Once the separation in time drops to less than half the dominant period of the wavelet destructive interference in the reflections from the top and bottom of the layer will occur.

However, as the layer continues to thin, the dominant period of the composite reflection event does not drop below $1/\tau_c$. The amplitude of the composite continues to drop. But not the period.
Tom Wilson, Department of Geology and Geography

Maximum Constructive Interference

Seismic Wavelet

Side lobe

Peak

Trough

Two-way interval time separating reflection coefficients is τ/2.

The peak-to-trough time equals τ/2.

Composite amplification

Summation

Model of a thinning layer

15,000 fps

11,300 fps

Low velocity sand

19,000 fps
These amplitude relationships are summarized below in the model seismic response of a thinning layer similar to that shown in the preceding slides.

The amplitude difference - trough-to-peak remains constant for two-way travel times much greater than half the dominant period.

As the top and bottom of the layers merge closer and closer together, the lead cycle in the reflection from the base of the layer overlaps with the follow-cycle in the reflection from the top and the amplitude of the composite reflection event begins to increase.
Layer thickness is simply $Vt/2$, where $t$ is the two-way interval transit time. Tuning occurs at two-way times equal to one-half the dominant period ($\tau_c/2$). If the interval velocity of the layer in question is known, the dominant period can be converted into the tuning thickness.

In this plot the conversion to thickness has already been made. Compute $\tau_c$.
Let layer thickness = $d$;
Then $\tau_c = 4d/V \approx 16\text{ms}$
$f_{\text{central or peak}} \approx 63\text{Hz}$

Difference of arrival time between the reflections from the top and bottom of the layer decreases abruptly at about 8 milliseconds.

8 milliseconds represents the two-way travel time through the layer; it is also the time at which tuning occurs and is half the dominant period of the seismic wavelet.

8 milliseconds is $\tau_c/2$ and the two way time through the layer. Thus, $\tau_c/4$ is the one-way time through the layer.
\( \tau /4 \), the one-way time through the layer, equals 4 milliseconds. The interval velocity in the layer is 11,300 f/s. Hence, the thickness of the layer at this point is \( \approx 45 \) feet. This is the tuning thickness or minimum resolvable thickness of the layer obtainable with the given seismic wavelet.

\[
11,300 \text{ f/s} \times 0.004 \text{s} = 45.2 \text{ feet}
\]

Amplitude spectra and wavelets

What is the amplitude spectrum of wavelet #5?

Broader spectra produce sharper, shorter duration wavelets

Ilmaz, 1987
Spectral bandwidth, wavelet duration in the time domain and resolution. $\tau_c$ is only one parameter that affects resolution. $\tau_b$ is also an important parameter.

The Convolutional Model

$$s(t) = \int_{-\infty}^{\infty} r(\tau) w(t - \tau) d\tau$$
The seismic response is dominated by reflections from layers 1 and 2. We see two prominent events. They are delayed because the wavelet phase is minimum.

The output is a superposition of reflections from all acoustic interfaces.

The wavelet in this case is also minimum phase.
One additional topic to consider is the process of wavelet deconvolution. As you've seen already, wavelet shape can affect geologic interpretations. Consider the following structural model:

**Subsurface structure - North Sea**

[Diagram of subsurface structure - North Sea]

Below is the synthetic seismic response computed for the North Sea model.

**Potential hydrocarbon trap?**

*Consider part 2 of the handout*
Consider the effect of wavelet shape on the geologic interpretation of seismic response. In the case shown below, the primary reflection from the base of the Jurassic shale crosses a side-lobe in the wavelet reflected from the overlying basal Cretaceous interval.

Deconvolution is a filter operation which compresses and simplifies the shape of the seismic wavelet. Deconvolution improves seismic resolution and simplifies interpretation.
North Sea Seismic display after deconvolution. The geometrical interrelationships between reflectors are clearly portrayed.

Questions?

If you haven’t already ... finish reading chapter 4!
Today's lab handout takes you through basic procedures needed to calculate amplitude spectra and seismic wavelets (Part 1) and then procedures for generating a synthetic seismogram.

Due Date: Next Wednesday