Seismic Attenuation: Impact on the AVO Response

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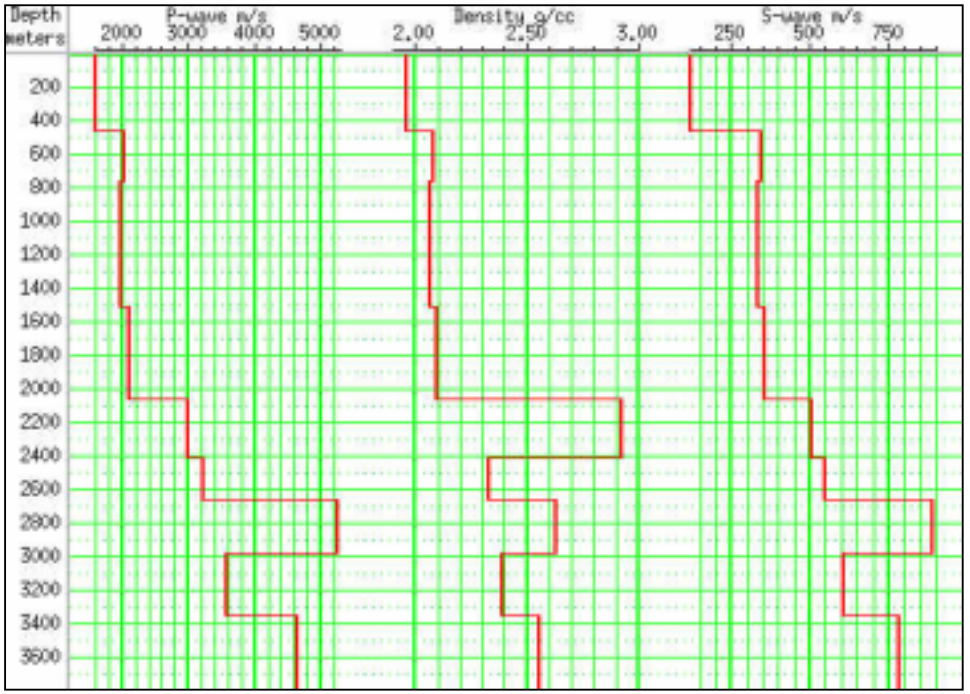
Outline

- Subsurface model
- Causal synthetic seismograms 1D
  - Standard linear solid
  - Futterman
  - Kjartansson
- Software comparison
  - Hampson-Russell
  - Osiris
- Effect of 1/Q on the AVO response
- Conclusions

Subsurface Model Utilized

Thickness	Vp (m/s)	Vs (m/s)	Rho (gm/cc)
450	1615	403	1.962
750	2050	1138	2.083
1500	2000	1111	2.070
2060	2120	1177	2.100
2410	3000	1666	2.931
2660	3240	1800	2.335
2975	5260	2922	2.636
3350	3590	1994	2.396
3800	4650	2583	2.556

“9-layer Model”



Kennett Algorithm

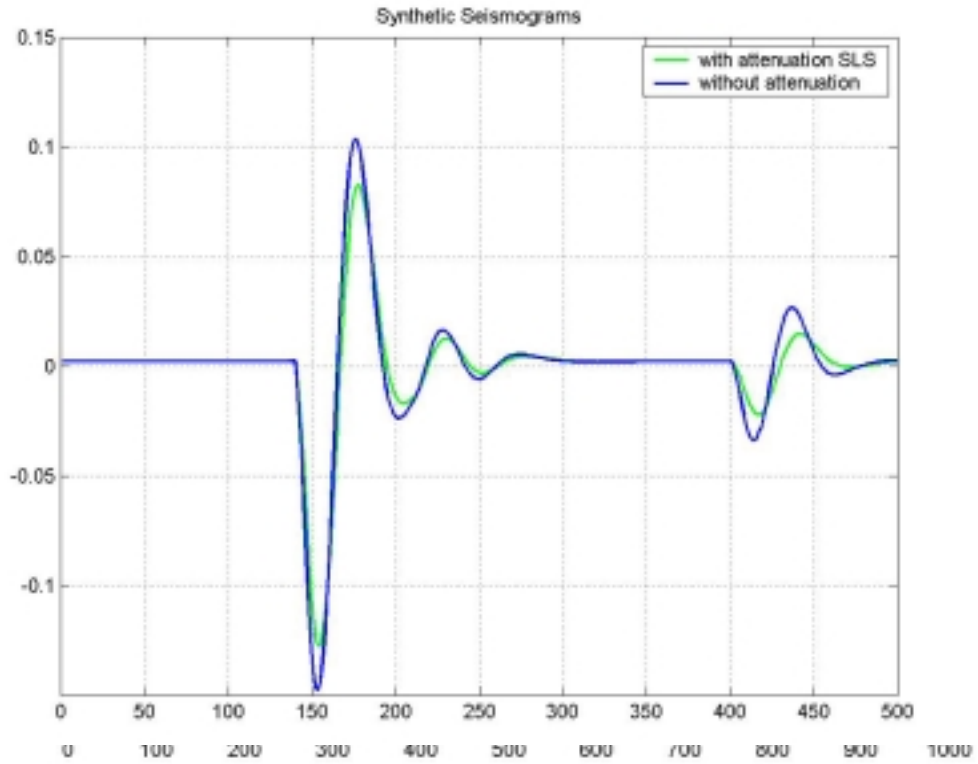
Algorithm to compute synthetic seismograms

- **Plane wave superposition**
- **Fourier space**
- **Builds up a reflection matrix layer by layer**
- **INCLUSION OF ATTENUATION** →
  - **SLS**
  - **Futterman**
  - **Kjartansson**

Seismogram 1D: Standard Linear Solid

$$M(\omega) = \frac{M_\infty [M_o + i \frac{\omega}{\omega_r} \sqrt{M_\infty M_o}]}{M_\infty + i \frac{\omega}{\omega_r} \sqrt{M_\infty M_o}}$$

$$\left(\frac{1}{Q_{\max}} \right) = \frac{1}{2} \frac{(M_\infty - M_0)}{\sqrt{M_\infty M_o}}$$

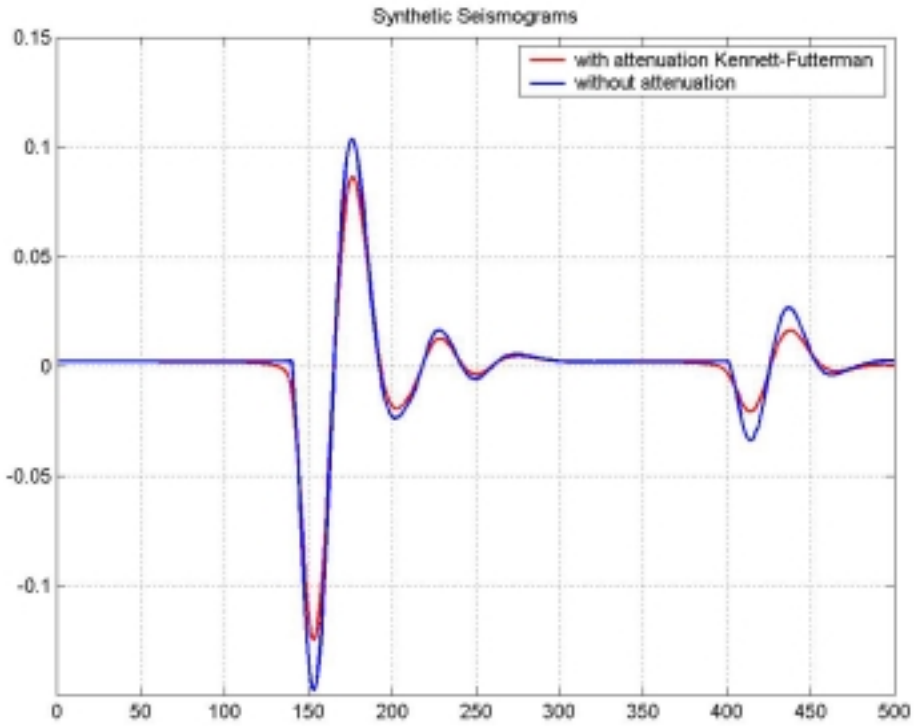


with attenuation SLS
without attenuation

Seismogram 1D: Futterman - Kennett

$$V_p(\omega) = V_p\left(I - i\frac{\operatorname{sgn}\omega}{2Q(\omega)}\right)$$

$$Q(\omega) = Q_o\left(I - \frac{\ln\left(\frac{\gamma\omega}{\omega_o}\right)}{\pi Q_o}\right)$$

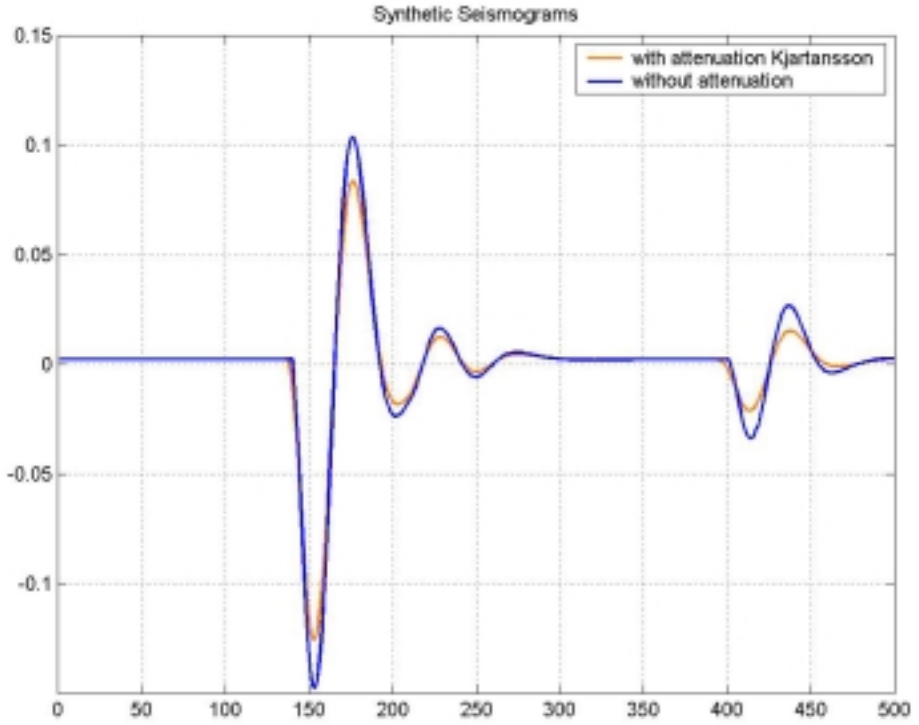


with attenuation Kennett-Futterman
without attenuation

Seismogram 1D: Kjartansson

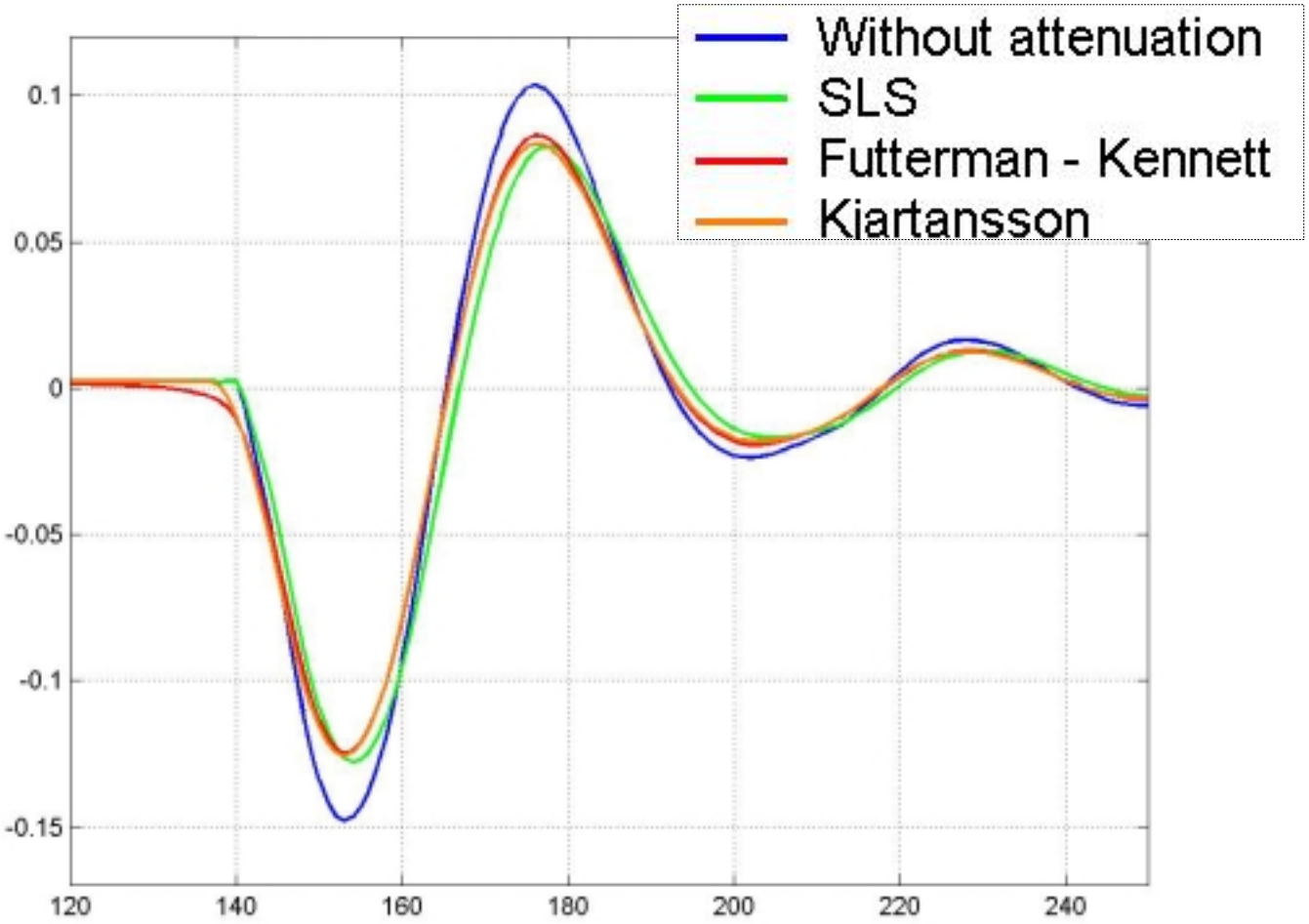
$$M(\omega) = M_o \left(\frac{i\omega}{\omega_o} \right)^{2\kappa}$$

$$\kappa = \frac{arctg\left(\frac{1}{Q}\right)}{\pi}$$

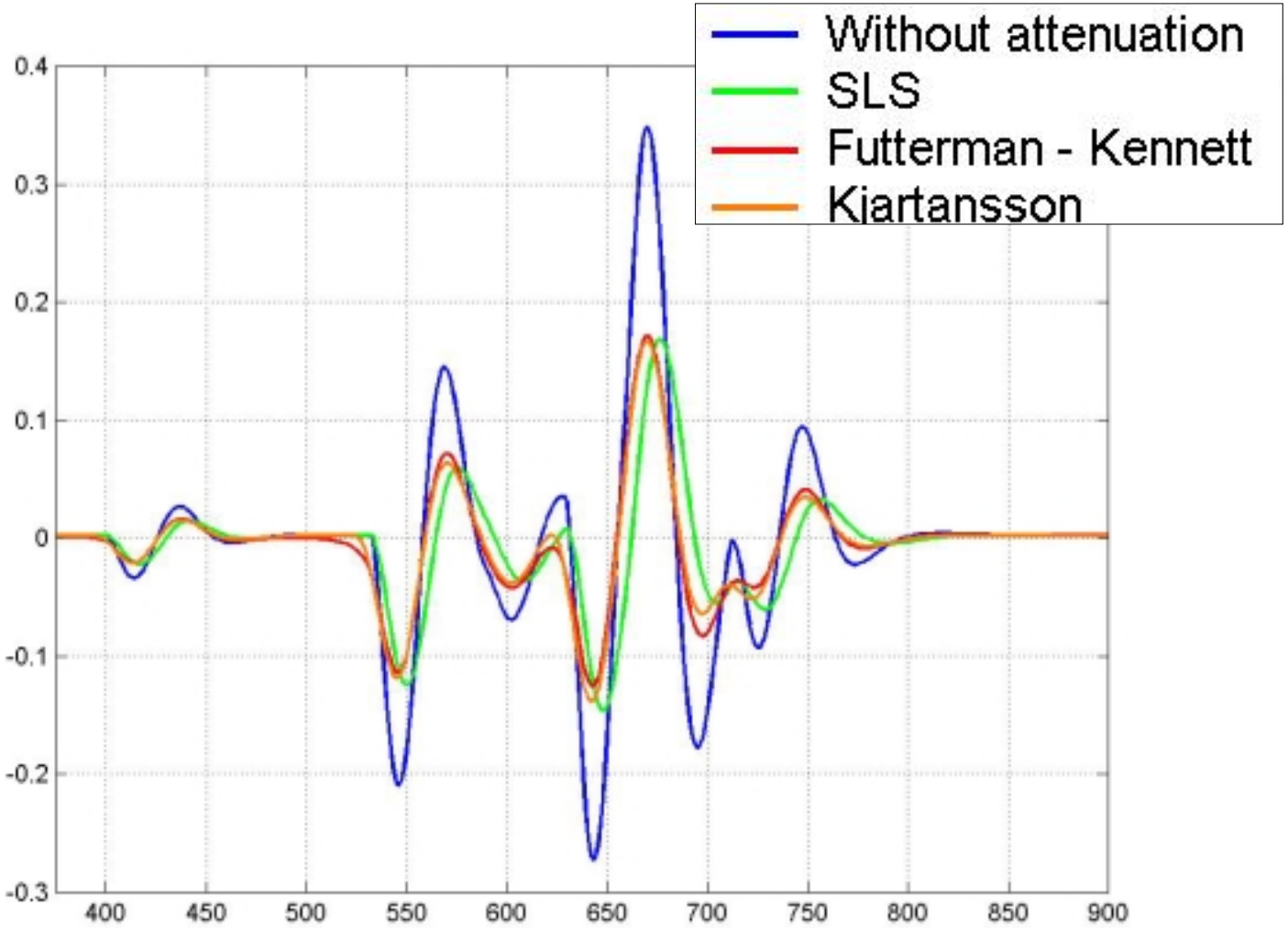


with attenuation Kjartansson
without attenuation

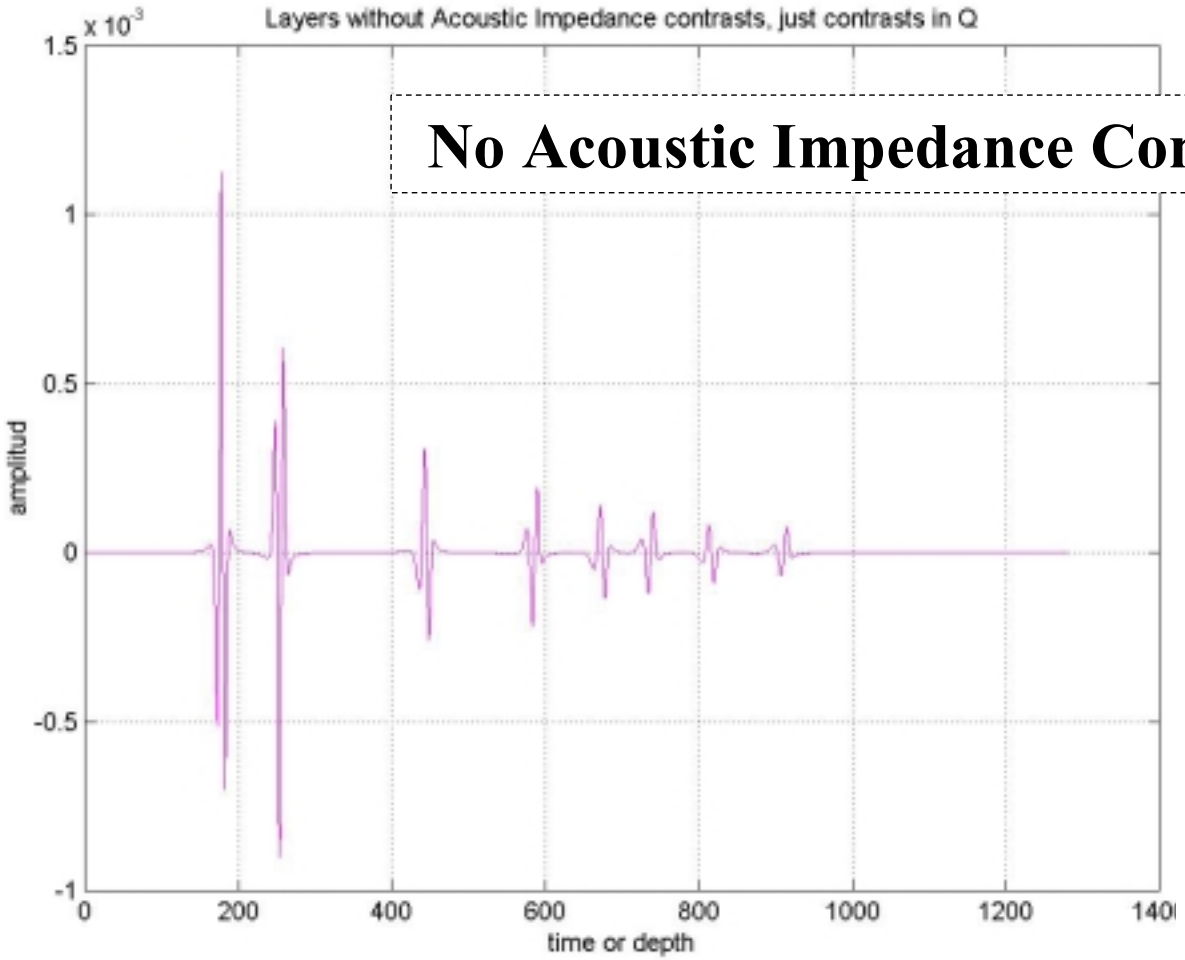
Seismogram 1D: Comparison



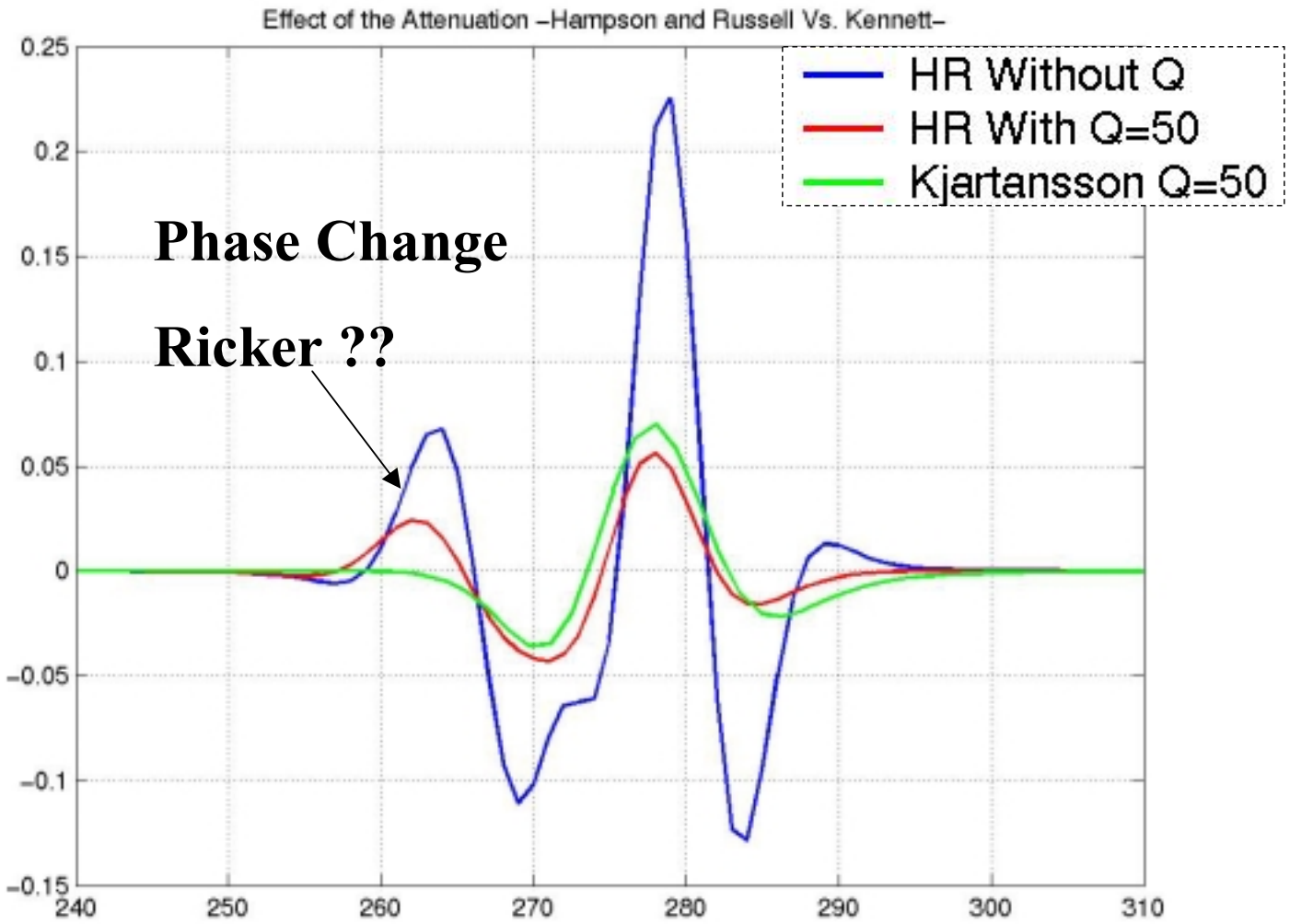
Seismogram 1D: Comparison



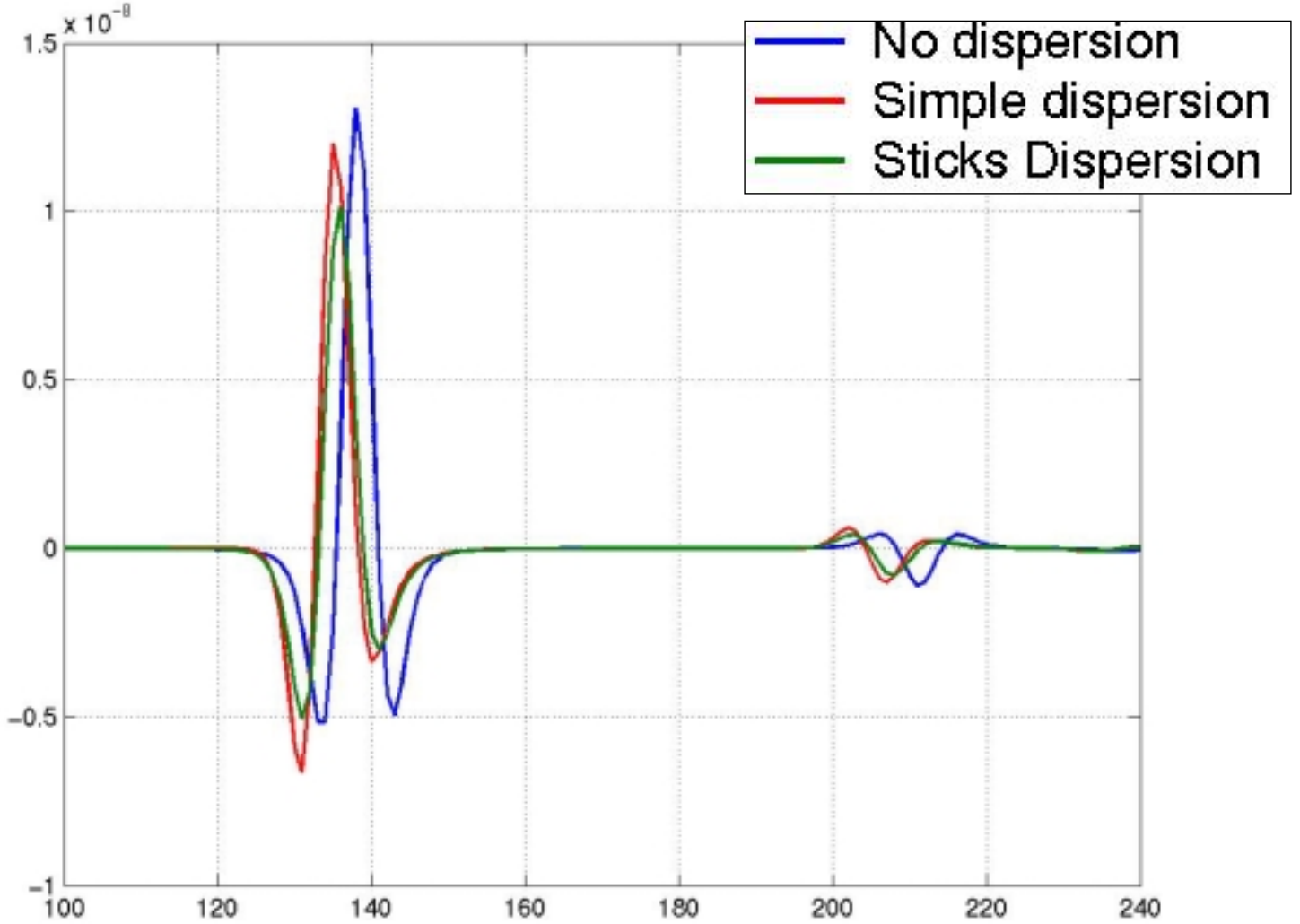
Impact of Q on the Reflectivity Series



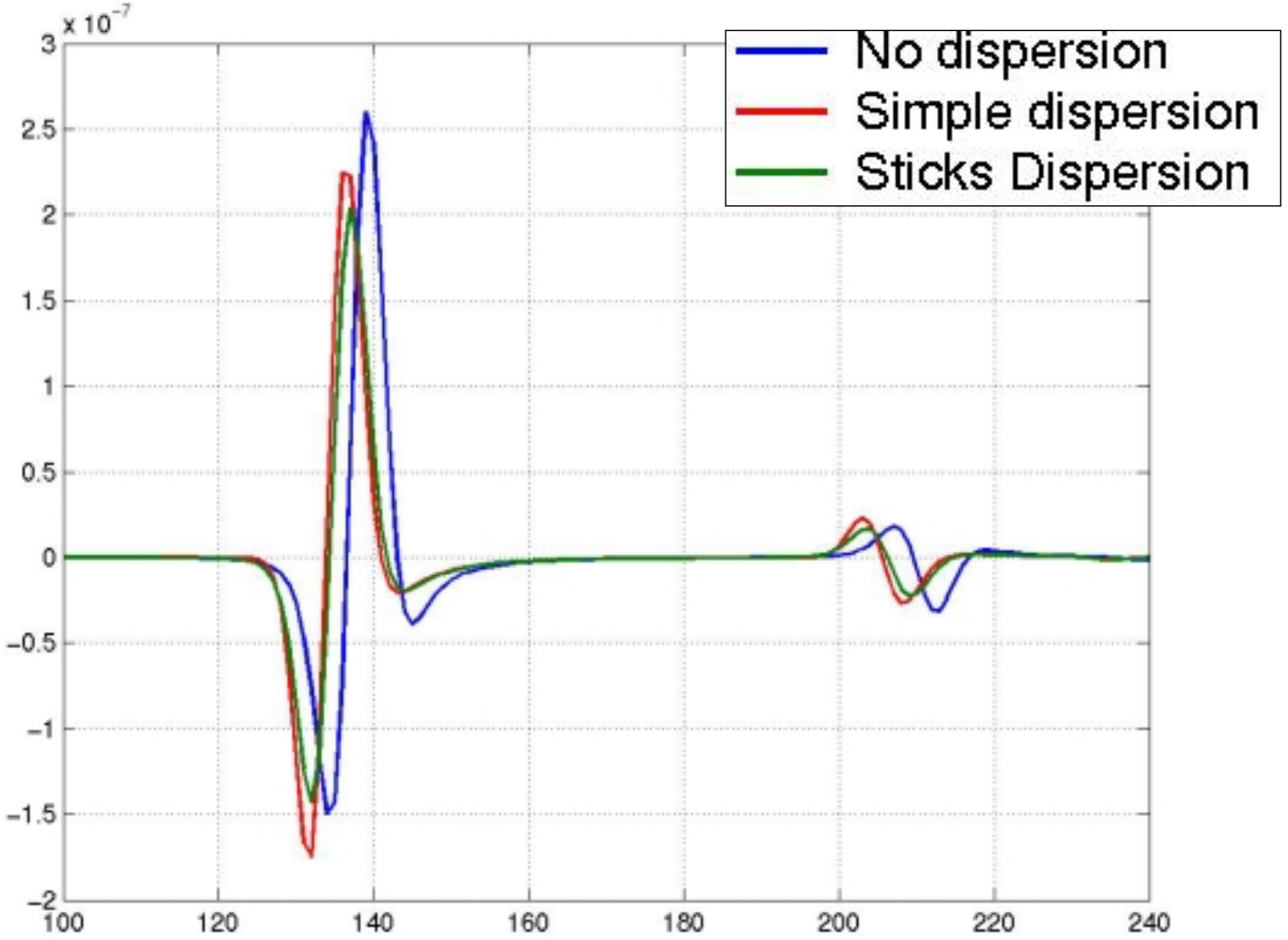
Hampson and Russell™



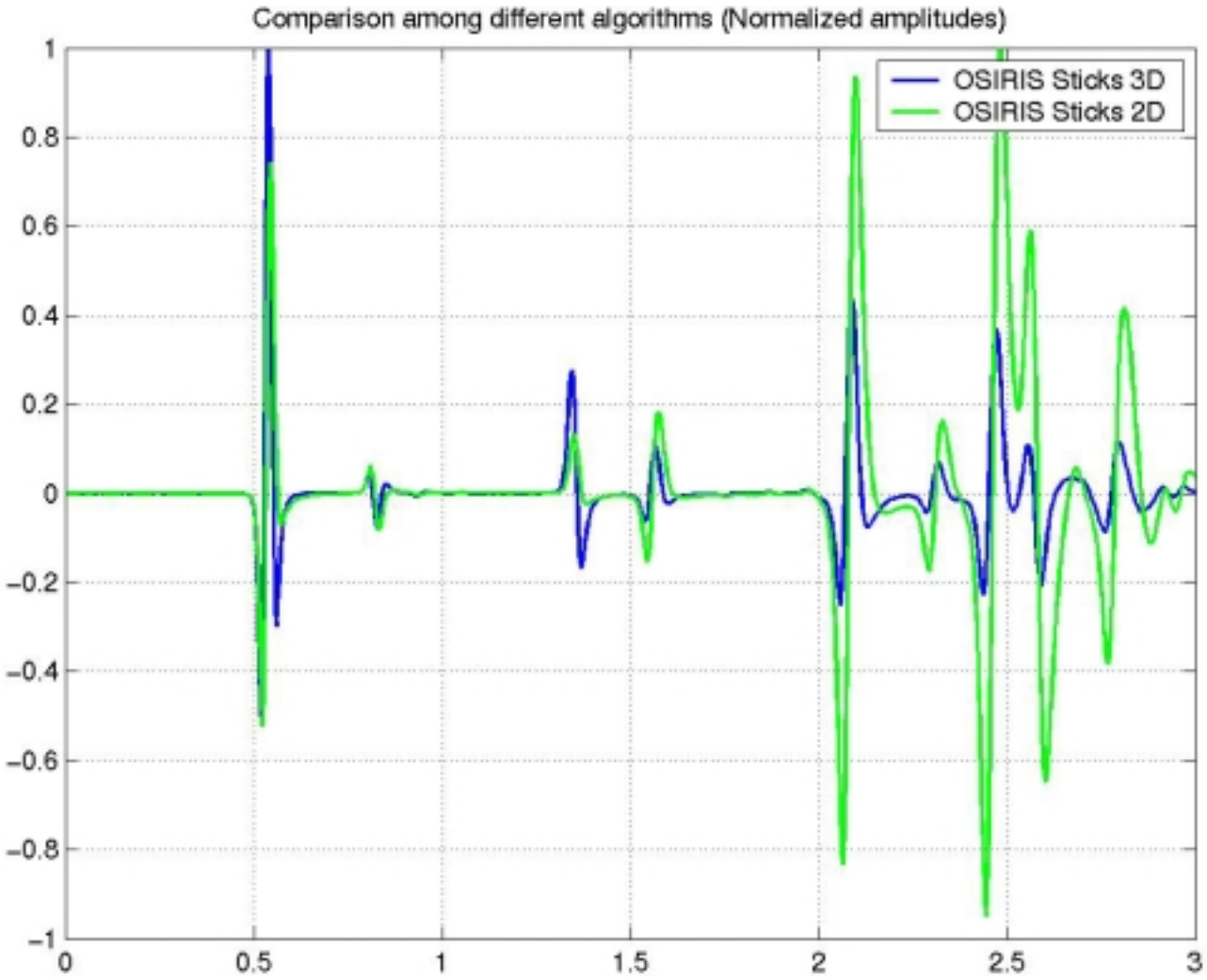
OSIRIS™: Divergence Corrections 3D



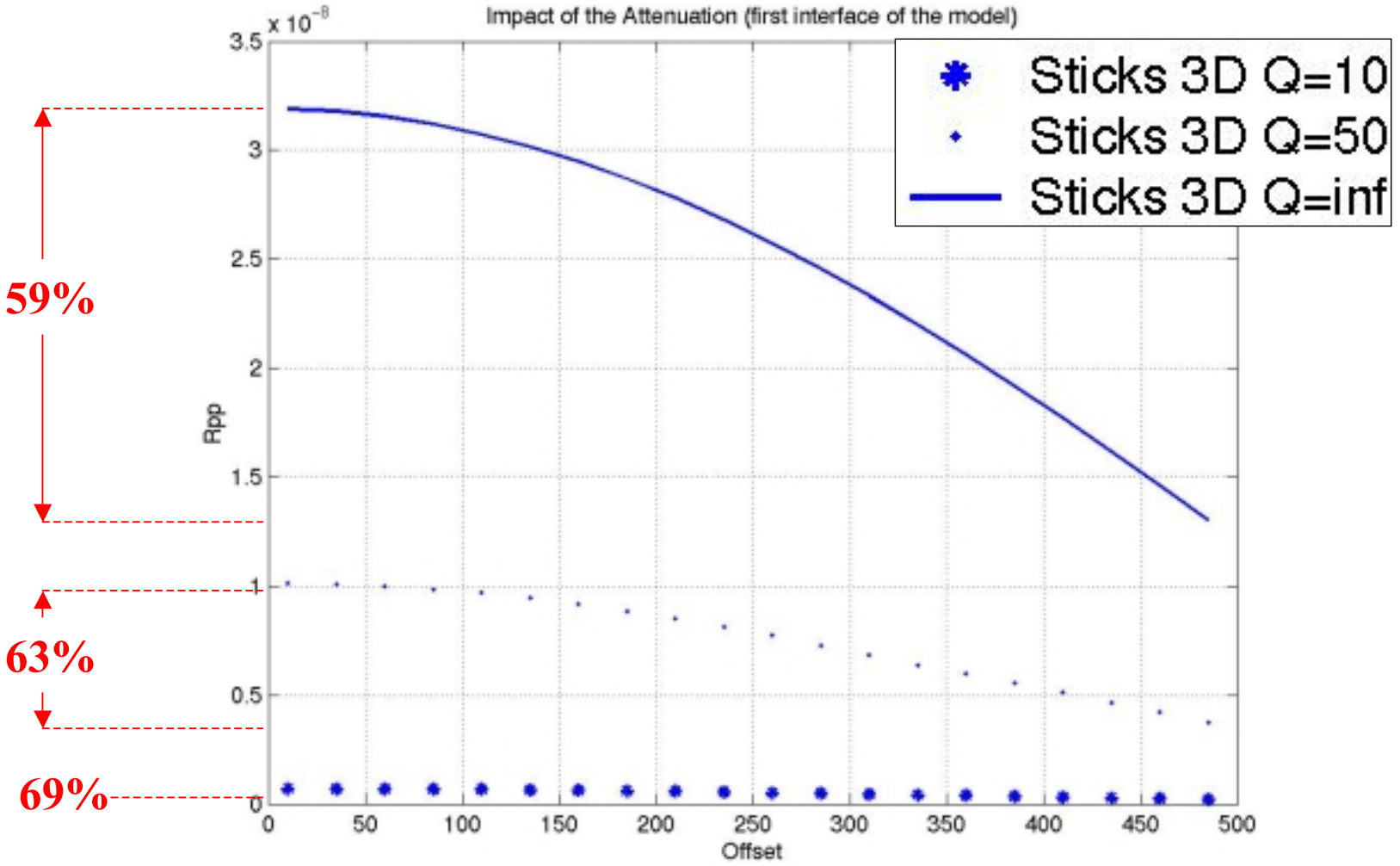
OSIRIS™: Divergence Corrections 2D



OSIRIS™: 2D Vs. 3D



Effect of Q (Wave Prop. 3D)



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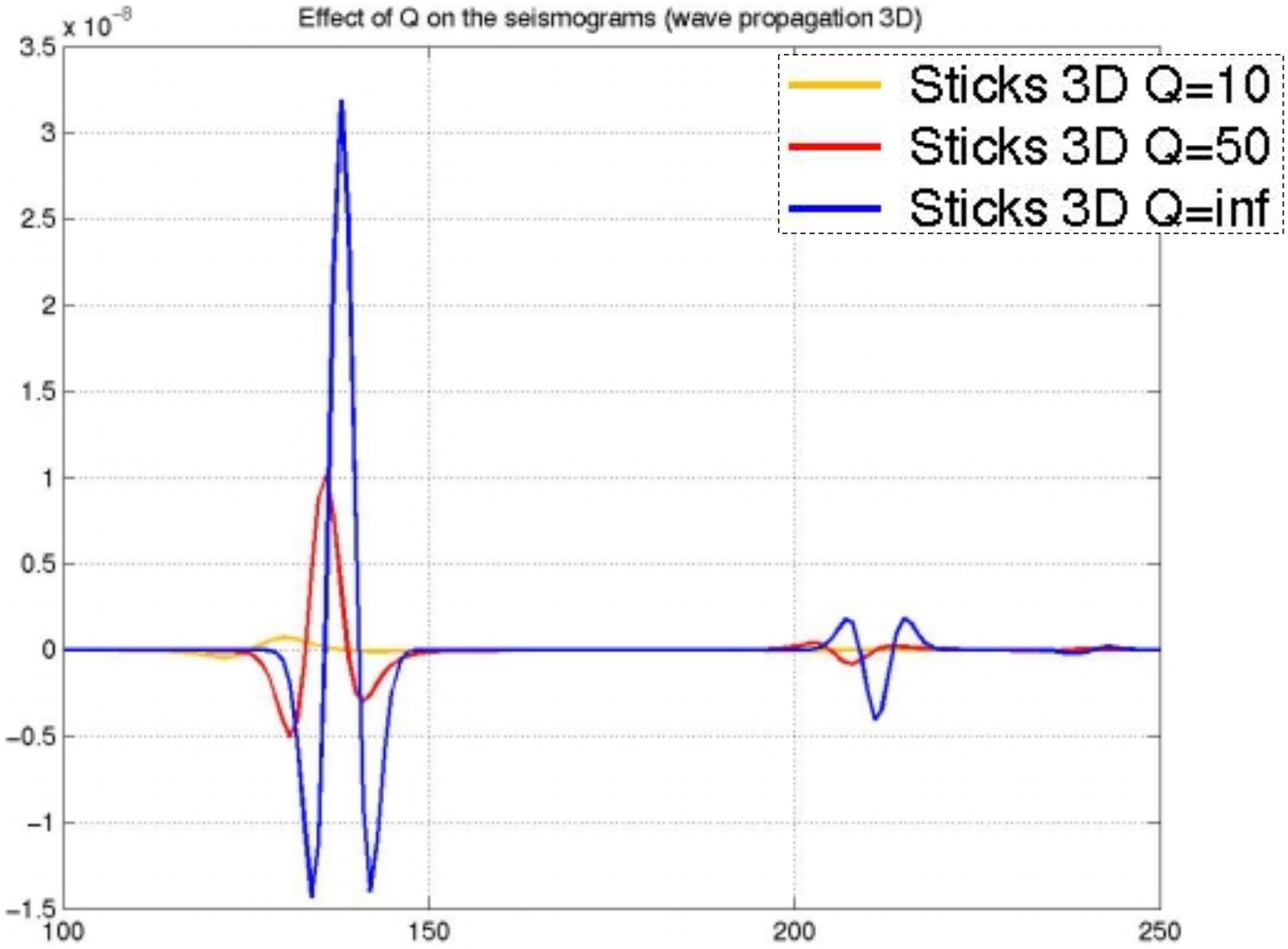

Conclusions

- Small differences among attenuation approaches.
- Q-contrasts can generate reflections.
- “Removing Q” in Hampson-Russell alters the phase spectrum. Problems of stability.
- Differences between consider either 2D or 3D wave propagation in seismogram computations (Osiris) and also in the kind of correction.
- Q has a considerable impact on the AVO response ~ 10% in the example.

Seismogram 1D: Standard Linear Solid

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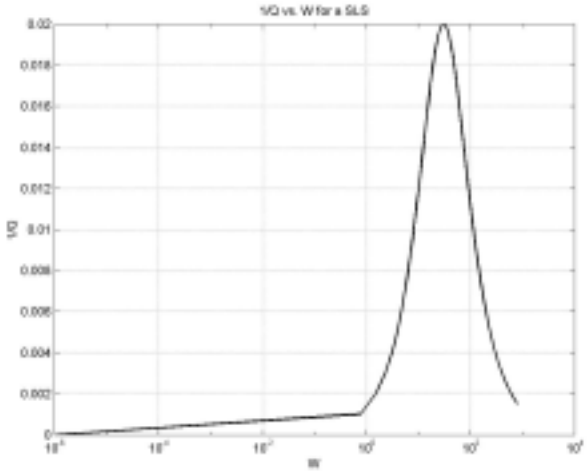

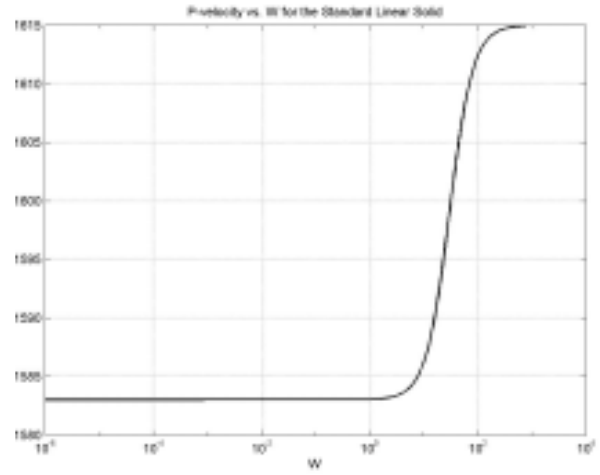

Hampson and Russell™