Intrinsic attenuation: removing the stratigraphic effect from attenuation measures

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Summary

Estimates of attenuation computed from seismic data are inherently composed of two parts: a local intrinsic effect, and a nonlocal stratigraphic effect. The former is a property of the rock that the wave is transiting through and represents actual loss of wave energy to heat. The latter is a wave interference due to the cumulative effect of short path multiples occurring along the transmission path. It is often desirable to estimate intrinsic attenuation as a reservoir parameter as it may indicate reservoir quality. However, attenuation measurements from seismic data will always consist of both intrinsic and stratigraphic effects so the isolation of the former requires the estimation of the latter. We investigate the possibility of using a visco-acoustic 1D synthetic VSP driven by finely sampled well information to estimate the stratigraphic attenuation. We then use these estimates to isolate the intrinsic attenuation from a zero offset VSP. We show that well-log sampling of 0.3048m in depth is sufficient to estimate the stratigraphic effect; however, the unavoidable occurrence of an unlogged overburden means that the magnitude of the estimate will always be too small. The estimates of total attenuation on a real VSP are made on the separated downgoing wavefield. Intrinsic attenuation then follows by subtracting the stratigraphic component, estimated from the synthetic VSP, from the measured total attenuation. Our estimates of intrinsic attenuation fail to show the theoretically expected monotonically increasing behaviour. Among the possible reasons for this are the imperfect nature of VSP wavefield separation, problems with receiver and sonic coupling in the borehole, the aforementioned unlogged overburden, and mode-converted scattered waves that are not included in the visco-acoustic approximation. These are topics for future research.

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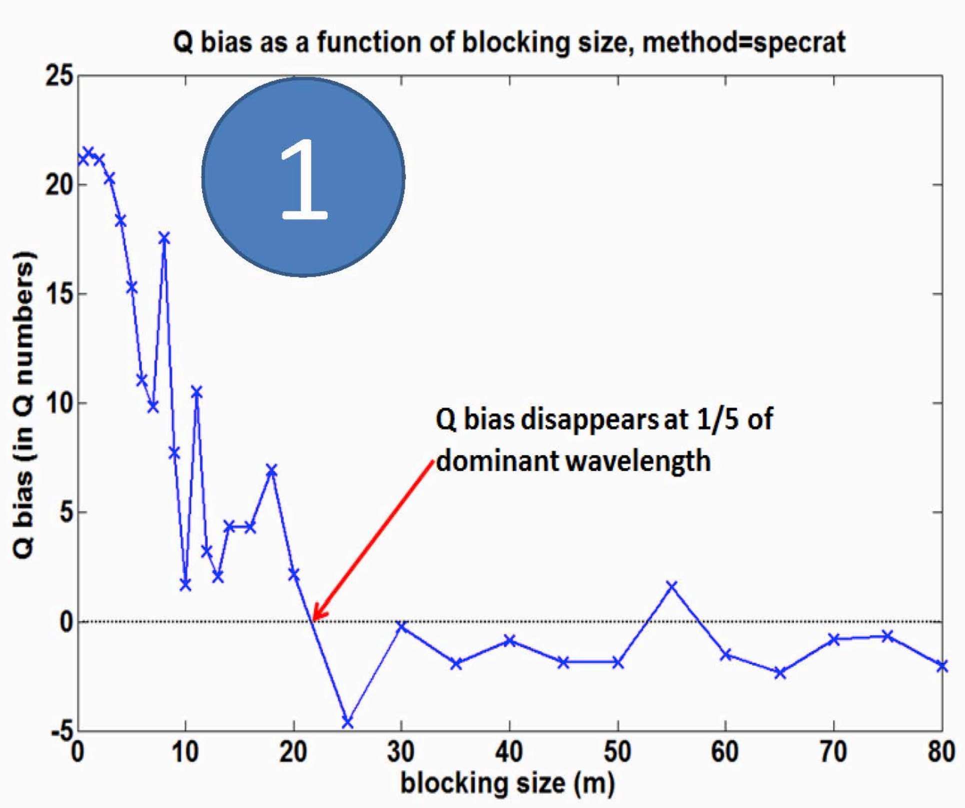

(From Margrave (2014)). The results of an experiment using different log blocking sizes and then measuring the apparent Q when the intrinsic Q is known.

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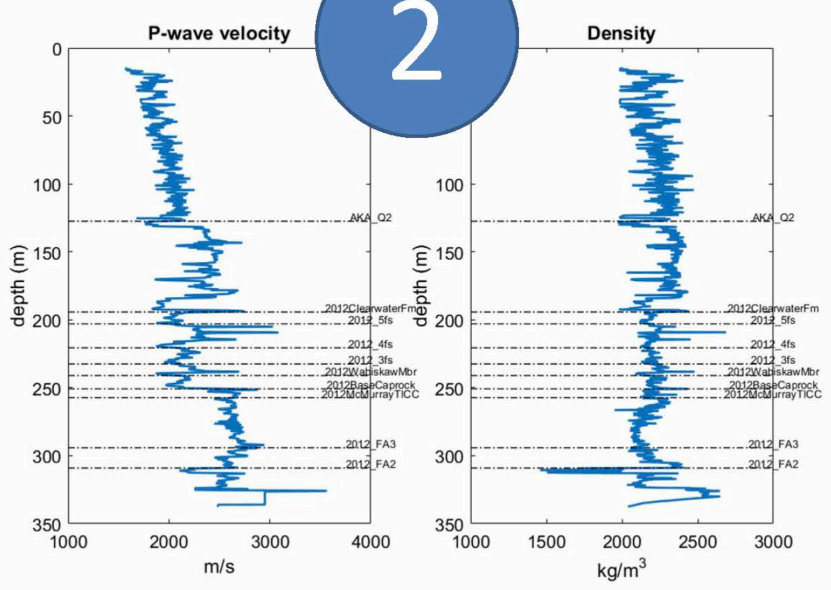

The sonic (left) and density (right) logs used in this study.

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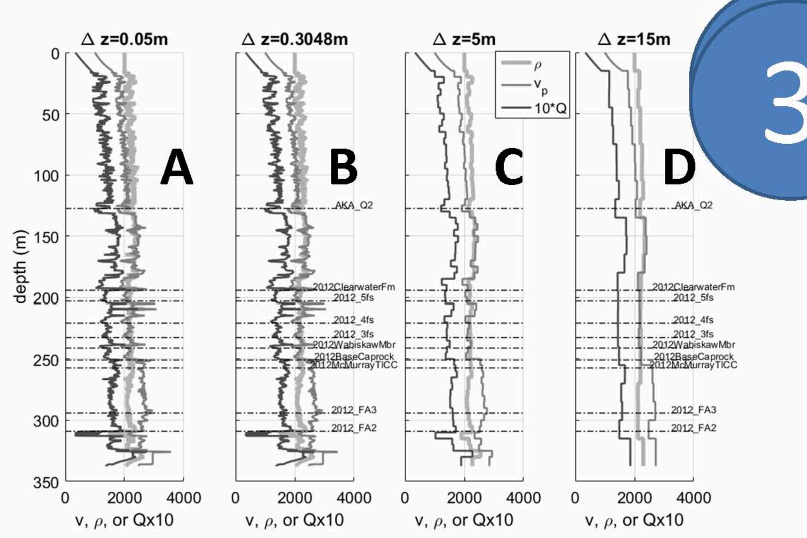

Logs after blocking at different sizes

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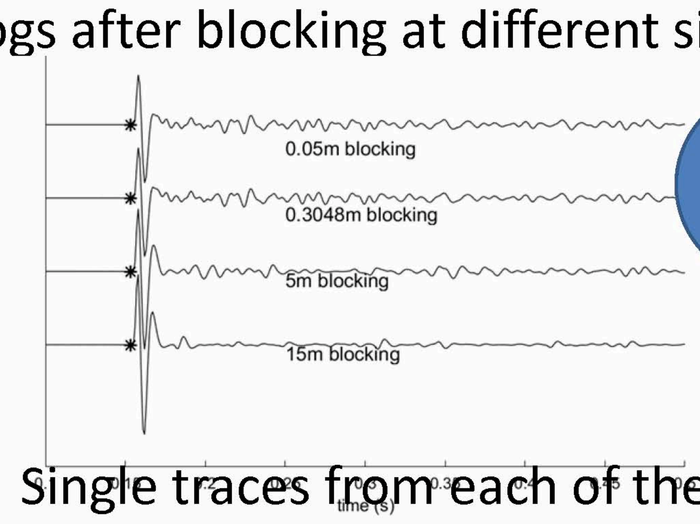

Single traces from each of the wavefields corresponding to the deepest receiver and the total field.

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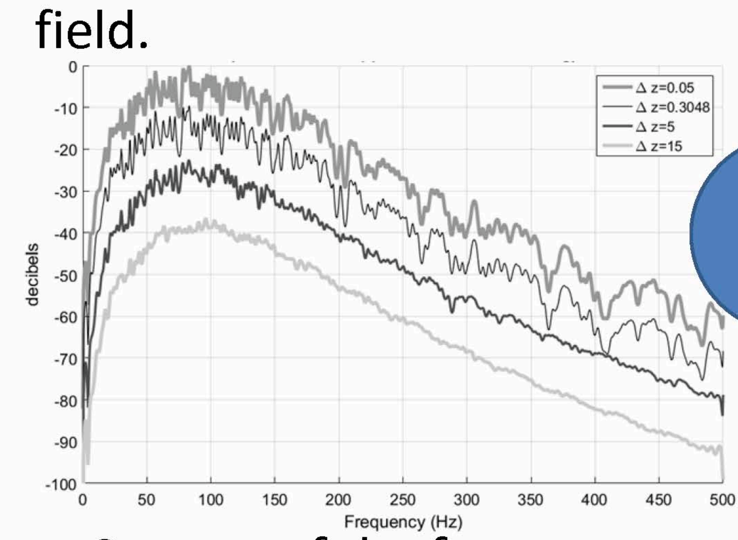

Spectra of the four traces

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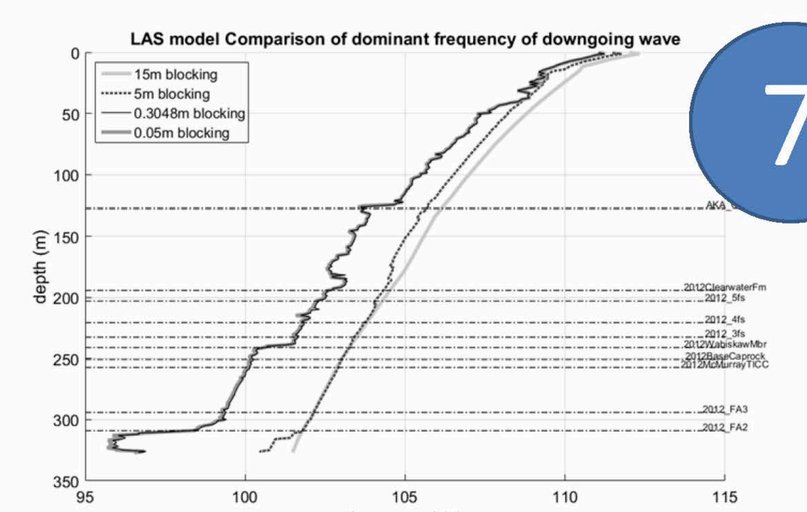

Synthetic VSP's from blocked logs

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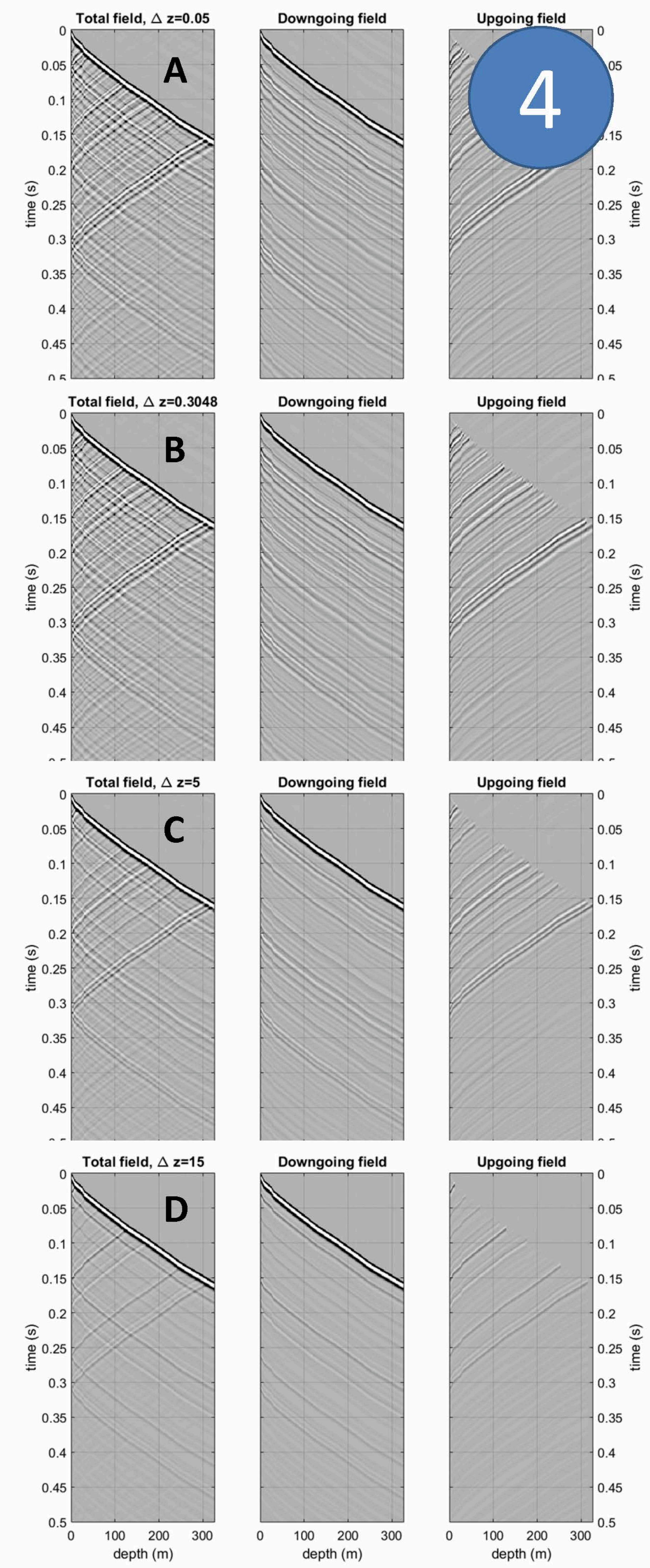

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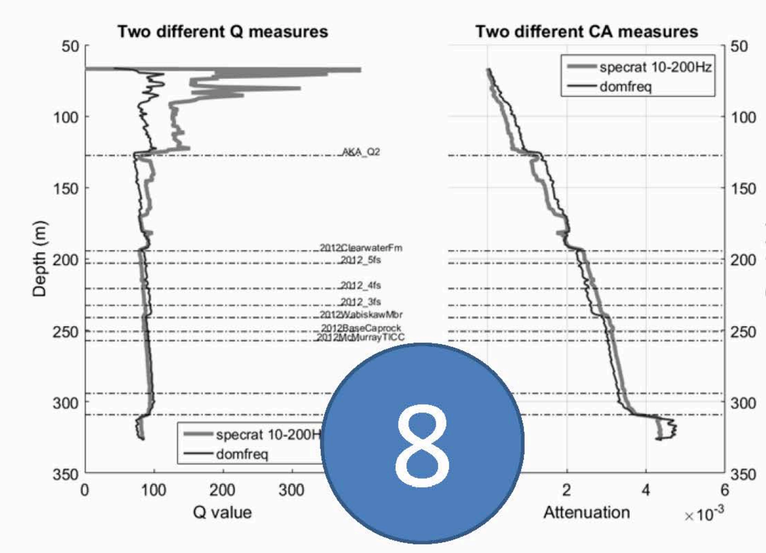

Cumulative attenuation is a more stable attenuation parameter than Q.

$$CA(t_1,t_2)=\frac{\pi(t_2-t_1)}{Q_{1,2}}$$

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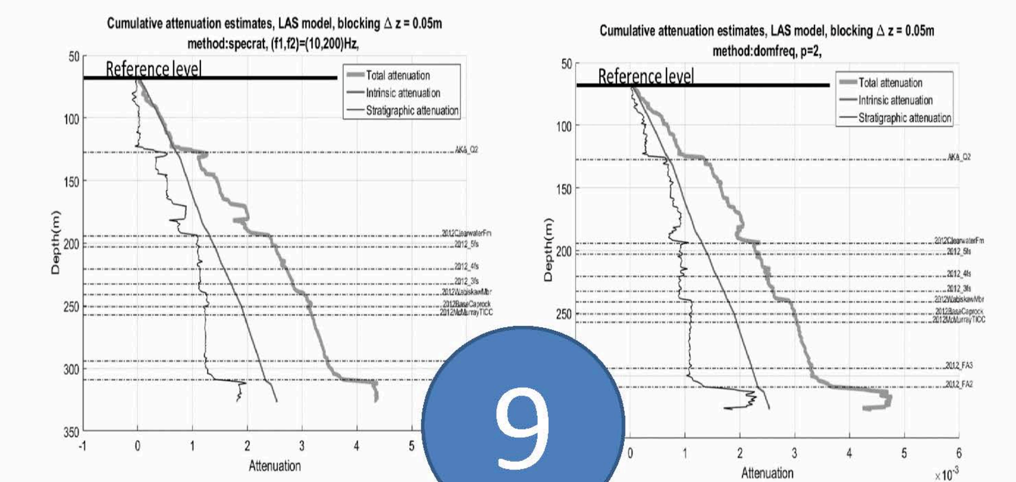

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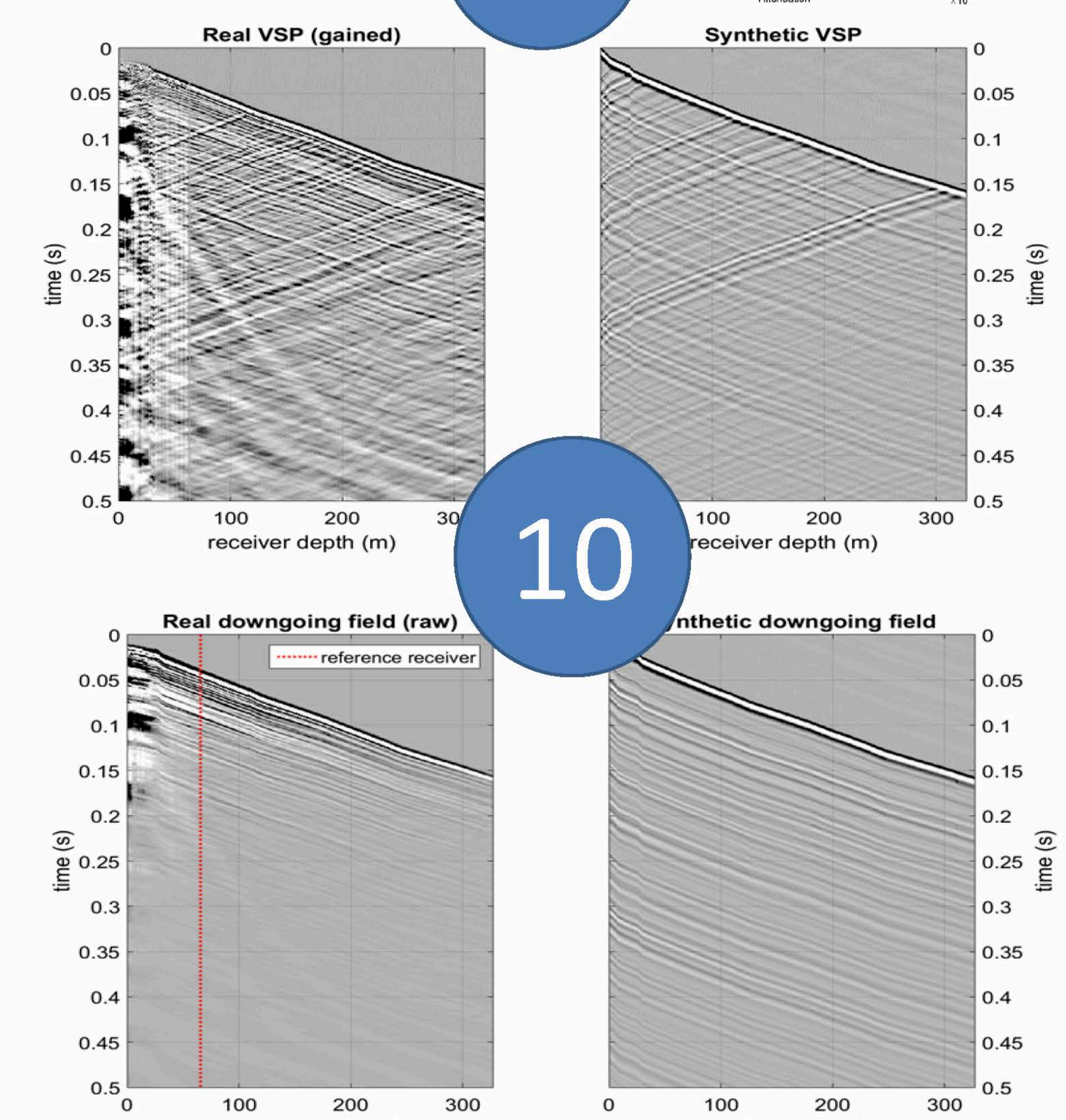

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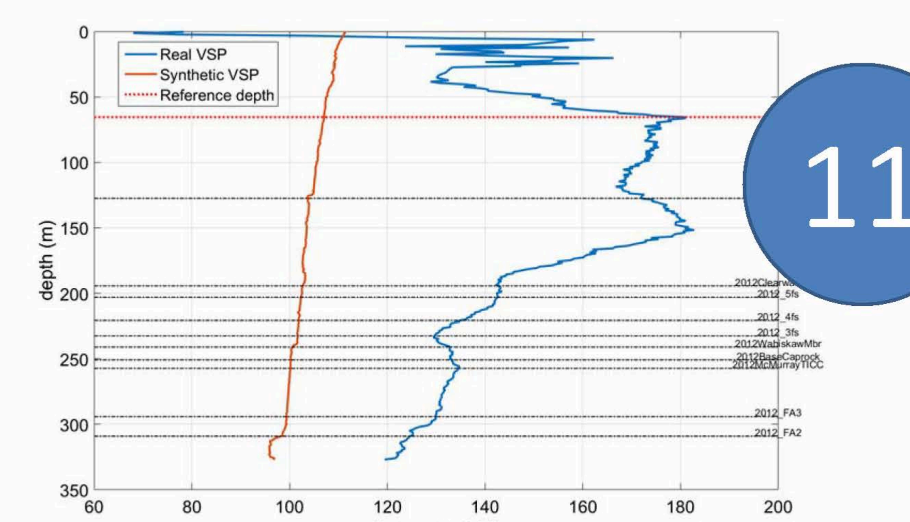

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