

Q-factor estimation

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Outline

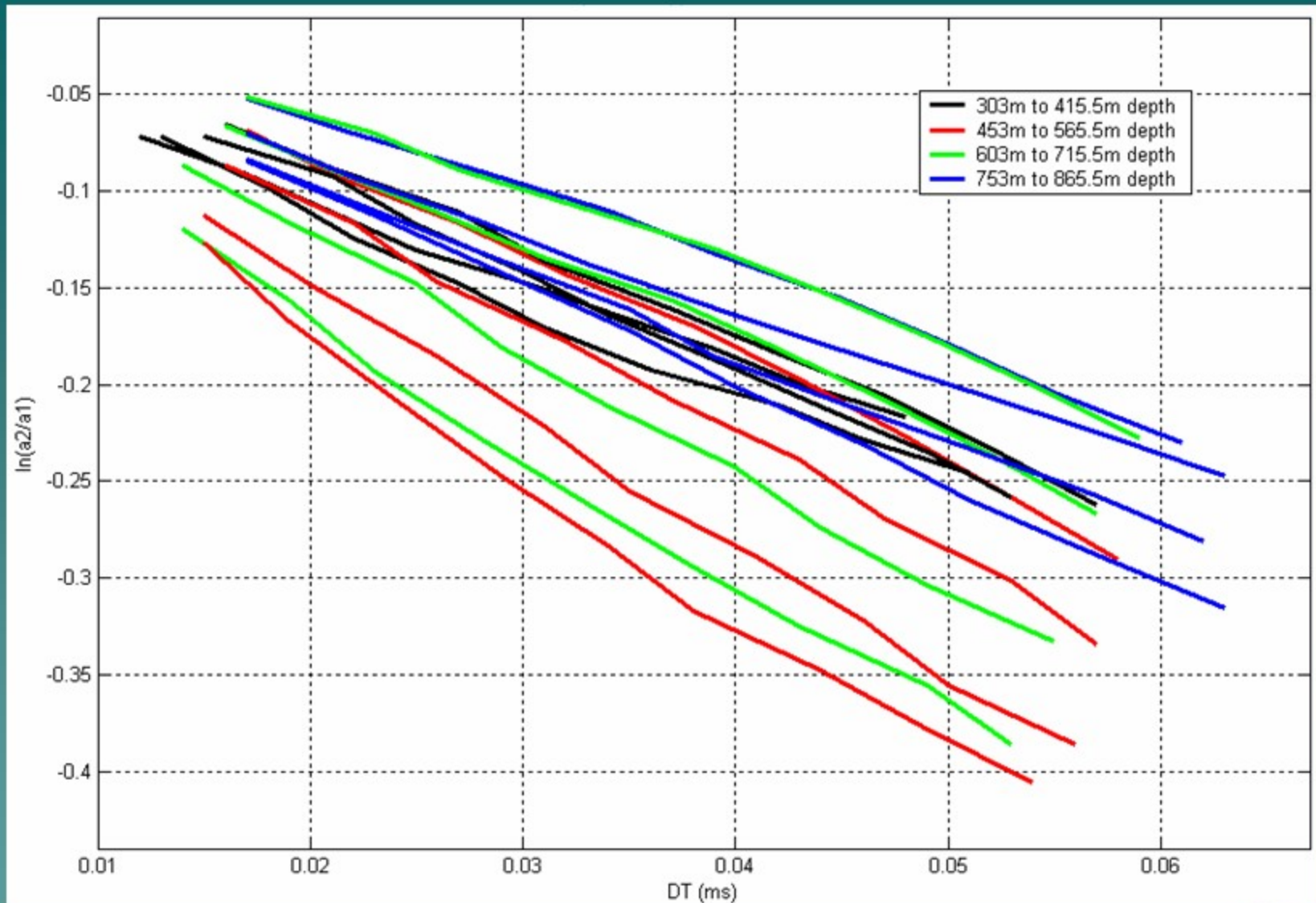
- ◆ Introduction
- ◆ Moveout compensation for VSP data
Q-estimation
- ◆ Transmission loss compensation for VSP data
Q-estimation
- ◆ Q_p estimation from a surface data model
- ◆ Q_p estimation from actual surface data at VSP location
- ◆ Conclusions
- ◆ Acknowledgements

Potential error sources for VSP data Q-estimation

- ◆ Moveout errors (spherical versus plane waves)
- ◆ Transmission loss errors
- ◆ Ray bending errors
- ◆ Q-anisotropy errors
- ◆ Soil compaction errors

$$\ln \left[\frac{a(t_2)}{a(t_1)} \right] = \ln \left[\frac{G_2}{G_1} \right] - \frac{\Delta t}{4Q} \left(\omega(t_1) + \omega(t_2) \right)$$

Log instantaneous amplitude ratio for analytical signal method
(Tonn, 1991)

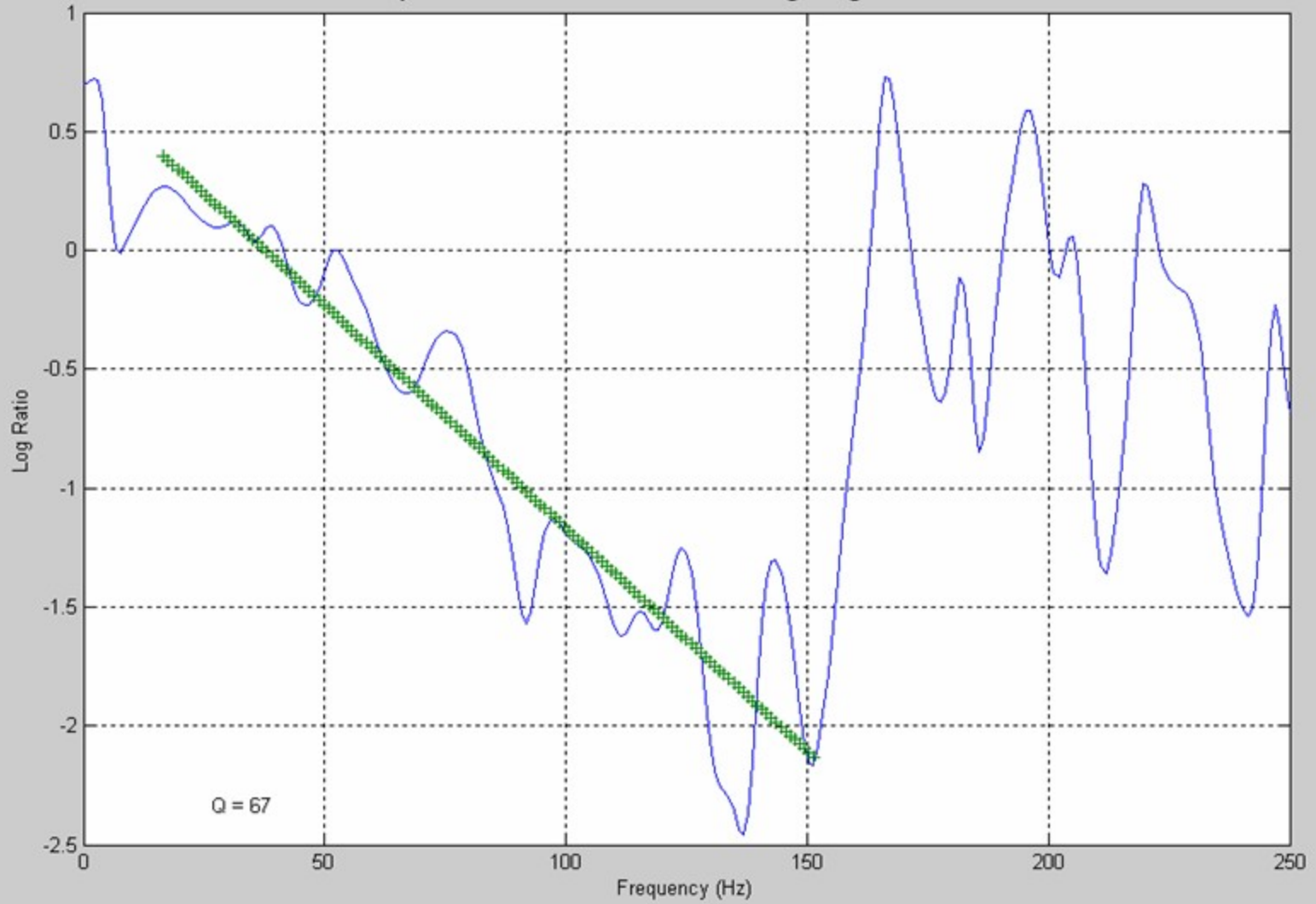


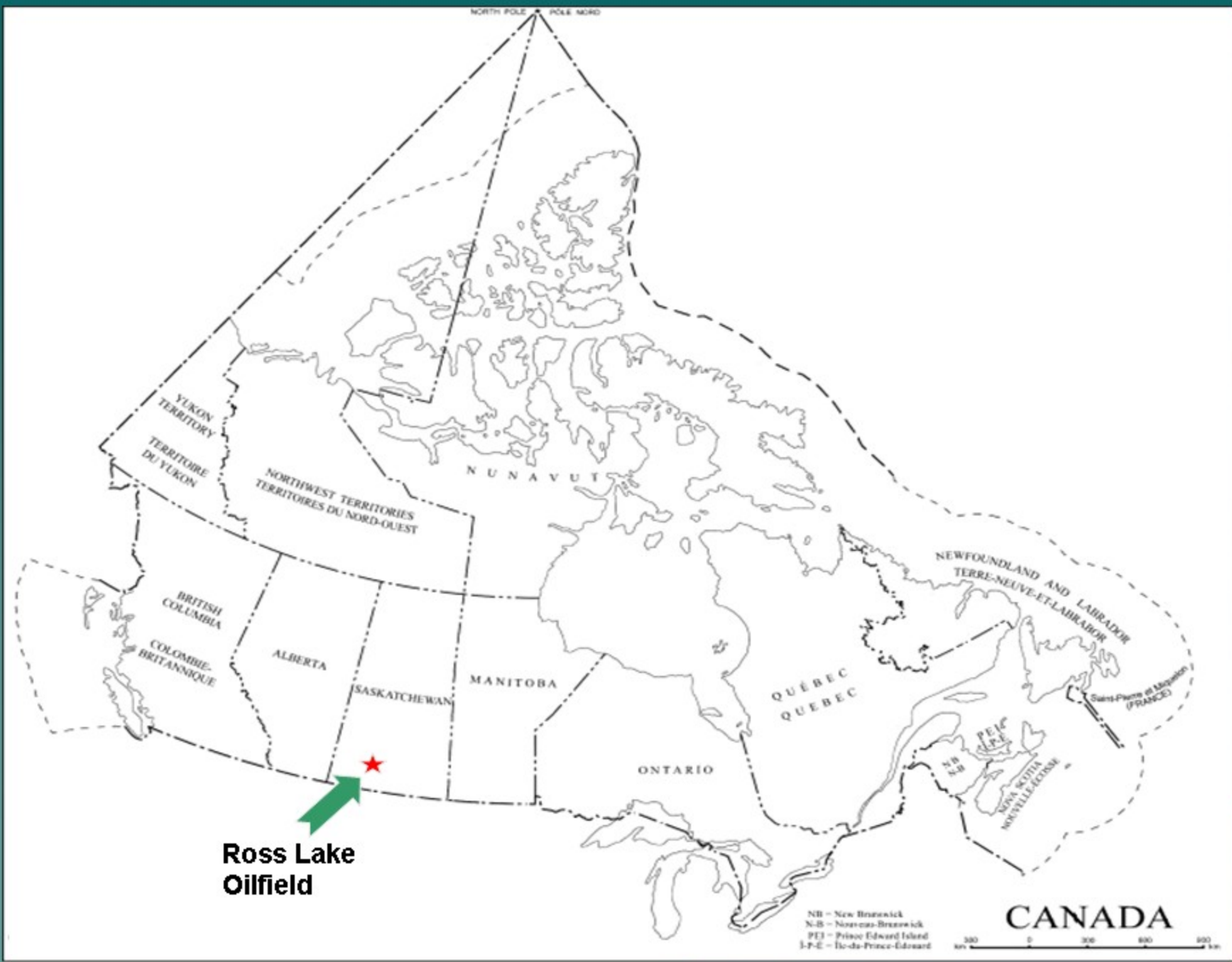
Log Amplitude Ratio versus Δt for Downgoing P-Wave Field

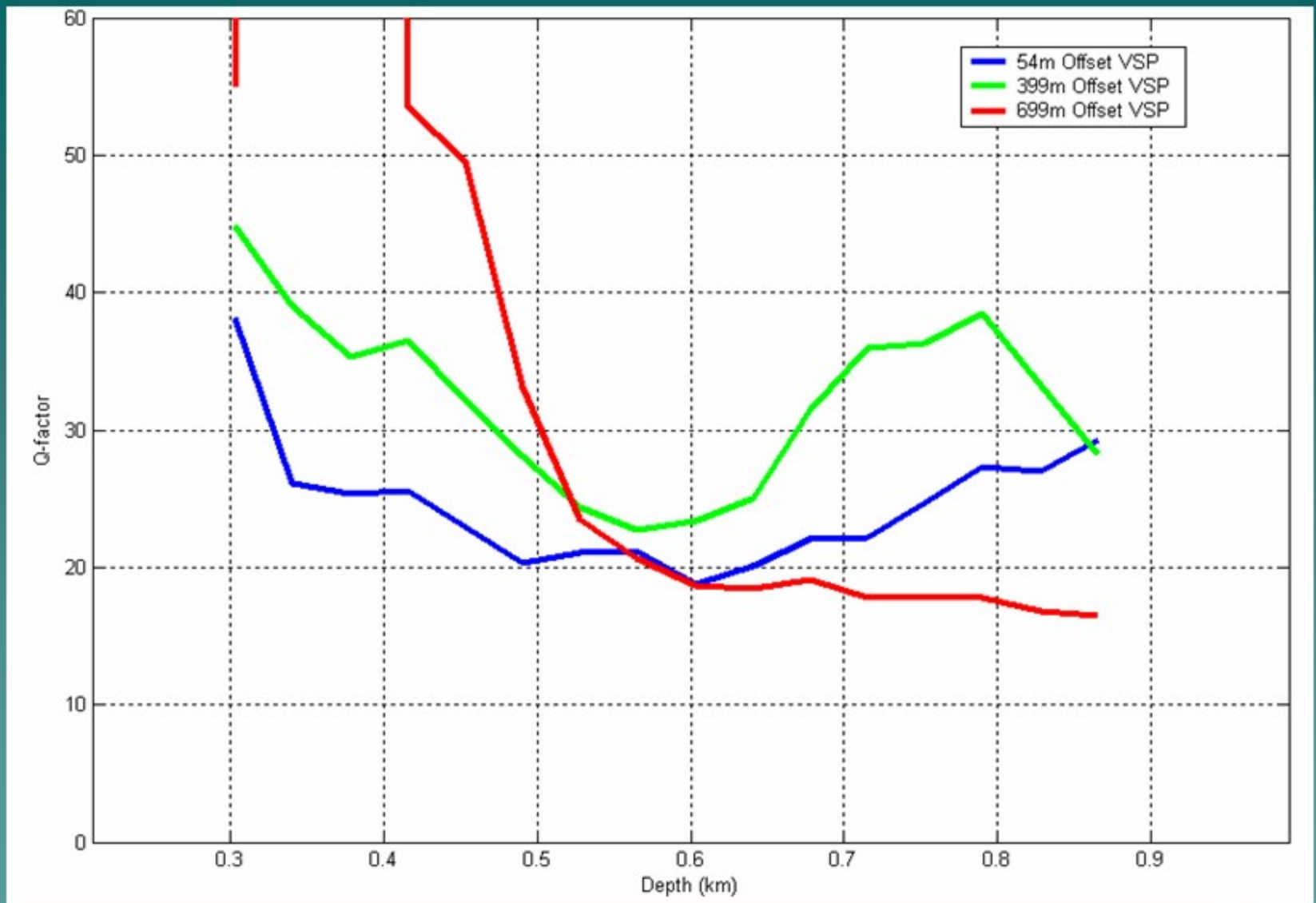
$$\ln \left[\frac{|A_2(\omega)|}{|A_1(\omega)|} \right] = (\text{const.}) - \omega \frac{d}{2cQ}$$

Spectral Ratio Method (e.g. Tonn, 1991)

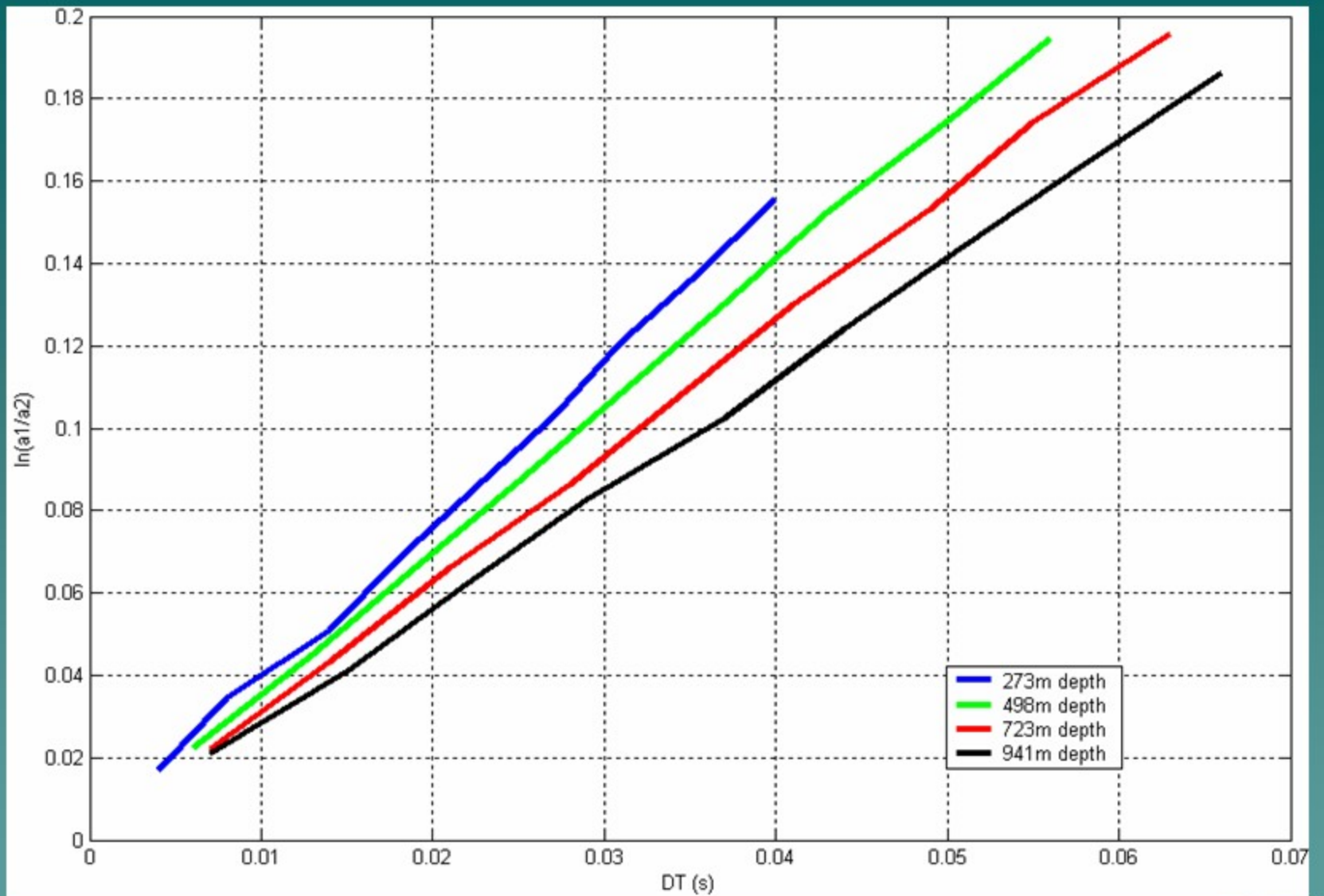
Spectral Ratio Plot of Downgoing P-Wave



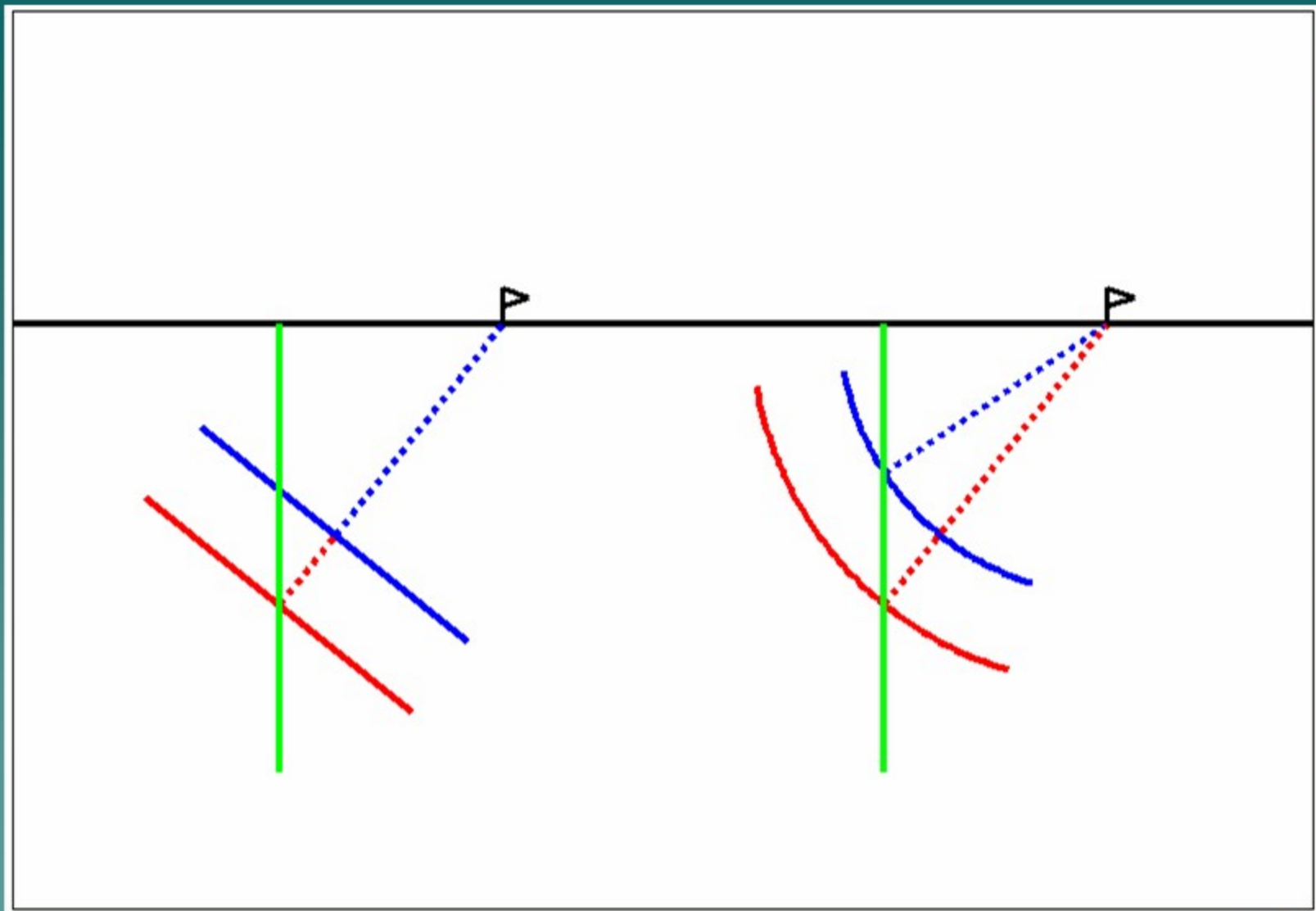




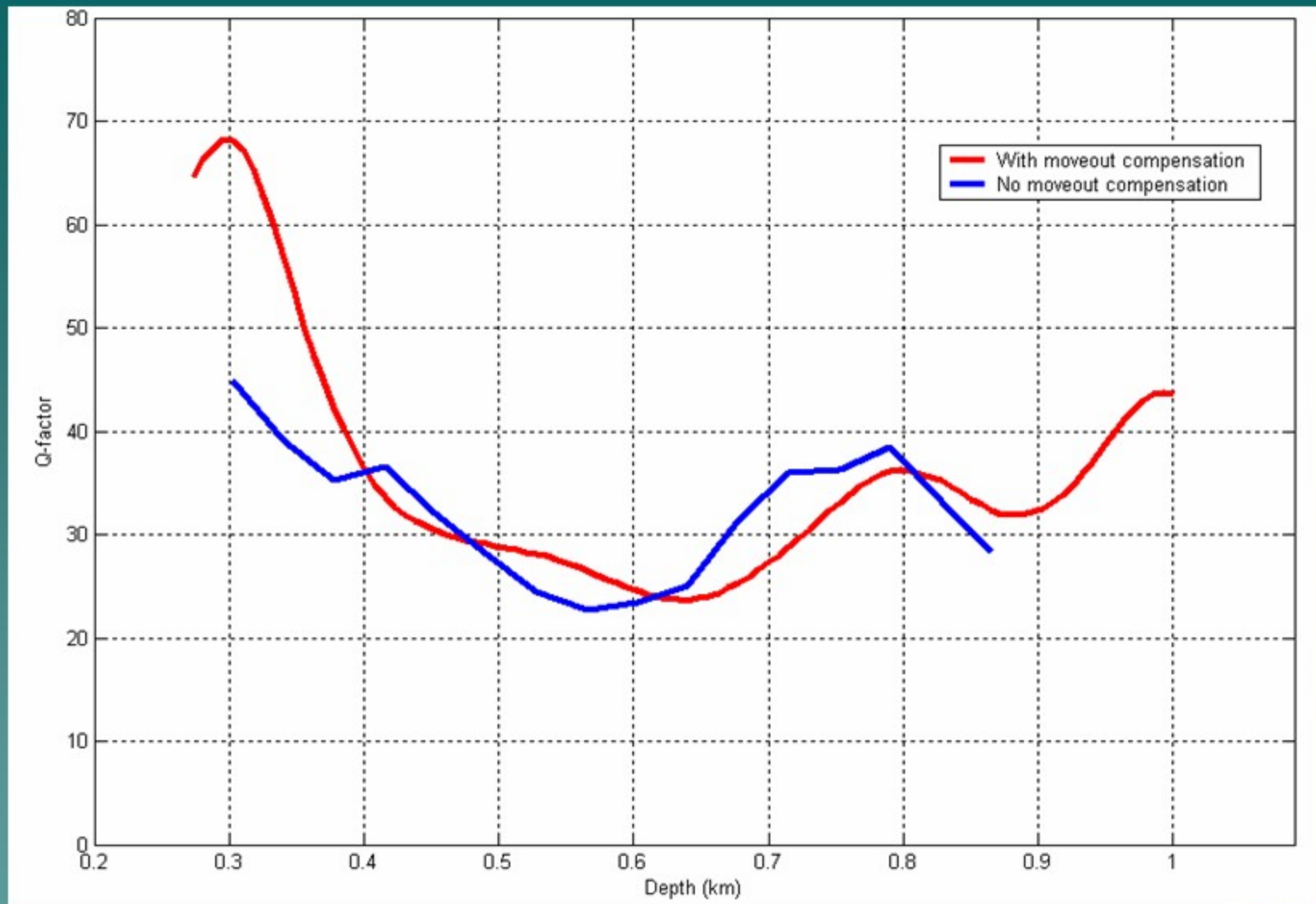
Quality Factor (Q) versus Depth



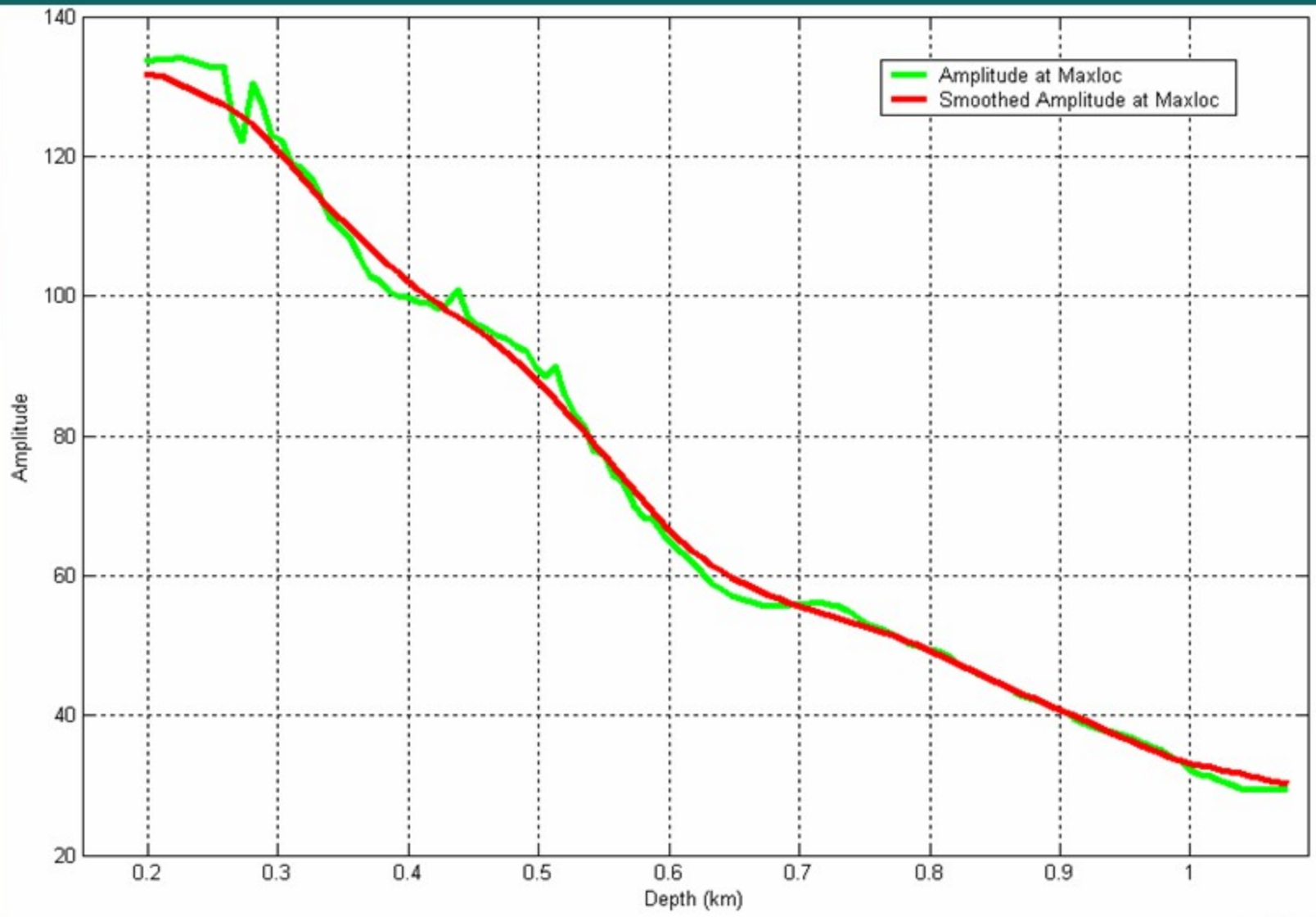
VSP-Model Log Amplitude Ratio versus Δt (Q=30, 399 m Offset)



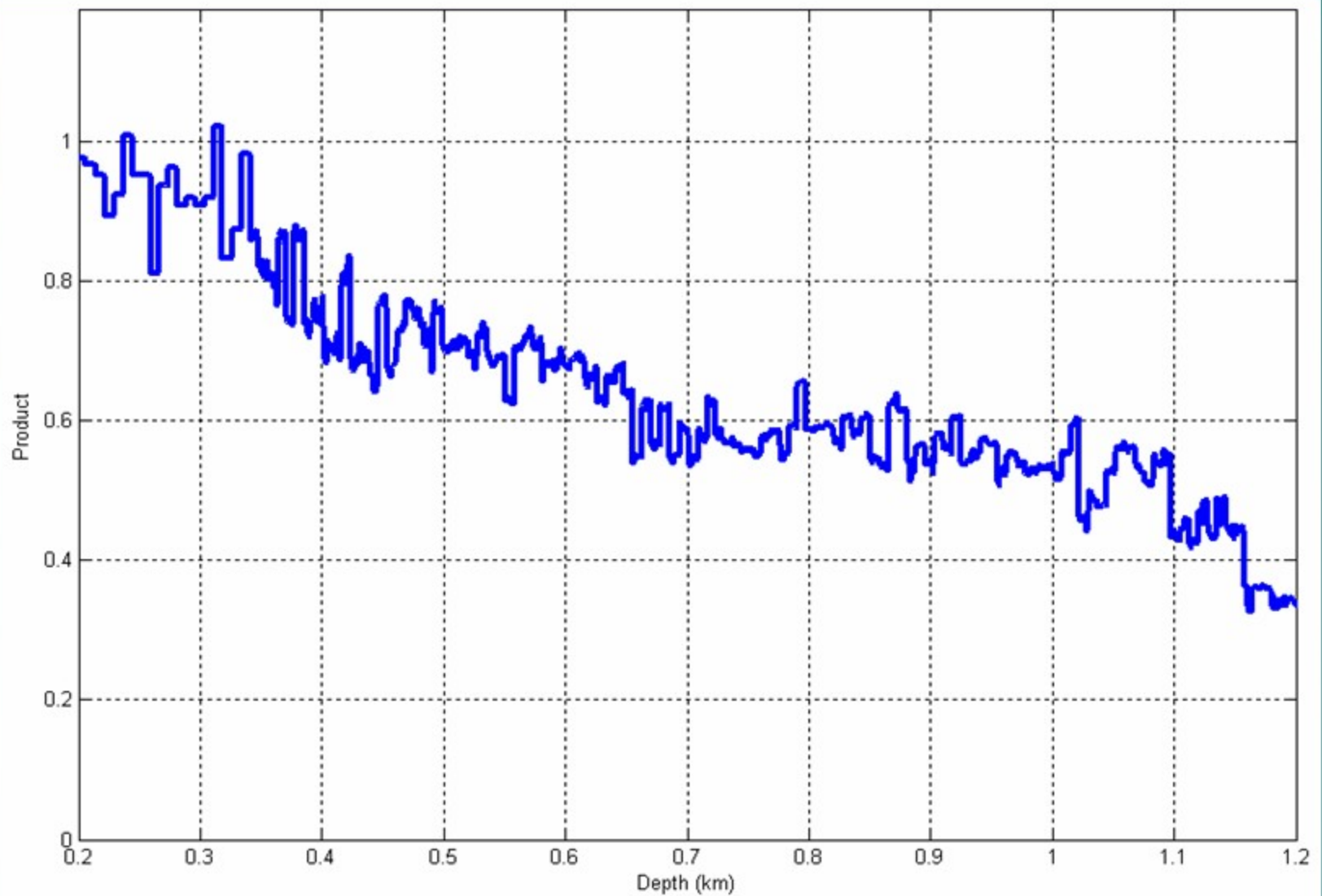
Plane Waves and Spherical Waves



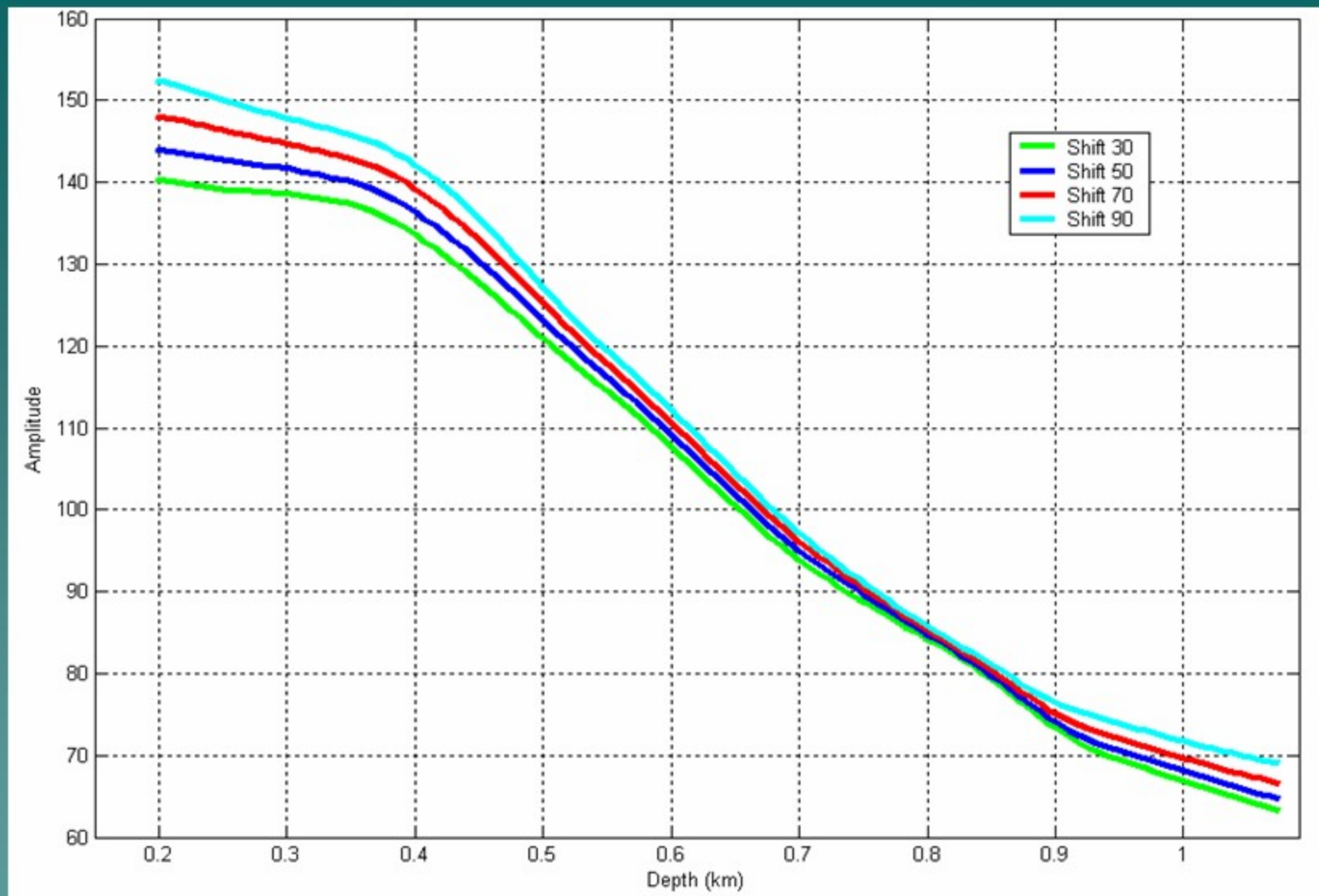
Quality Factor (Q) versus Depth (399 m Offset VSP)



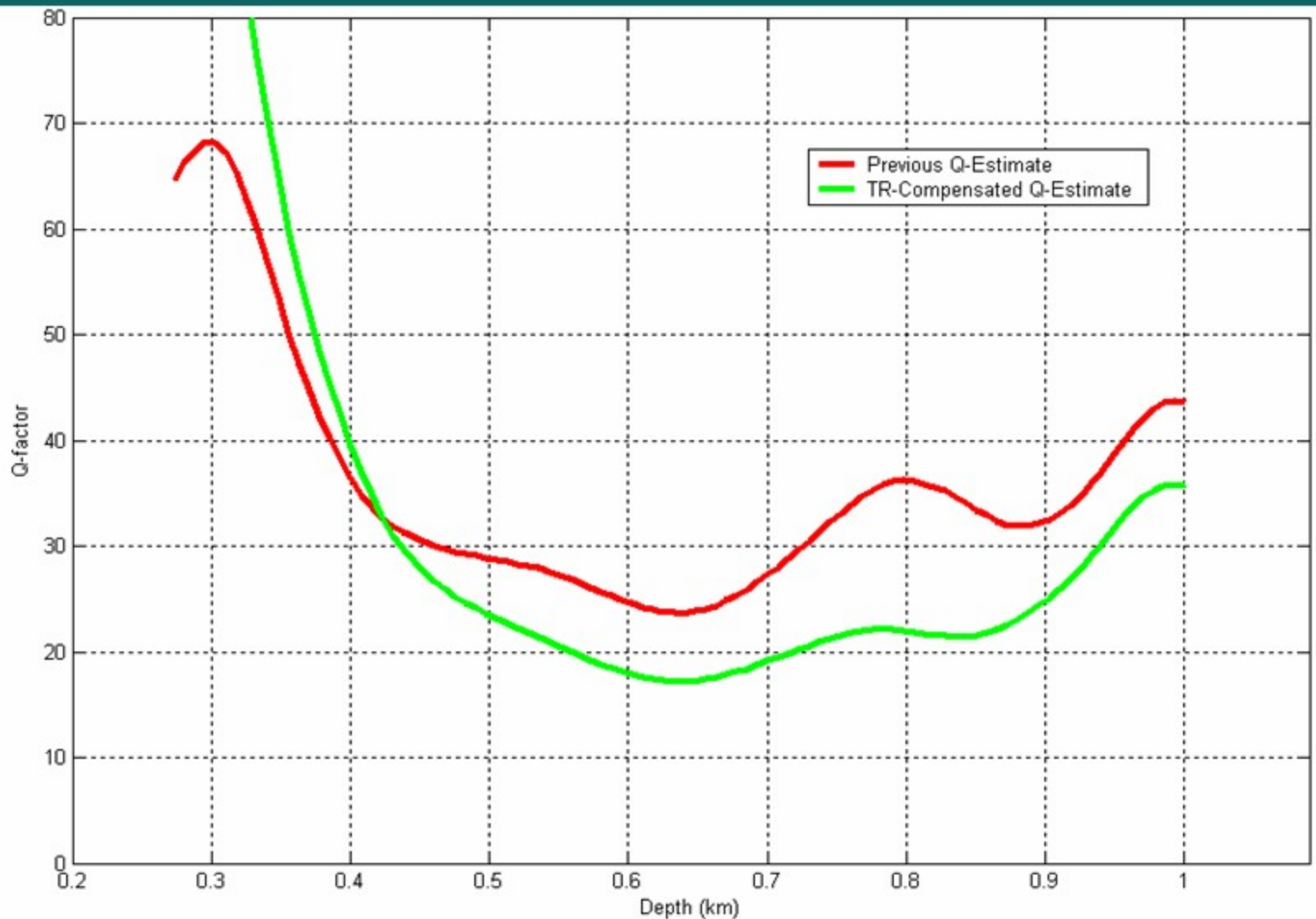
VSP Data Instantaneous Amplitudes (399 m Offset VSP)



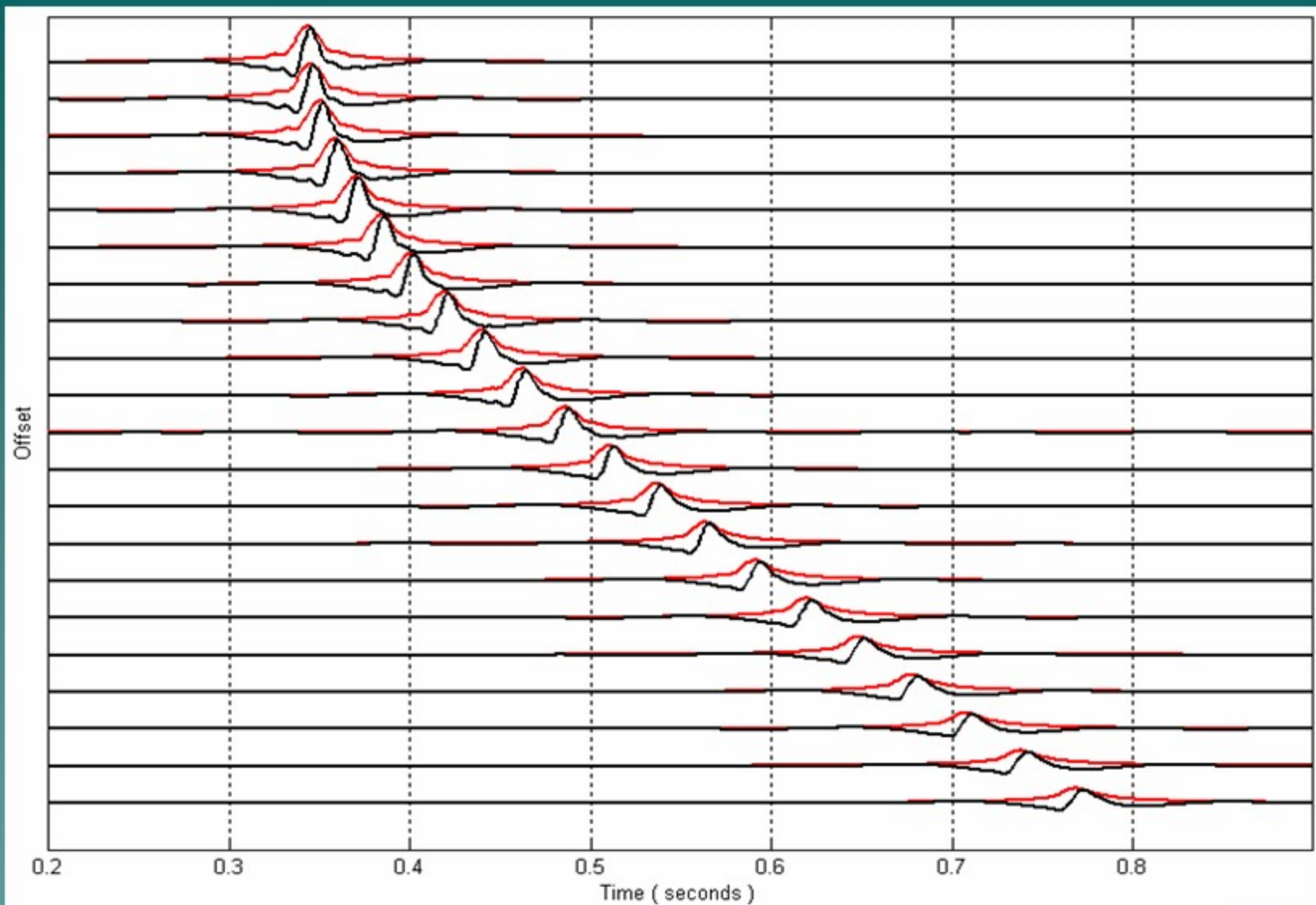
Cumulative Transmission Coefficient



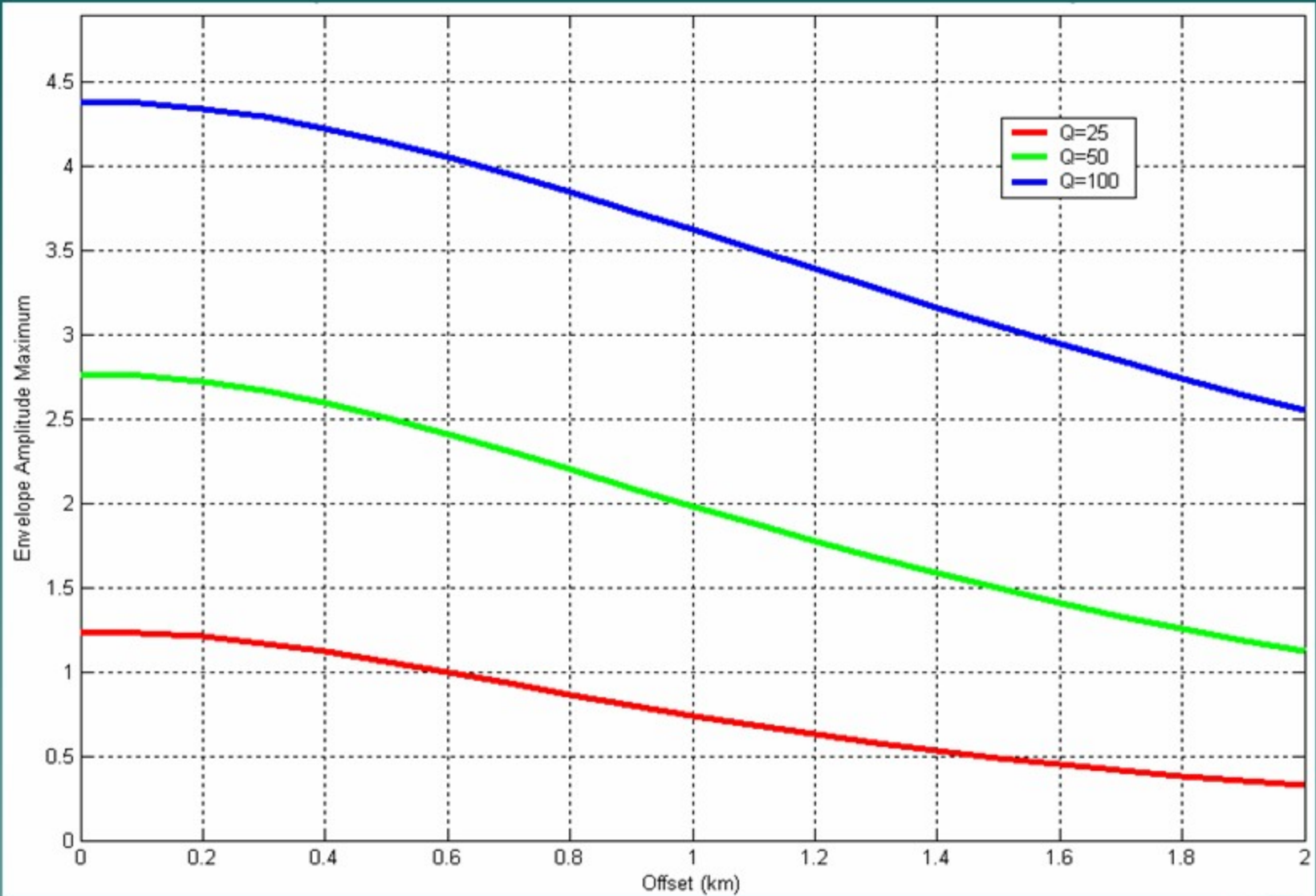
Transmission Loss Compensated Instantaneous Amplitudes



Compensated Q-Estimates versus Depth (399 m Offset VSP)



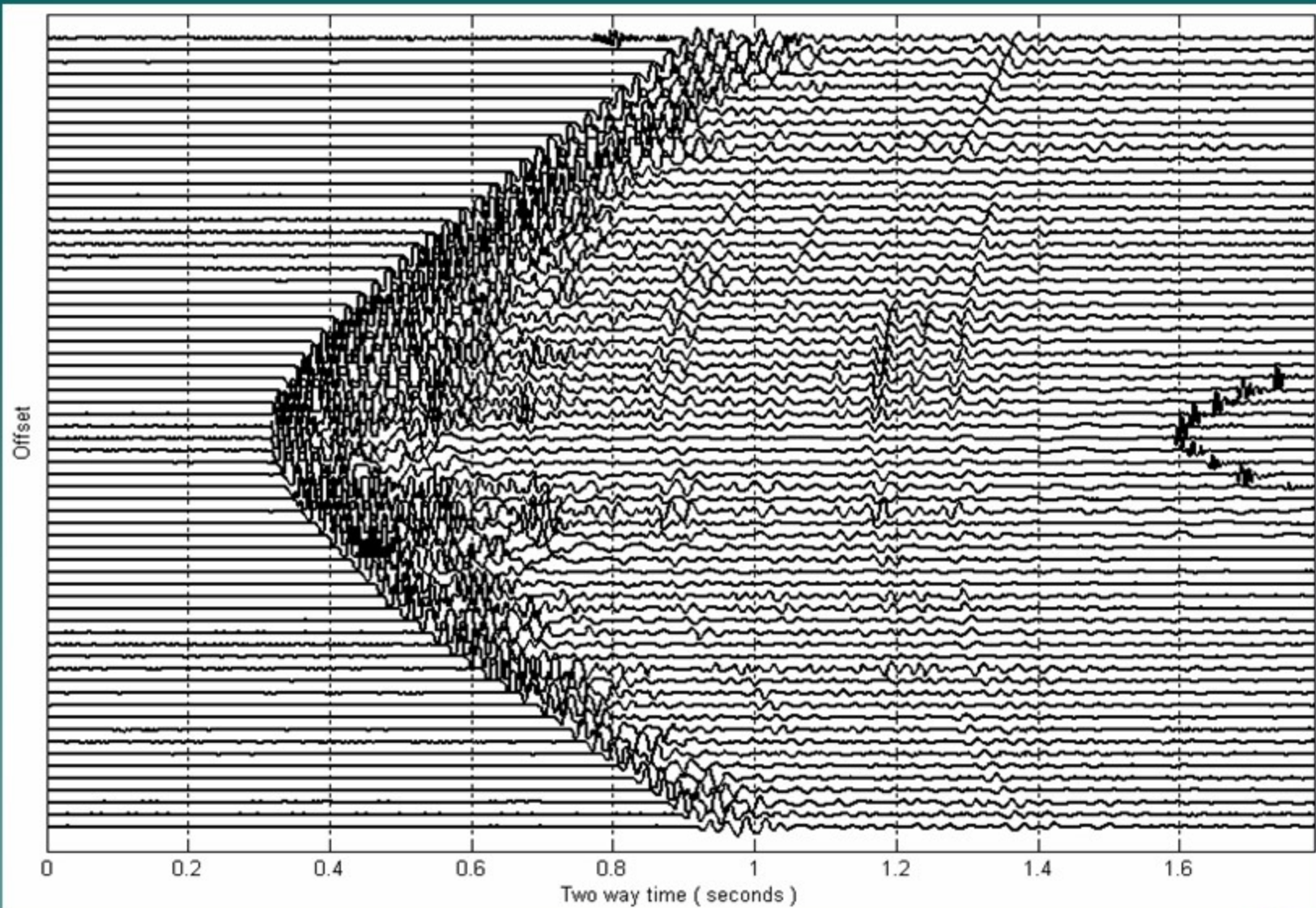
Surface Model Traces ($Q=50$, $Z=500$ m, 8/12-80\100 Hz Ormsby)



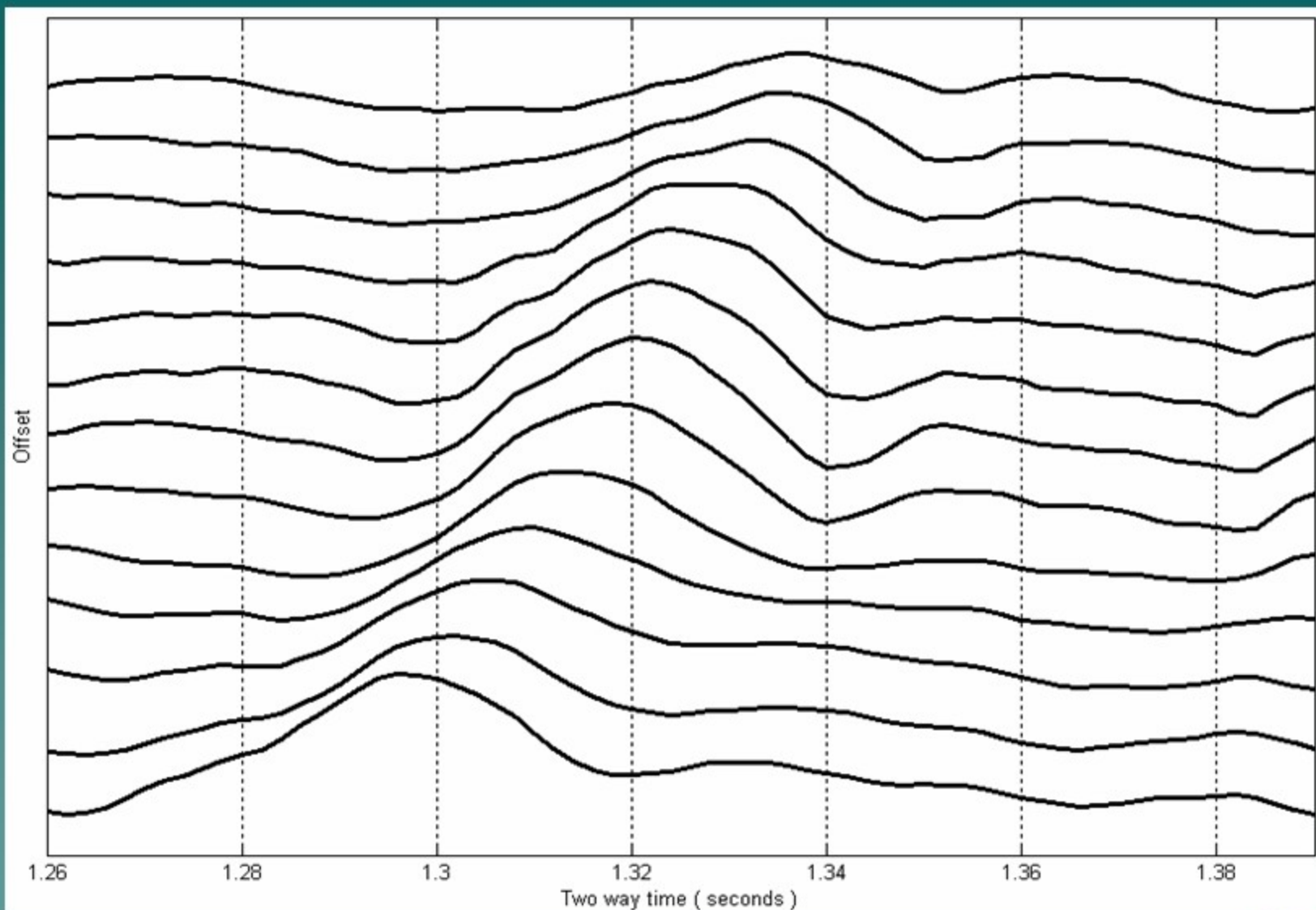
Peak Envelope as a Function of Offset

Surface Model Q-estimation error

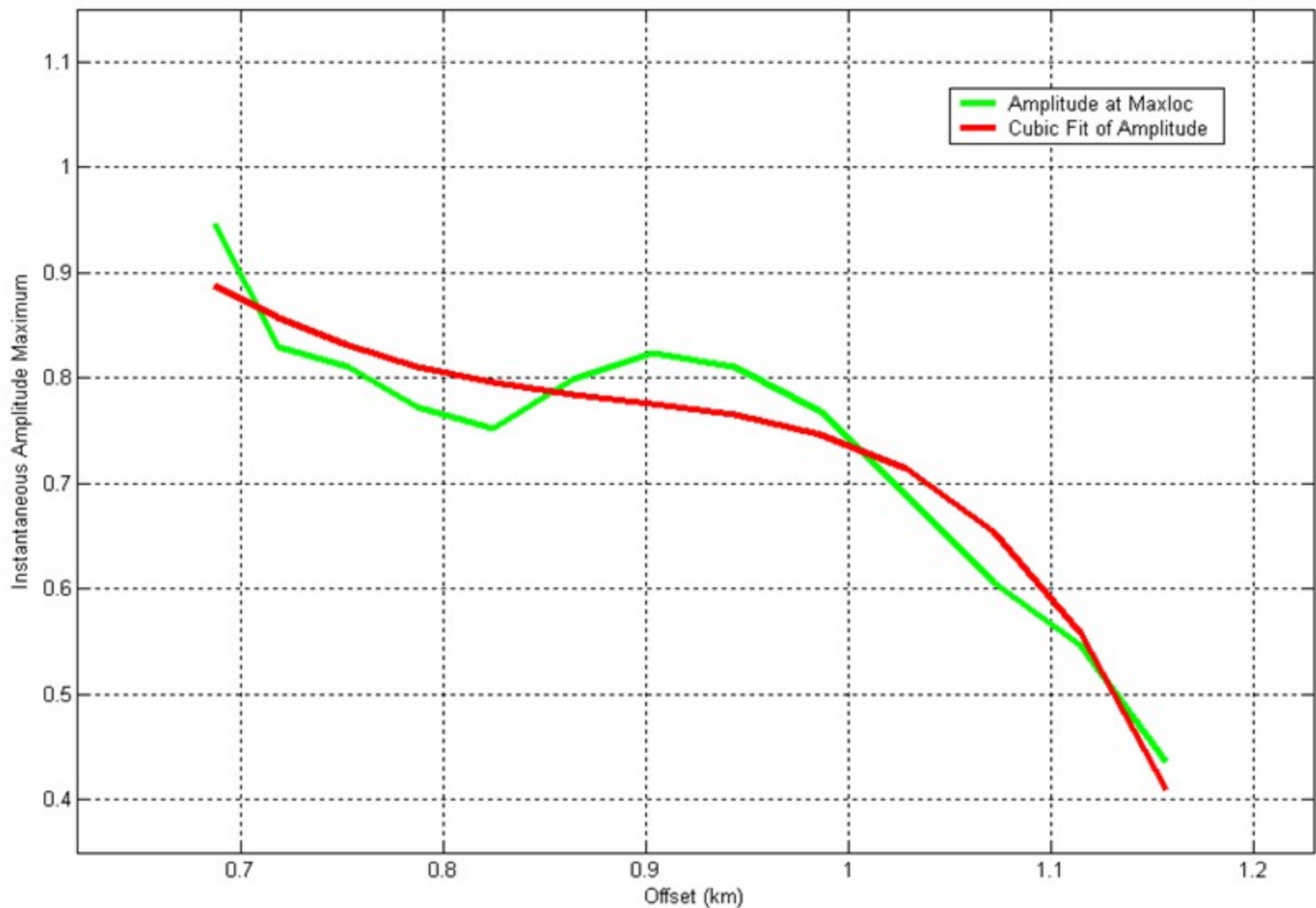
Q_{model}	25	50	100
Q_{estimate}	23.4	49.4	103.1
Percent Error	-6.4	-1.2	3.1



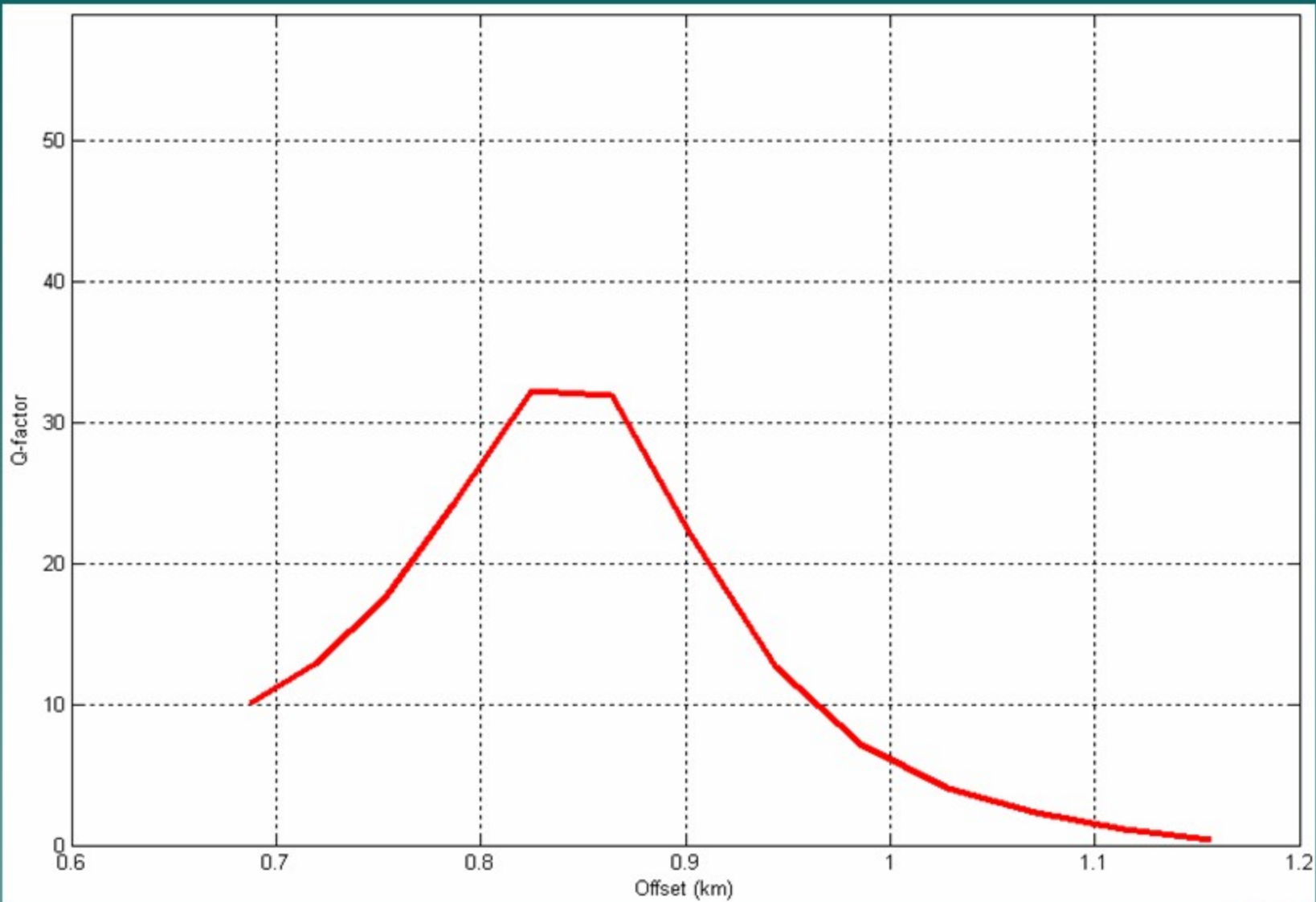
Surface-Data Shot Record



Surface-Data Analysis Window (Five Trace Envelope Average)



Instantaneous Amplitude versus Offset (Surface-Data)



Quality Factor (Q) versus Offset (Surface-Data)

Conclusions

- ◆ Moveout compensation for offset VSP surveys changes Q-estimates insignificantly
- ◆ Transmission loss compensation changes Q-estimates insignificantly
- ◆ Large Q-factors at shallow depths are highlighted by moveout compensation and transmission loss compensation
- ◆ Q-factors can be extracted from surface model data with only a few percent estimation error
- ◆ Amplitude preserving noise reduction must be explored

Acknowledgements

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