Information measure on a field VSP data set

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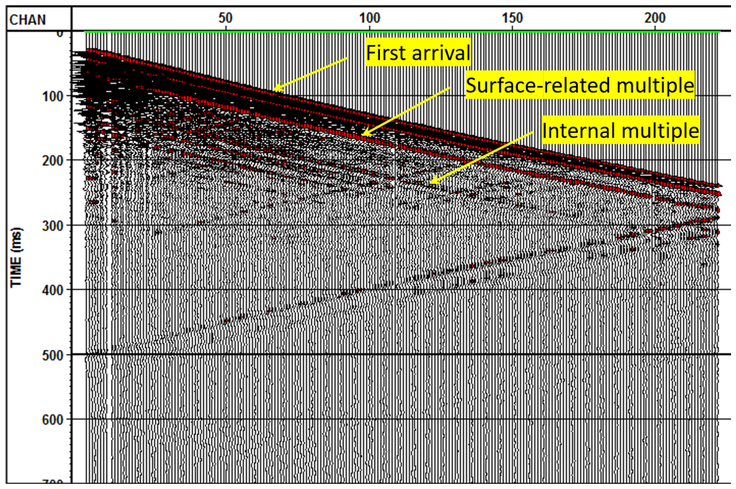
ABSTRACT

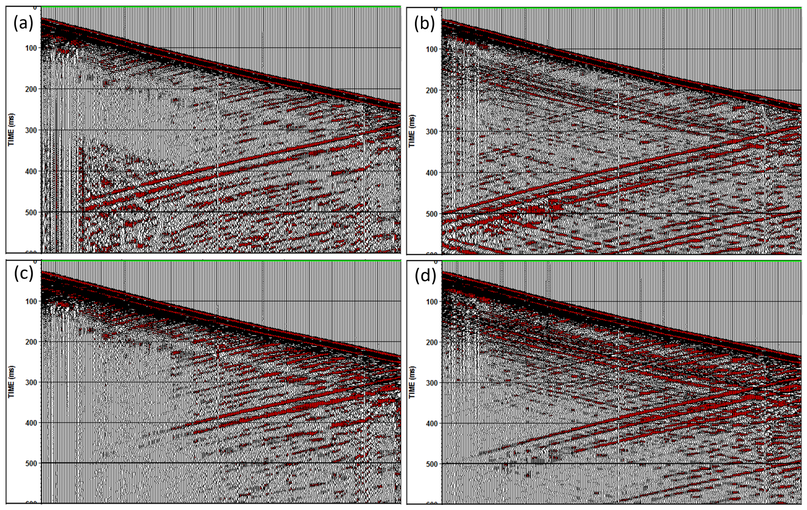
A Shannon entropy measure that has been conducted on synthetic VSP data is applied to a field VSP data set aiming at characterizing intrinsic Q and stratigraphic (extrinsic) Q. A zero-offset VSP record is processed differently to generate four wave fields, in which the intrinsic Q and extrinsic Q effects are removed selectively. We find that the measure entropies for the wave fields under the combined or separated effects of intrinsic Q and extrinsic Q are significantly different. Moreover, the entropy result of the wave field containing both intrinsic and extrinsic Q effects indicates that the extrinsic Q strength relative to total Q is weak (<20%) in this region, complies with the estimated Q from the spectral ratio method.

Pre-processing of the real VSP data



A controlled trial consisting of four wave fields including various attenuation factors is designated for the entropy measure. The wave fields contain respectively attenuating effects of: a) neither absorption nor internal multiples; b) internal multiples only; c) absorption only; and d) both absorption and internal multiples.

The zero-offset VSP record shown above (Hall et al., 2012) was processed to preferentially eliminate the undesired attenuation factors. A predictive deconvolution was first applied to the record to remove source ghost. This generated wave field (d). Then we applied a 3.2 exponential gain to (d) to get wave field (b). Meanwhile, we applied another predictive deconvolution to wave field (d) to eliminate the internal multiples in the field to get (c). To get wave field (a), both the 3.2 exponential gain and the internal-multiple-eliminating predictive deconvolution were applied to wave field (d).

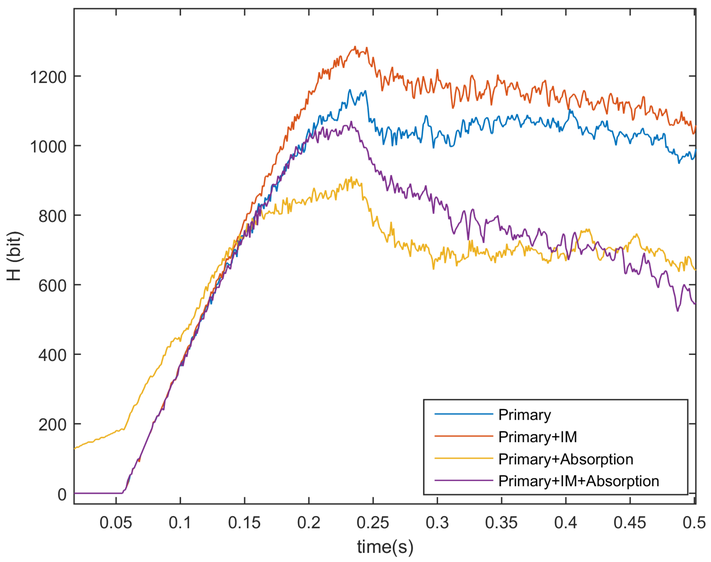


First-order entropy measure on real VSP data sets

Wave field containing complex reflecting events can be thought as carrying considerable amount of information in it, whereas those excludes complex reverberations might be said to have relatively small amount of information. In information theory, we use Shannon entropy to measure the amount of information in a message. By assuming each time snapshot of a VSP data set to be a message, the Shannon entropy measure is adapted to the seismic record (Lv and Innanen, 2016). The amount of information in the record can thus be measured.

This study investigates how first-order entropy changes with time for the processed real VSP data sets.

Result



- Wave fields including internal multiples contribute to entropies with larger peaks than entropies of other wave fields (comparing red and purple curves to the blue and yellow ones respectively);
- Wave fields including absorption contribute to entropies with smaller peaks (purple and yellow curves) than entropies of other wave fields (red and blue curves);
- Intrinsic Q and extrinsic Q have opposite effects on the entropy variation result, as in the synthetic data experiments.

Information measure as an indicator of relative strength of intrinsic Q and extrinsic Q

We derived a negative entropy peak increase from wave field (a) entropy to wave field (d) entropy from the measured entropy result of the field data, which implies that extrinsic Q in this region is rather weak, possibly accounts for less than 20% of the total attenuation strength (conclusion of the synthetic data experiment). This complies with the Q estimation from the spectral ratio method, according to which extrinsic Q accounts for approximately 15% of the total attenuation in this region.

Depth range (m)	120-328	330-502
Intrinsic α_x (nepers/wavelength)	0.069	0.080
Apparent α_x (nepers/wavelength)	0.080	0.094
Percentage of extrinsic α_x in total α_x (%)	15	15

CONCLUSION

The Information measure result on the field VSP data supports conclusions that were drawn in synthetic data experiment. The information measure is robust.

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