GG450

April 20, 2010

Seismic Reflection V
Data Interpretation I

Today's material comes from p. 200 - 218 in the text book.

Please read and understand all of this material!

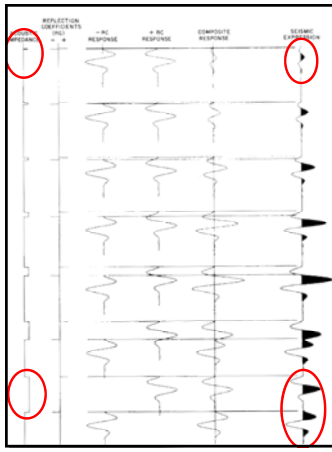
Seismic Resolution

Resolution defines your spacing (horizontal resolution) and dominant source frequency (vertical resolution).

What do we mean by *resolution*?

Suppose we are looking out a window and see an object in the distance. We have *detected* the object, but we can't tell what it is.

When we get our binoculars and look at the object, we see that it is actually not one thing, but it is two cars. We can now say that we *resolved* the two objects.



How thick does a bed have to be for us to be able to resolve the top and bottom of the bed?

Or, how thin does a bed have to be before we can no longer resolve the top and bottom of the bed?

Vertical Resolution

How thin a layer can we resolve?

Dependent on seismic wavelength

Reflectors are barely resolved when their separation = $\lambda/4$

$\lambda = v/f$ (velocity=frequency x wavelength)

If v = 2000 m/s, and f = 30 Hz

Separation = (66.67 m)/4 = 16.67 m

If v = 8000 m/s and f = 20 Hz

Separation = (400 m)/4 = 100 m

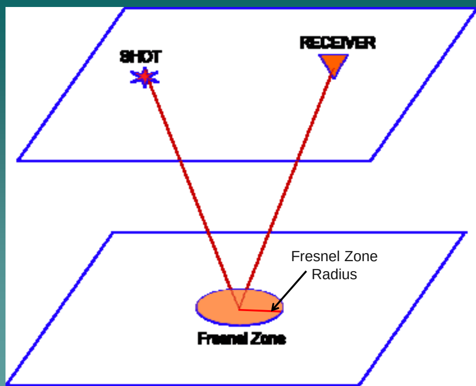
If v = 2000 m/s and f = 3500 Hz

Separation = (0.5714 m)/4 = 0.1428 m

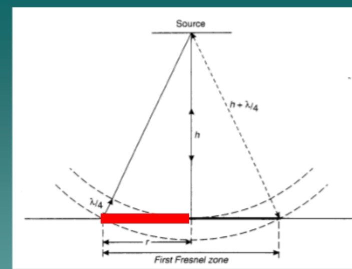
Seismic Resolution

Horizontal resolution:

The reflection of interest comes from a region of the reflector determined by the frequency and the depth to the reflector, the Fresnel (pronounced "Fernel") zone. This is *the zone on the reflector where the reflected signal comes back to the surface in phase and adds to the energy return at the receiver.* We can also call this the acquisition *footprint*.



Wavefronts & Fresnel Zones



$r^2 \sim \lambda h/2$

$r = \sqrt{\frac{\lambda h}{2}}$

$r = \frac{v}{2}\sqrt{\frac{t}{f}}$

(t = 2-way time)

The 1st Fresnel zone on a reflector at a depth h below the source of the spherical wave

Fresnel Zone Examples

$$r = \sqrt{\frac{\lambda h}{2}}$$

Reflector Depth	V	f	λ	Zone Radius
1000 m	2000 m/s	25 Hz	80 m	200 m
1000 m	1500 m/s	100 Hz	15 m	87 m
1000 m	1500 m/s	10 kHz	0.15 m	~ 8.5 m
2000 m	3000 m/s	15 Hz	200 m	~450 m

Fresnel Zones

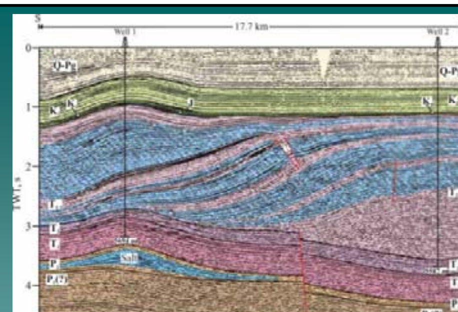
Geophone spacing controls horizontal resolution in a reflection survey, so geophone spacing should be no more than $\lambda h/2$ so that horizontal resolution is limited by the physics rather than by the survey design.

BUT, if your target is deep, there's no sense in spacing shots and geophones too close because resolution is already limited by the Fresnel zone.

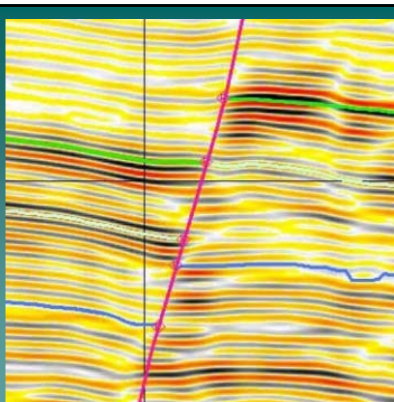
Resolution

Resolution *decreases* rapidly with depth as more and more area on the reflection interface is "averaged" to form the reflection signal.

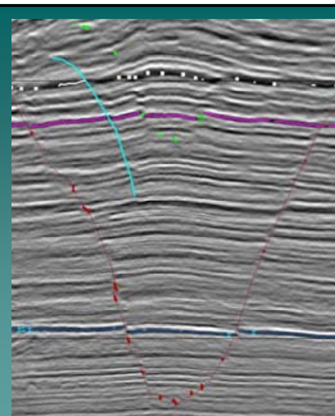
Resolution *increases* as frequency increases, since a smaller area will be in phase.



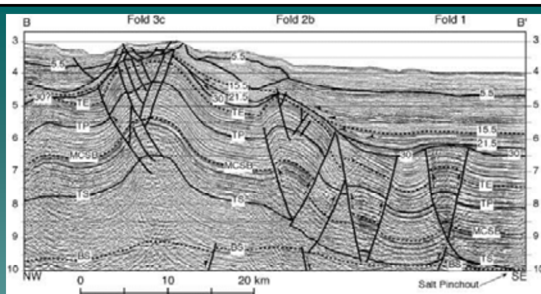
Here is an example of a “fully interpreted” seismic profile. What is the event history here?



Here is a detail of an interpretation. We usually draw lines on the reflecting horizons first, then try to pick faults where reflection terminate.



Another example of fault interpretation.



Folds and faults in the Gulf of Mexico.