Apex Spectral Technology, Inc.

Presents

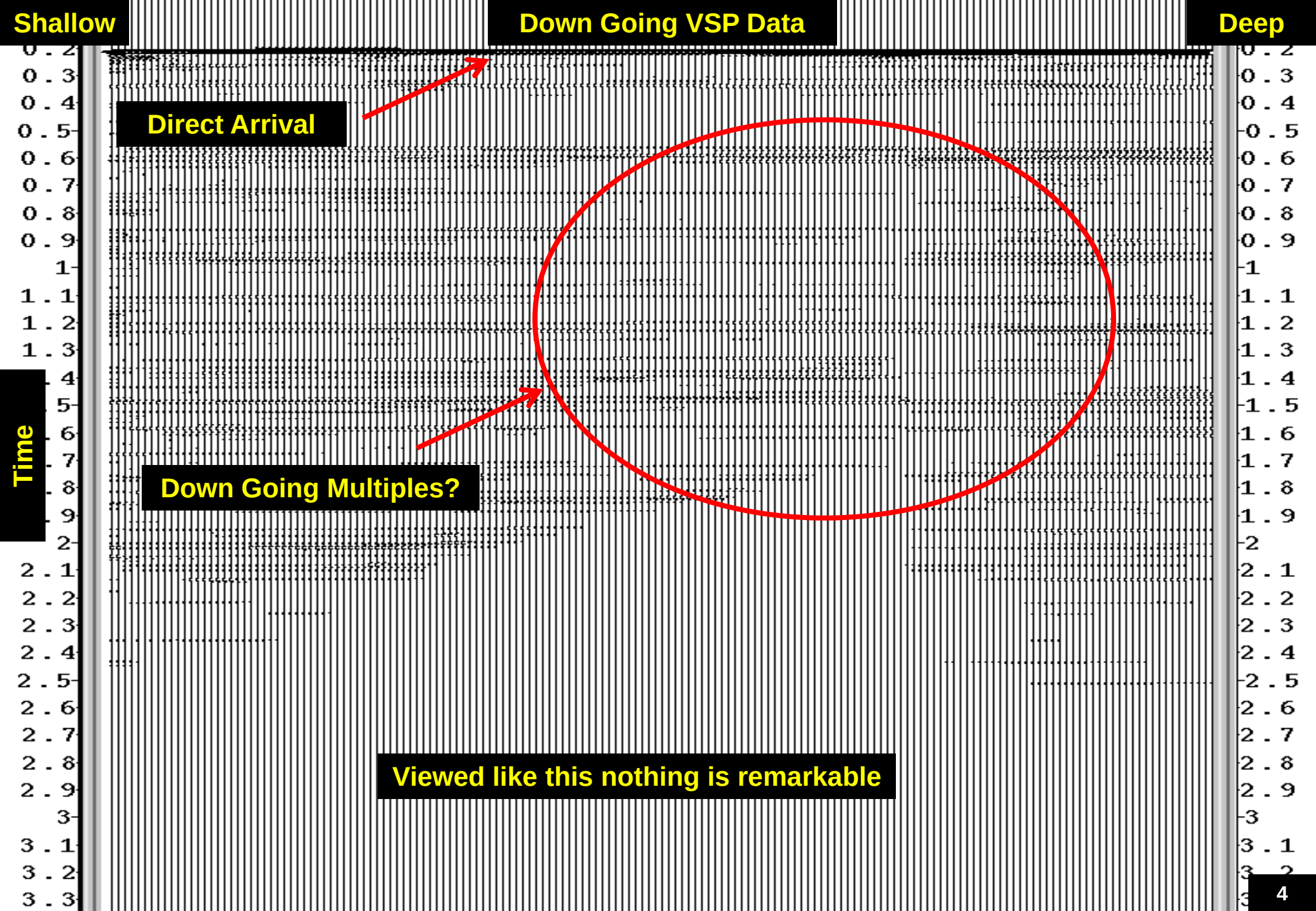
Can Q Explain the Observations Made on a VSP?

Q Has Been Offered as The Explanation

- Q has been offered as The Explanation
  - For lower frequency of seismic at later times
  - For changes in wave shape on full waveform sonic logs
  - For frequency variations on VSP data
- Many attempts have been made to measure Q, which most would agree have been less than compelling with difficulties ascribed to noise, reflections, inadequate acquisitions, etc. Often to address these inconveniences select data has simply been discarded.

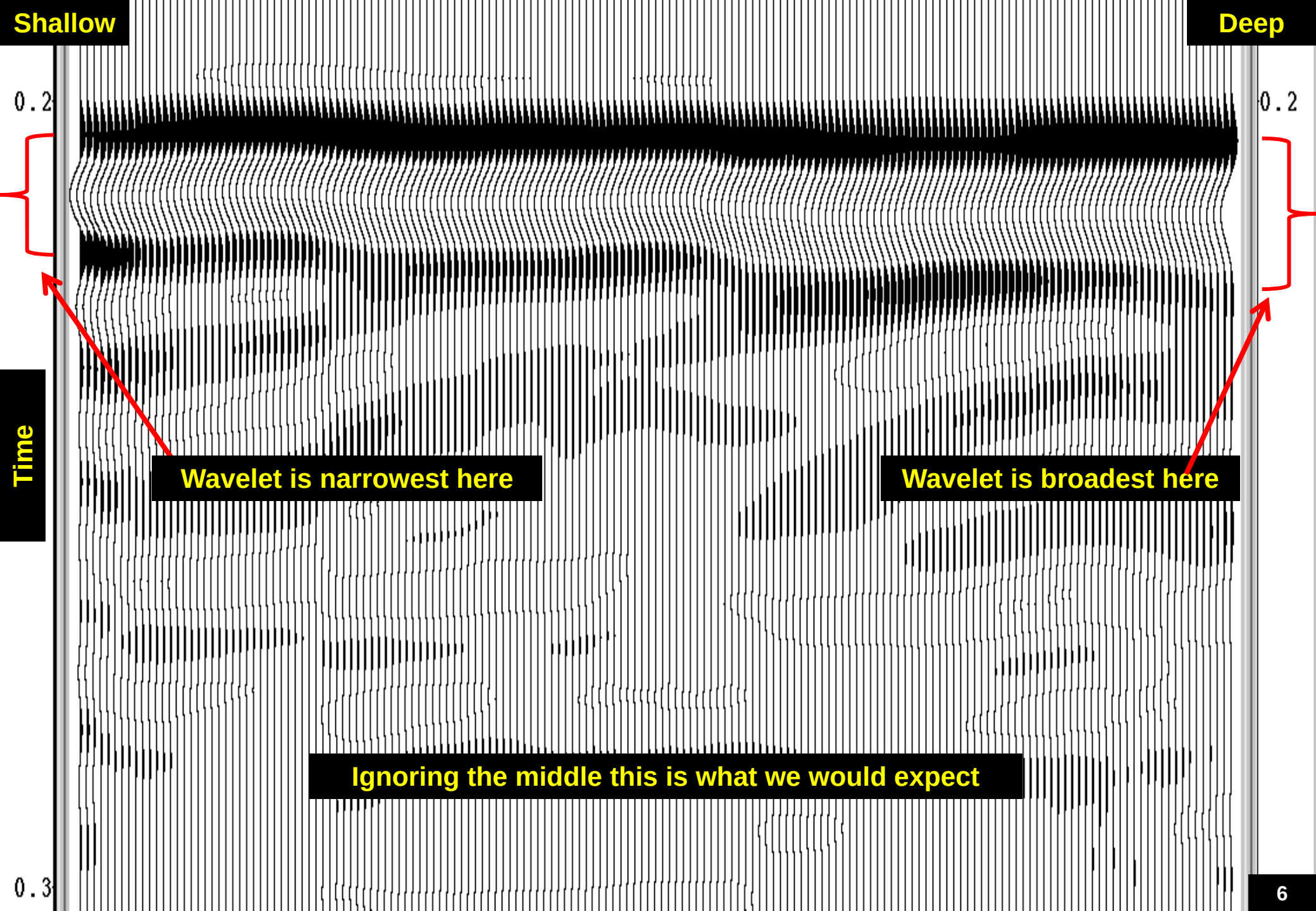
Downgoing VSP Waves

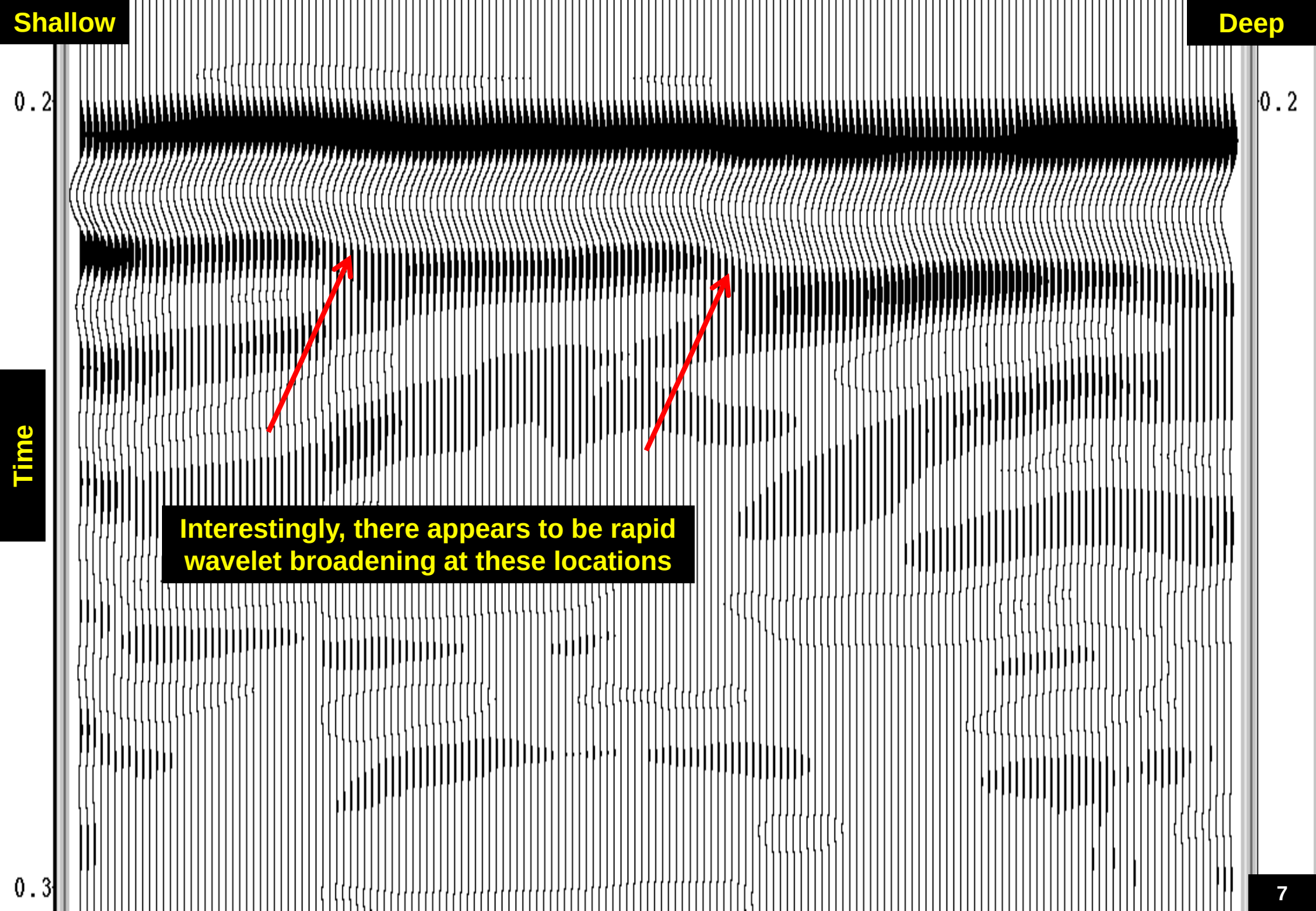
- Down going waves from a VSP are a good place to try to measure Q
- Down going waves are not contamination from reflections
- Down going waves require only minimal processing

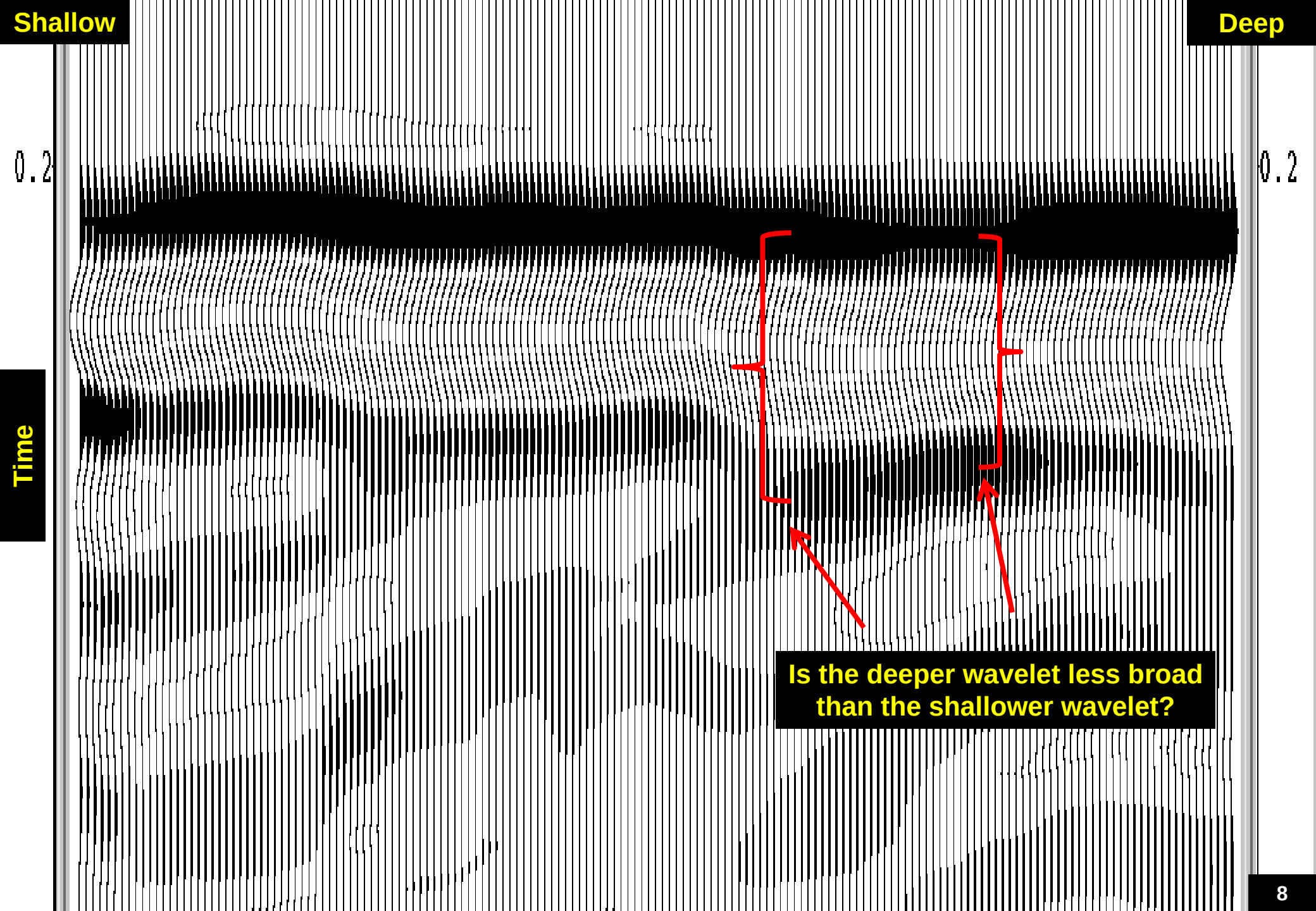

Shallow
Down Going VSP Data
Deep
Direct Arrival
Down Going Multiples?
Time
Viewed like this nothing is remarkable

What is Expected?

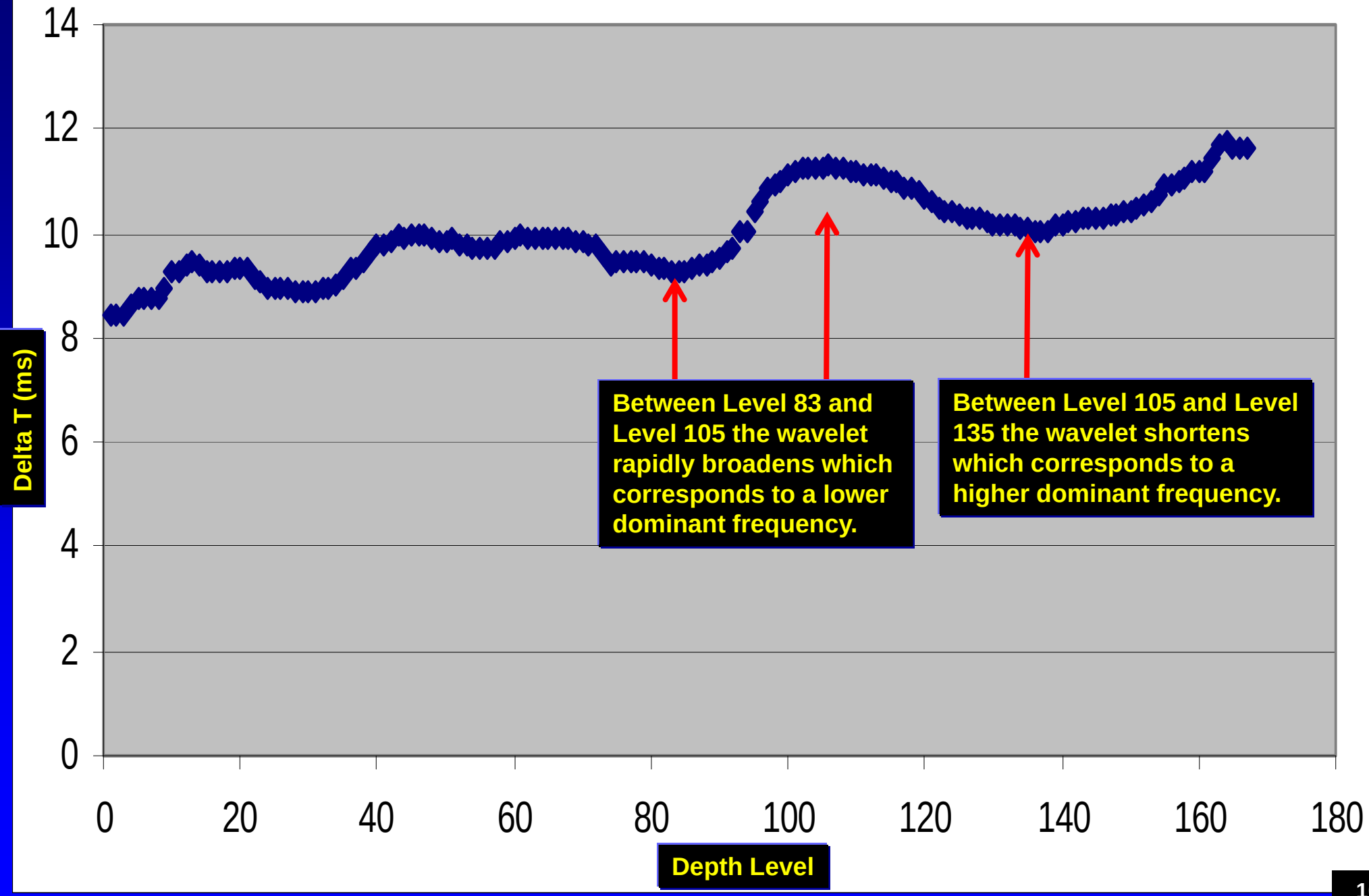
- If we carefully examine the direct arrival wavelet, we would expect the wavelet to be narrowest (i.e. highest frequency) at the shallowest depth level and to get longer at deeper depths as high frequencies are attenuated.
- Assuming the rate of attenuation is uniform, we would expect a gradually broadening wavelet at deeper levels.
- We would not expect a wavelet from a deeper depth level to be narrower than a wavelet from a shallower level.


Shallow
Deep
0.2
0.2
Time
Wavelet is narrowest here
Wavelet is broadest here
Ignoring the middle this is what we would expect
0.3


Shallow
Deep
0.2
0.2
Time
0.3
Interestingly, there appears to be rapid wavelet broadening at these locations


Shallow
Deep
0.2
0.2
Time
Is the deeper wavelet less broad than the shallower wavelet?

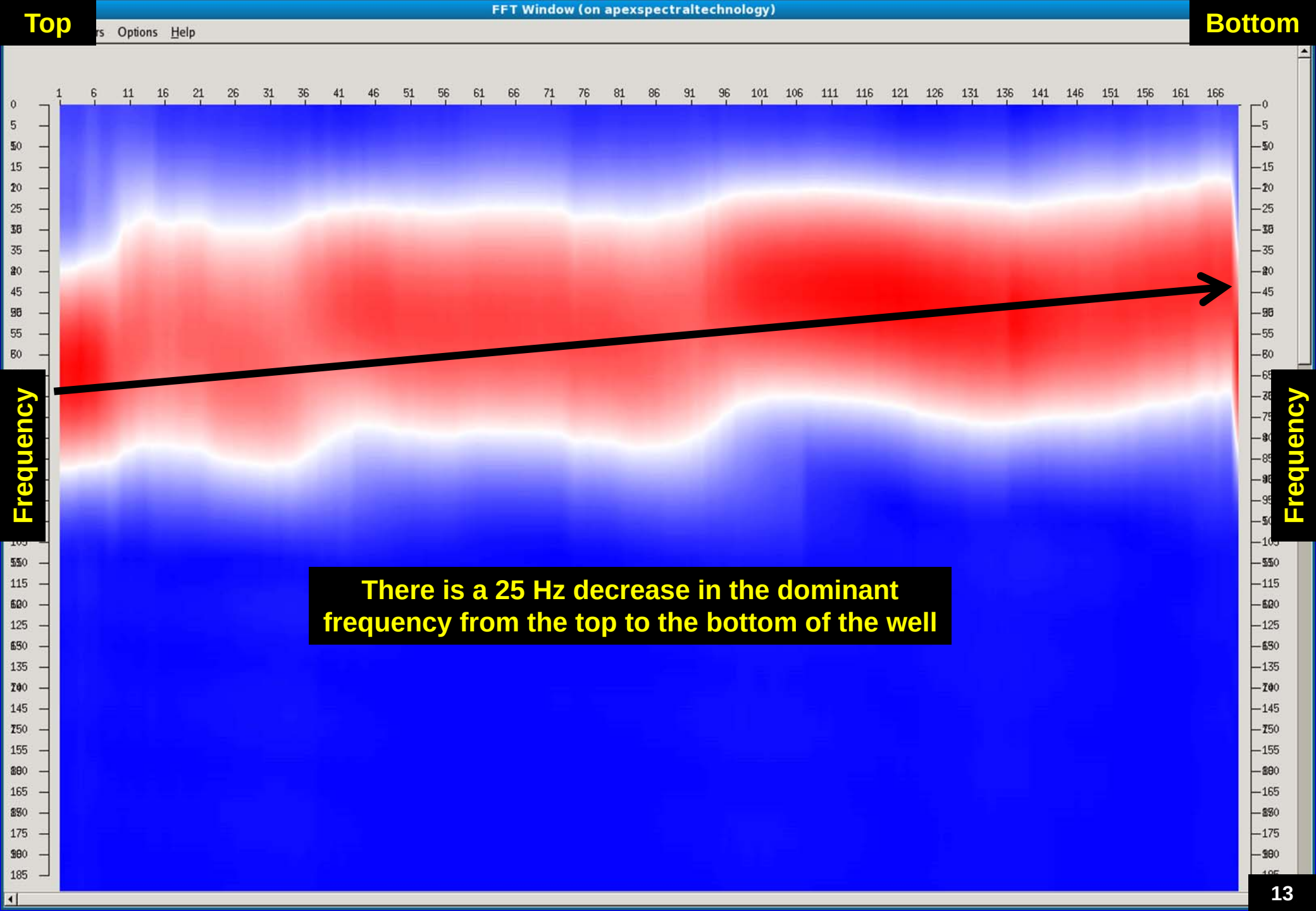
A straightforward way to measure the frequency content of the direct arrival is by measuring the time difference from the zero crossing before the direct arrival to the zero crossing after the direct arrival.

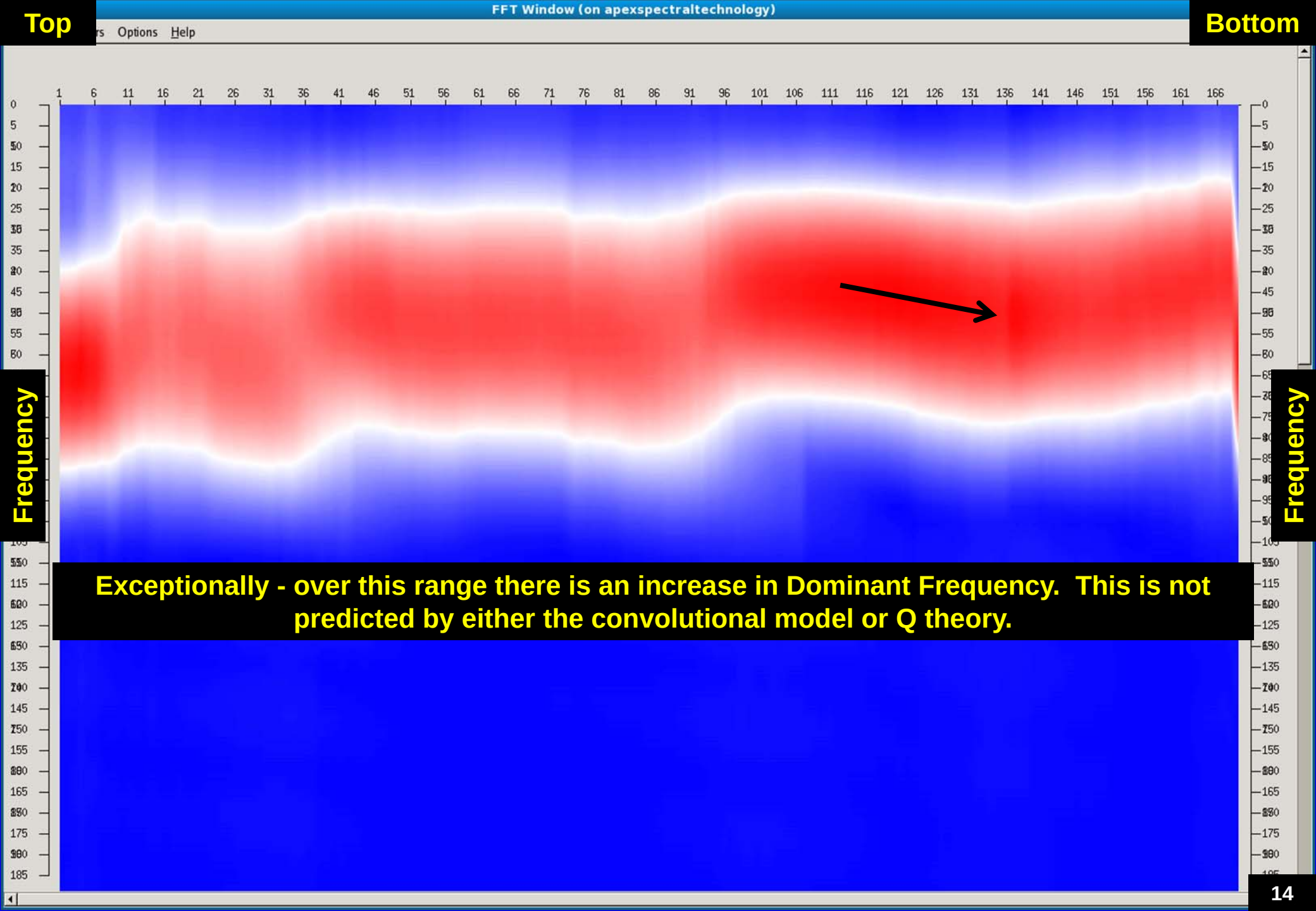

14
12
10
8
6
4
2
0
Delta T (ms)
0
20
40
60
80
100
120
140
160
180
Depth Level
Between Level 83 and Level 105 the wavelet rapidly broadens which corresponds to a lower dominant frequency.
Between Level 105 and Level 135 the wavelet shortens which corresponds to a higher dominant frequency.

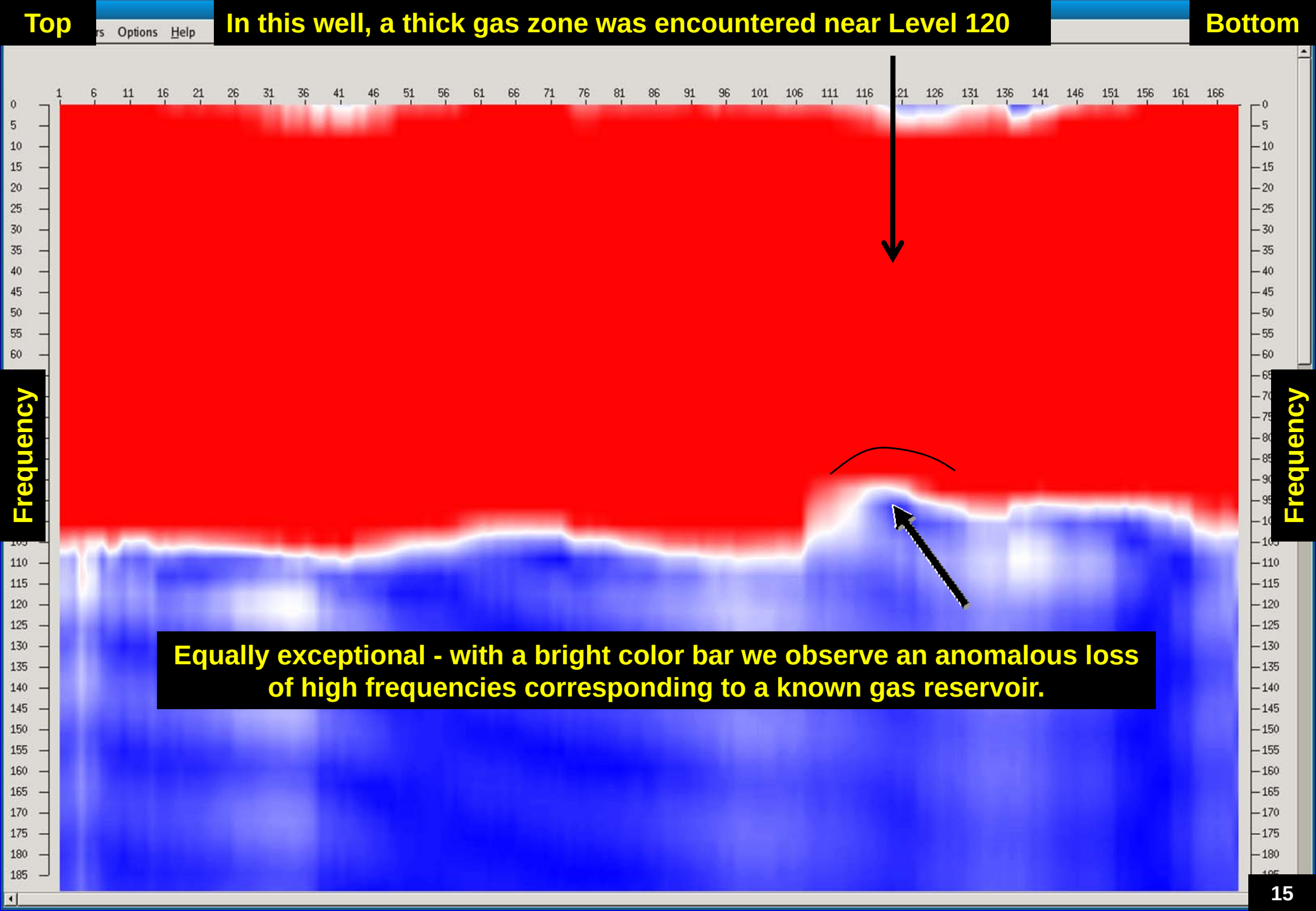
This Phenomenon can not be caused by Q

- If we were to try to use this data to measure Q, we would not obtain reasonable results over many of the levels.
- Rather we would be forced to discard the measurements made at several levels.
- It seems likely a plausible explanation for the need to discard data is that more phenomenon are at work than only Q.

We can make a similar measurement by calculating an FFT on the direct arrivals


Top
Bottom
FFT Window (on apexspectraltechnology)
Options
Help
Frequency
Frequency
There is a 25 Hz decrease in the dominant frequency from the top to the bottom of the well


Top
Bottom
FFT Window (on apexspectraltechnology)
Options
Help
Frequency
Frequency
Exceptionally - over this range there is an increase in Dominant Frequency. This is not predicted by either the convolutional model or Q theory.


Top
In this well, a thick gas zone was encountered near Level 120
Bottom
Options Help
Frequency
Frequency
Equally exceptional - with a bright color bar we observe an anomalous loss of high frequencies corresponding to a known gas reservoir.

Some Possible Explanations Working in Conjunction with Q

- Fining downward sequences cause the frequency of the travelling wave to increase
- Frequency dependant reflection coefficients
- Conversion of P wave to shear wave energy causes the frequency of the transmitted P wave to increase
- Our layers act similar to springs and tend to vibrate independent of the exciting wavelet
- Attenuation may in some cases result more low frequencies being attenuated than high frequencies