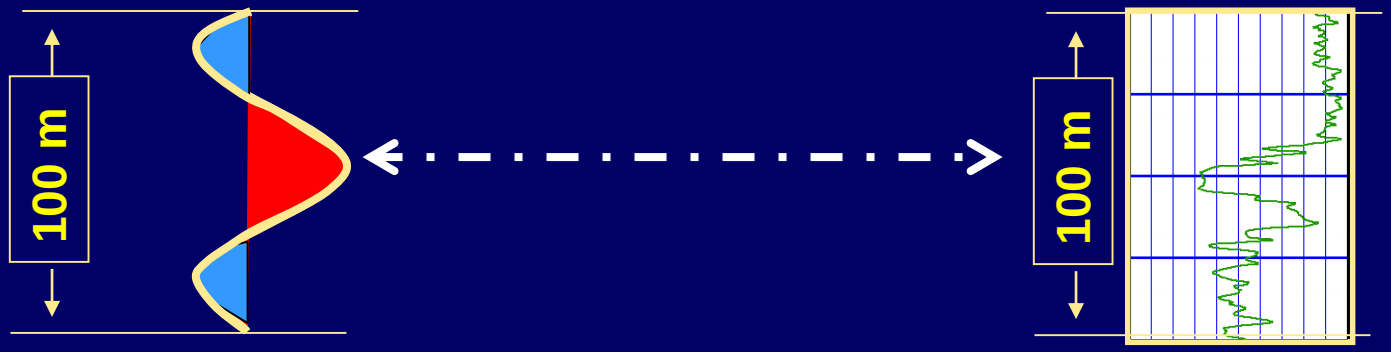
# Comparison of Seismic and Well Data

## Seismic Data

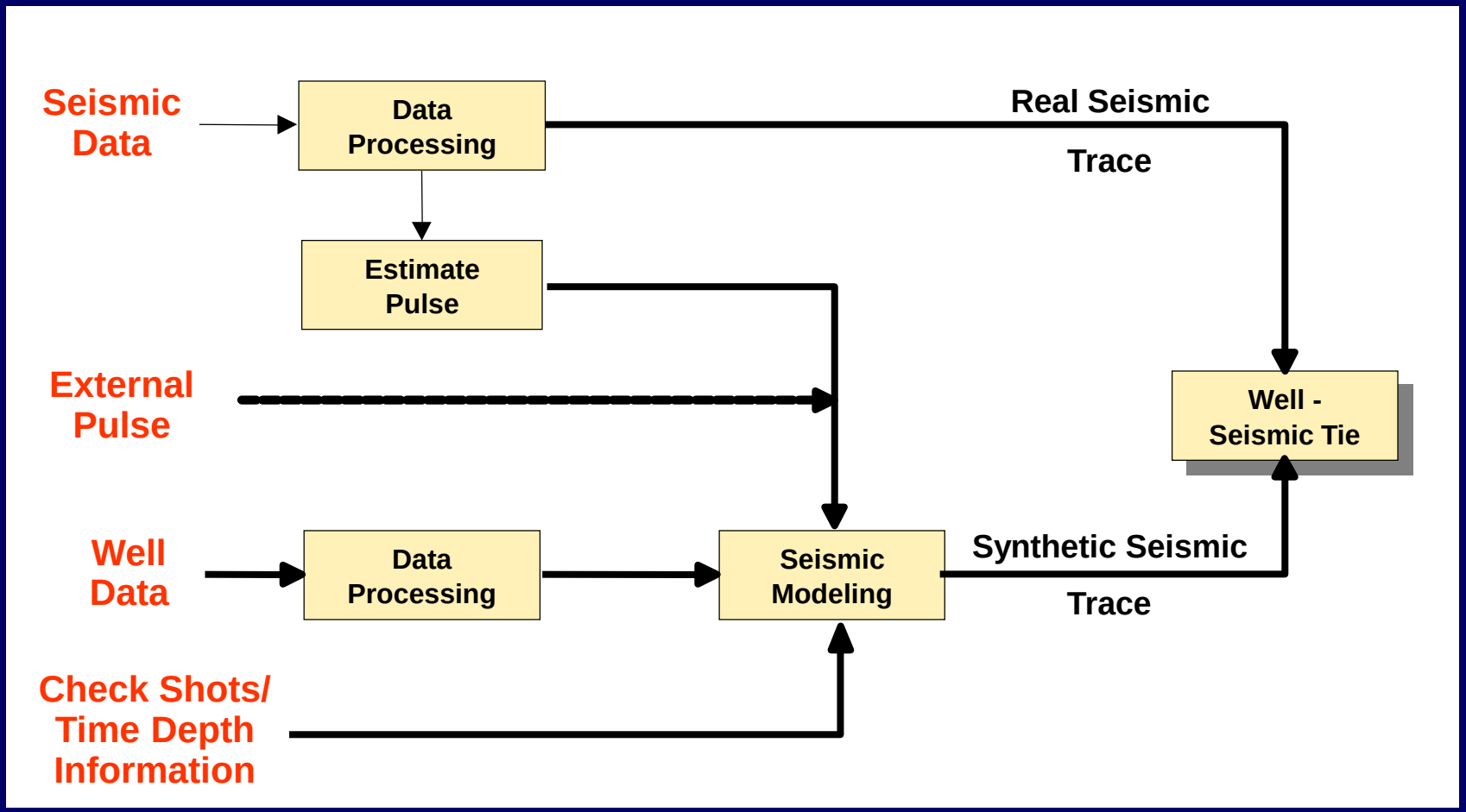
- Samples area and volume
- Low frequency 5 - 60 Hz
- Vertical resolution 15 - 100 m
- Horizontal resolution 150 - 1000 m
- Measures seismic amplitude, phase, continuity, horizontal & vertical velocities
- Time measurement

## Well Data

- Samples point along well bore
- High frequency, 10,000 - 20,000 Hz
- Vertical resolution 2 cm - 2 m
- Horizontal resolution 0.5 cm - 6 m
- Measures vertical velocity, density, resistivity, radioactivity, SP, rock and fluid properties from cores
- Depth measurement



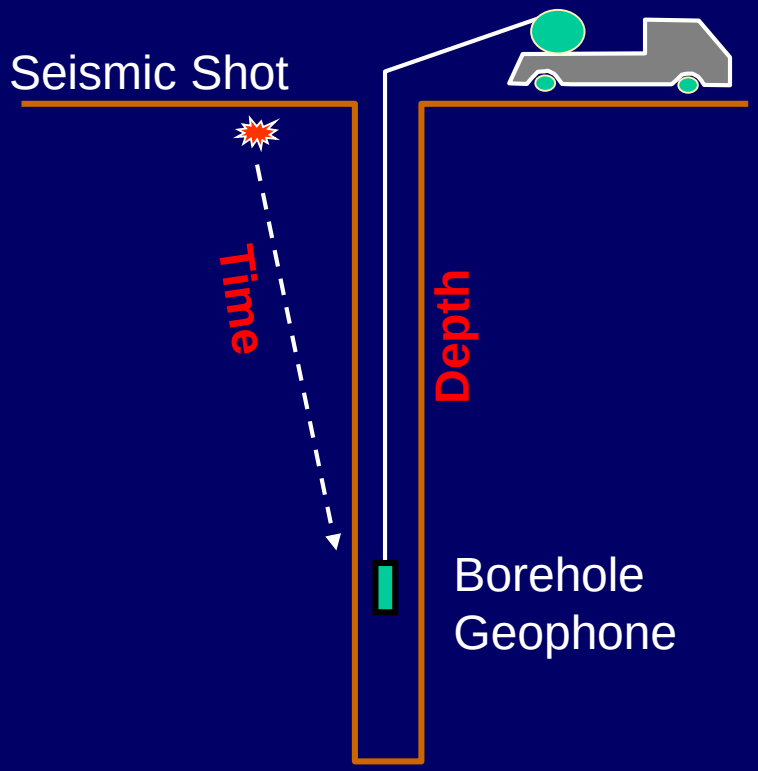
# Seismic-Well Tie Flow-Chart



# Check Shot Data

Check shots measure the vertical one-way time from surface to various depths (geophone positions) within the well

- Used to determine start time of top of well-log curves
- Used to calibrate the relationship between well depths and times calculated from a sonic log



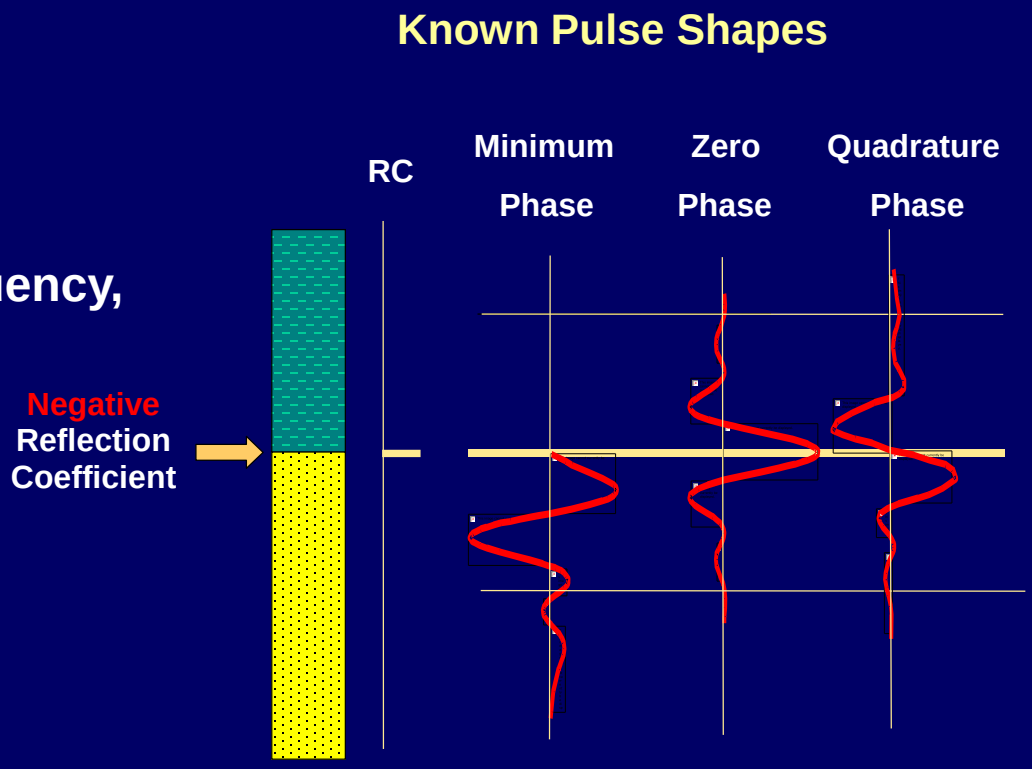
# Pulses Types

Two options for defining the pulse:

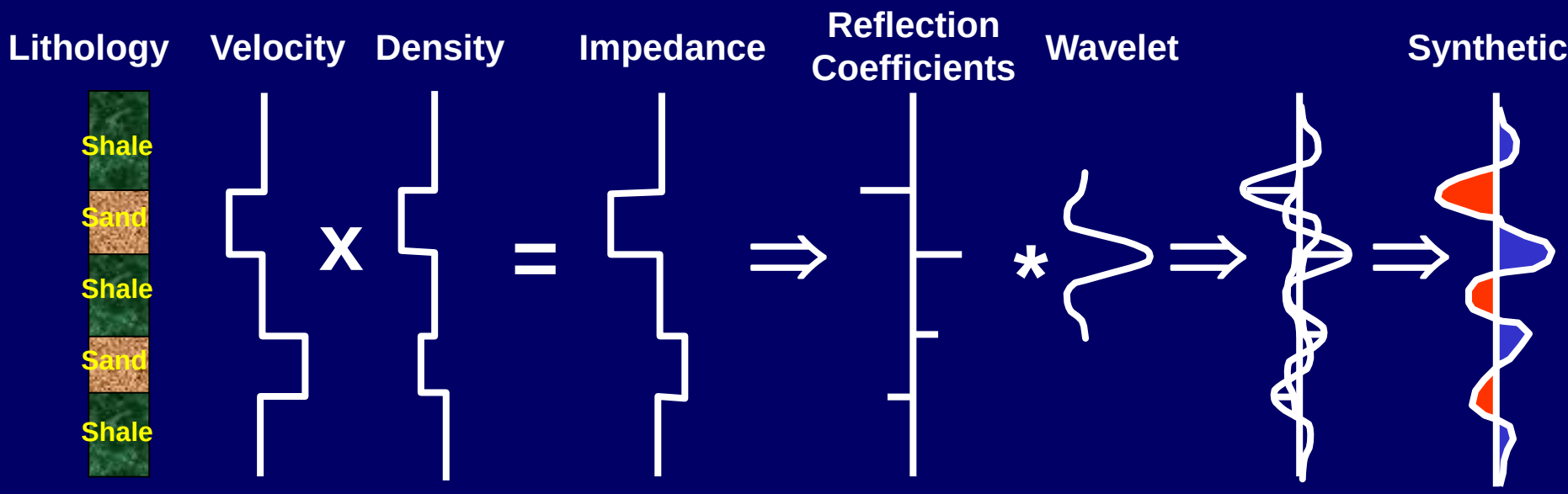
A. Use software that estimates the pulse based on a 'window' of the real seismic data at the well (recommended)

B. Use a *standard pulse shape* specifying polarity, peak frequency, and phase:

- Minimum phase
- Zero phase
- Quadrature



# The Modeling Process

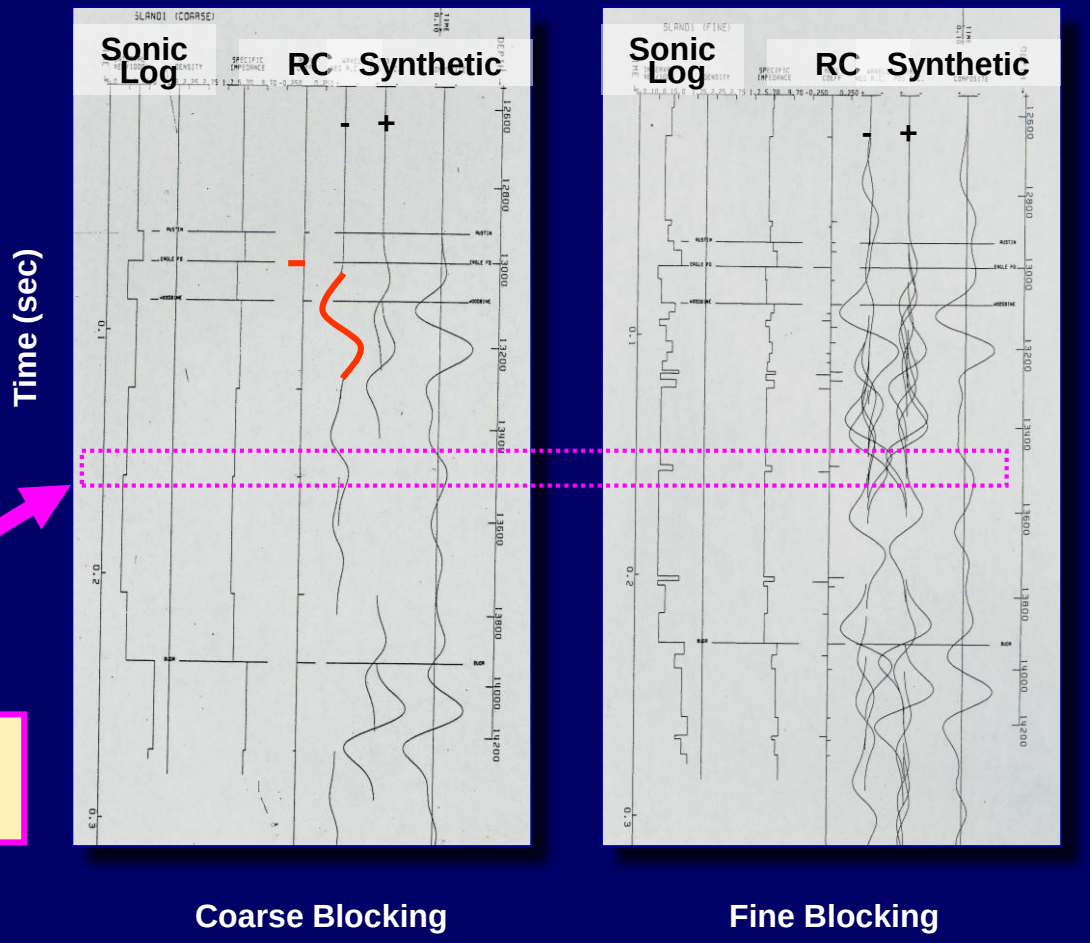



- We 'block' the velocity (sonic) and density logs and compute an impedance 'log'
- We calculate the reflection coefficients at the step-changes in impedance
- We convolve our pulse with the RC series to get individual wavelets
- Each RC generates a wavelet whose amplitude is proportional to the RC
- We sum the individual wavelets to get the synthetic seismic trace

# Impact of Blocking

- For typical seismic data, blocking on the order of 3 m (10 ft) is the recommended minimum
- Using coarser blocking helps identify the major stratigraphic contributors to the peaks and troughs

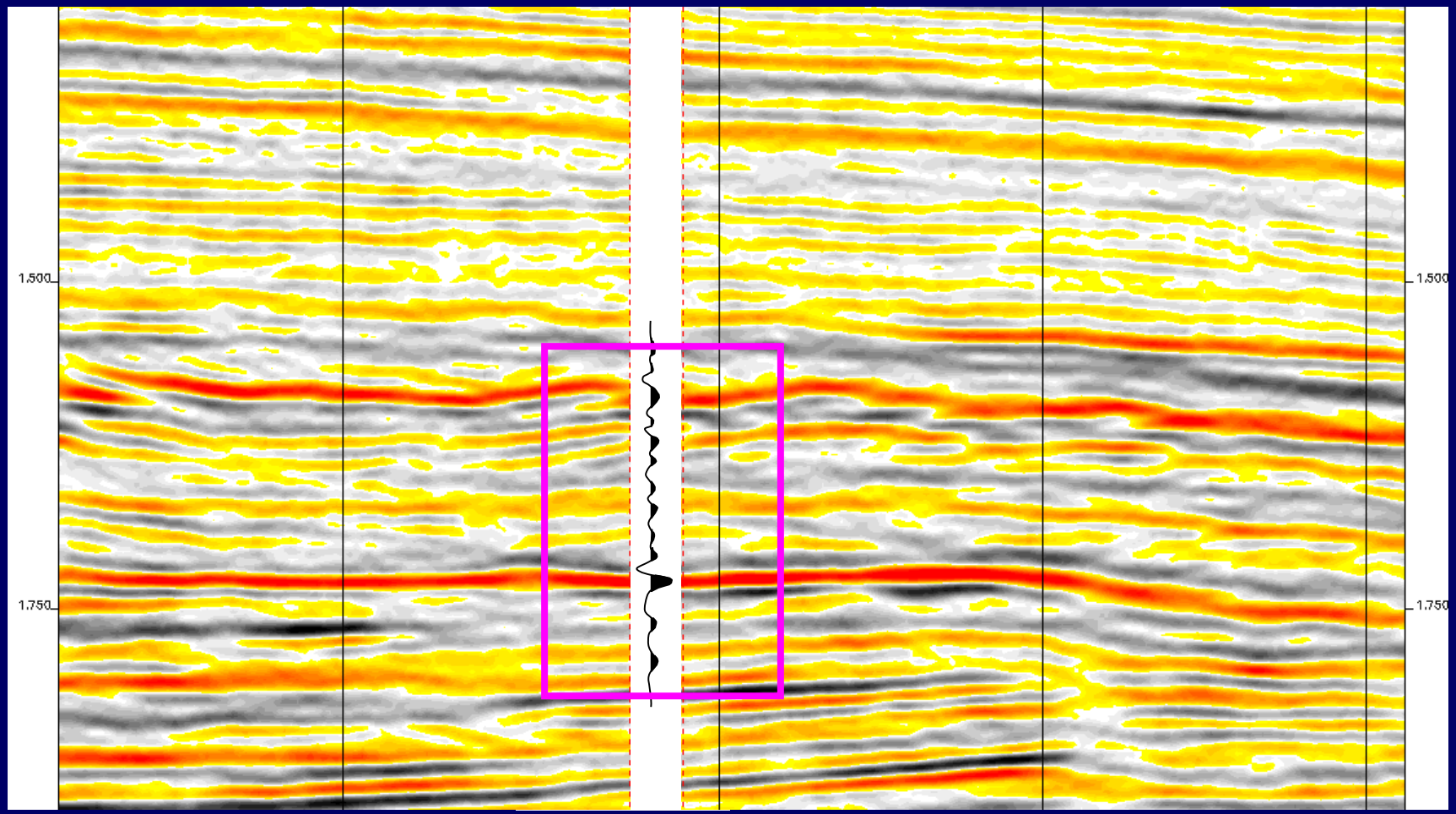
Thin beds have almost no impact due to destructive interference




Coarse Blocking

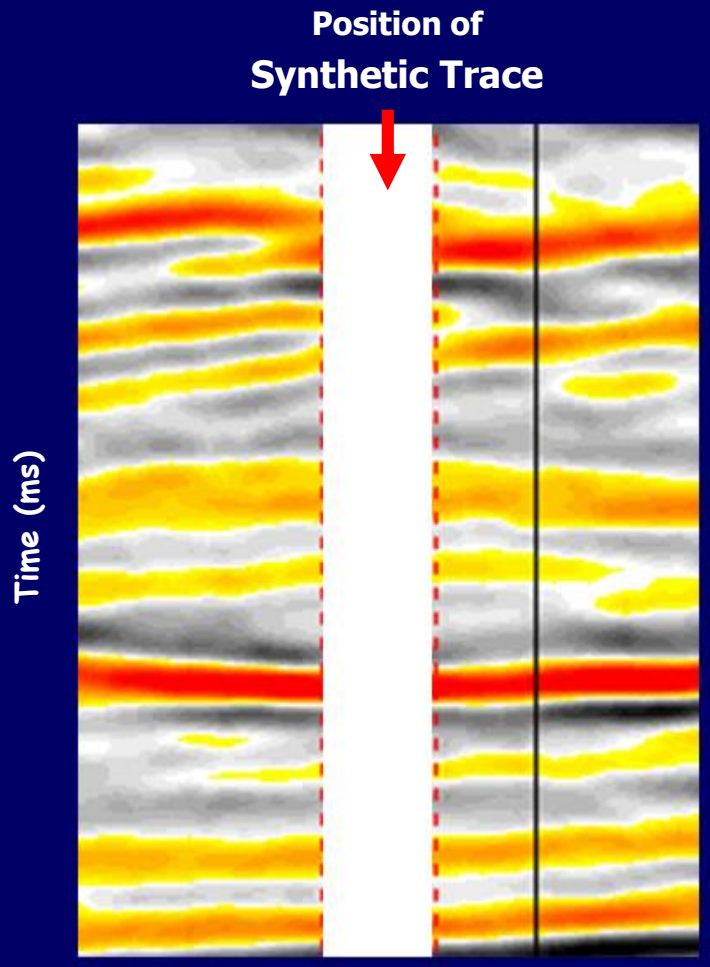
Fine Blocking

# Our Example



# Tying Synthetic to Seismic Data

- Position synthetic trace on seismic line.
  - Project synthetic along structural or stratigraphic strike if well is off line



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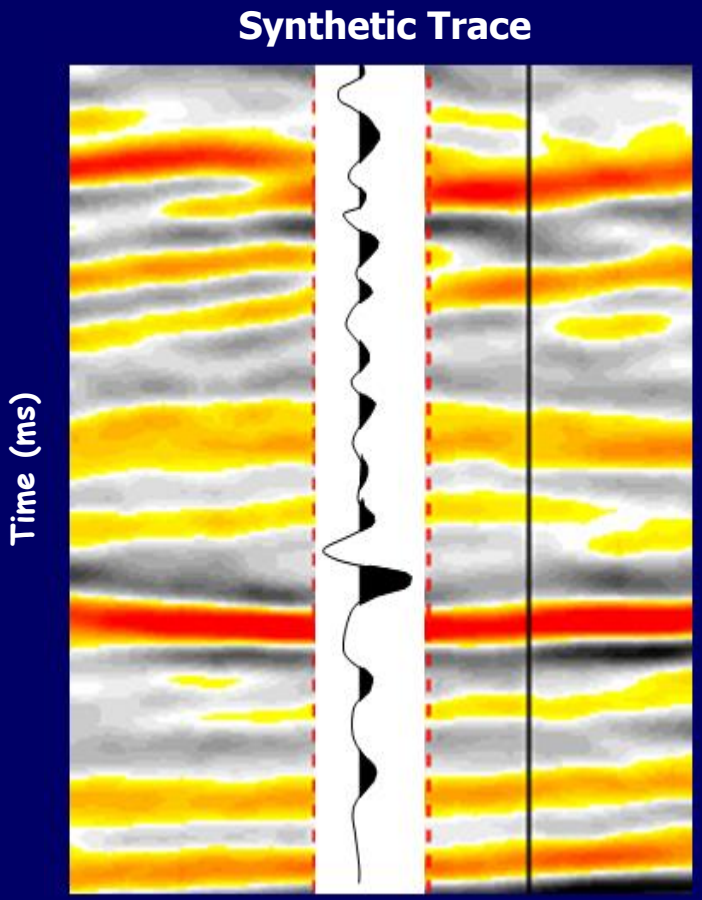
- Reference datum of synthetic to seismic data (usually ground level or seismic datum)
  - Without check shots estimate start time of first bed



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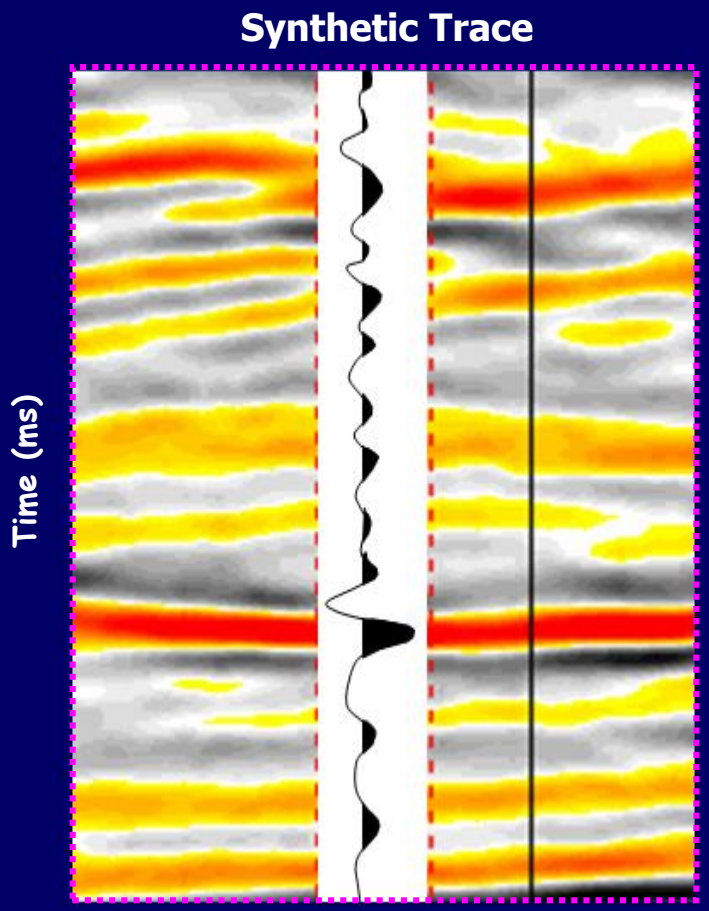
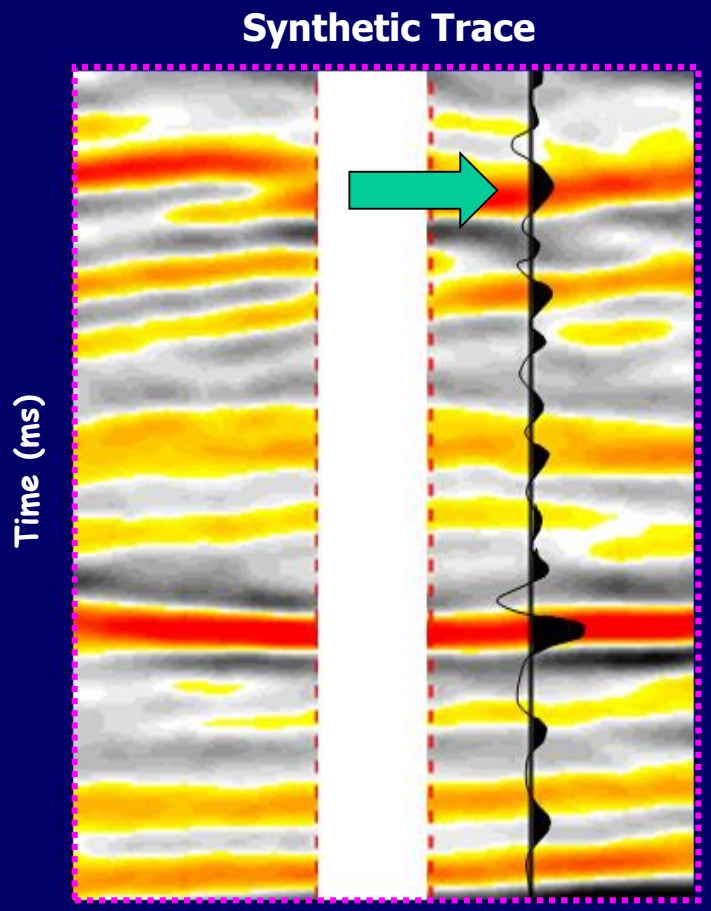
- Reference datum of synthetic to seismic data (usually ground level or seismic datum)
  - Without check shots estimate start time of first bed
- Shift synthetic in time to get the best character tie
  - Use stratigraphic info on detailed plot to help
  - determine the best fit.



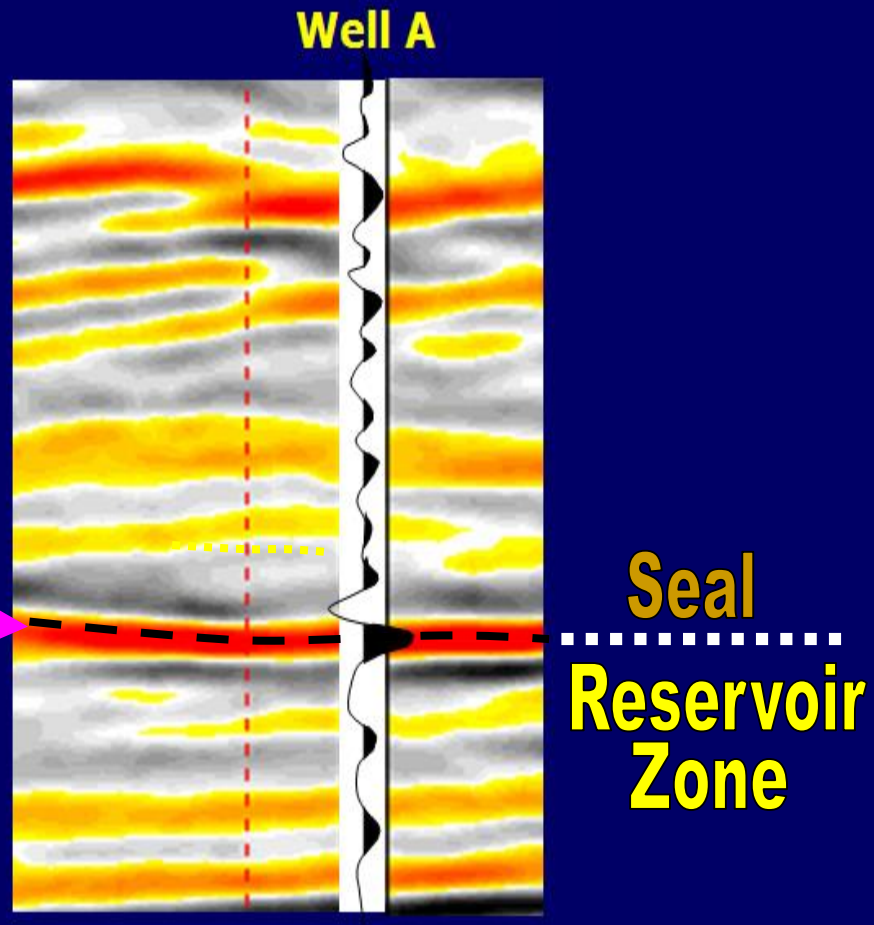
# Tying Synthetic to Seismic Data

- If justified, shift synthetic laterally several traces to get the best character tie
- Character tie is more important than time tie
  - We can use a cross-correlation coefficient as a measure of the quality of the character tie



# Tying Synthetic to Seismic Data

- Accept the tie that yields best character tie with least time shift in the zone of interest (reservoir)




The top of the reservoir should be mapped on this peak (red)

# Assumptions for Synthetic Well Ties

## Seismic Data

- Noise free
- No multiples
- Relative amplitudes are preserved
- Zero-offset section

## Synthetic Seismograms

- Blocked logs representative of the earth sampled by the seismic data
- Normal incidence reflection coefficients
- Multiples ignored
- No transmission losses or absorption
- Isotropic medium (vertical and horizontal velocities are equal)

# Common Pitfalls

- Error in well or seismic line location
- Log data quality
  - washout zones, drilling-fluid invasion effects
- Seismic data quality
  - noise, multiples, amplitude gain, migration, etc
- Incorrect pulse
  - Polarity, frequency, and phase
  - Try a different pulse; use extracted pulse
- Incorrect 1-D model
  - Blocked logs, checkshots need further editing
  - Incorrect start time or improper datuming
  - Amplitude-Versus-Offset effects
  - Bed tuning
- 3-D effects not fully captured by seismic or well data