Imaging a landfill with Seismics

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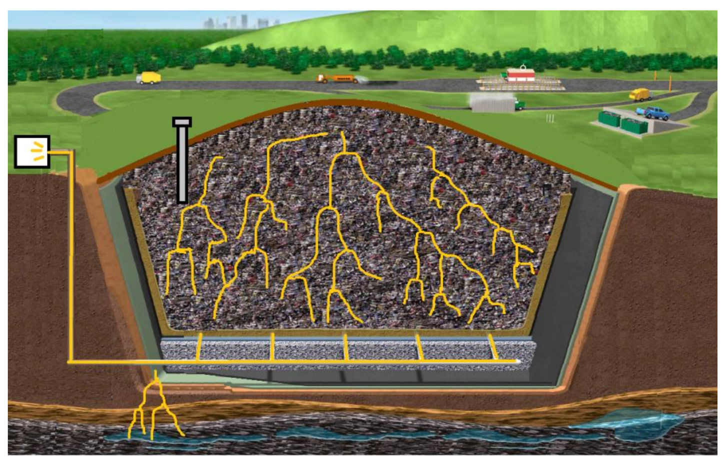
Introduction

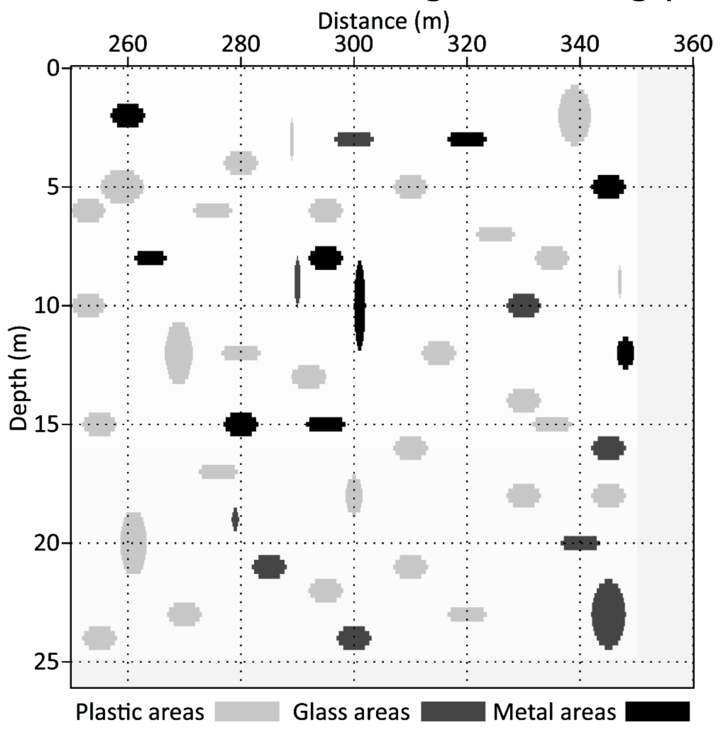


Our group develops a user-friendly technique that can predict the emission potential of landfills. This way the landfills will no longer be a danger to the environment and a burden on society. We try to image the high density areas inside the landfill that act as an obstruction to the fluid flows and have an impact on the treatment technology (Figure 1).

Figure 1: Representation of a landfill. Leachate (yellow lines) and gas emissions have to be sustained.

Method - Model

We want to define what the best method to image the subsurface of a landfill is, therefore we compare between conventional reflection seismics (CRS) and seismic interferometry (SI) applied on CRS, different acquisition geometries and test the sensitivity of CRS and SI on time-lapse non-repeatability errors, migration velocity errors and errors during the muting procedure.



We created a velocity and density model that represents a landfill (Figure 2) and computed the seismic wavefield using a finite difference code (Thorbecke and Draganov, 2011). Although we have receivers and sources only on the surface we can still apply SI (van Wijk, 2006), however, one side illumination may occur resulting in non-physical events (Snieder et al., 2006). Nevertheless, the high density areas inside the landfill can act like scatterers, which back-scatter sufficient energy from the subsurface and thus can compensate for the one-side illumination (Wapenaar, 2006).

Figure 2: The velocity model used for the comparisons. Besides the gray scale areas there is also a background velocity gradient present.

Results - Conclusions

1. Comparing between CRS and SI, we see that SI performs more precise imaging with less artifacts, and higher resolution (Figure 3). The red circles on all images show the location of the scatterers.

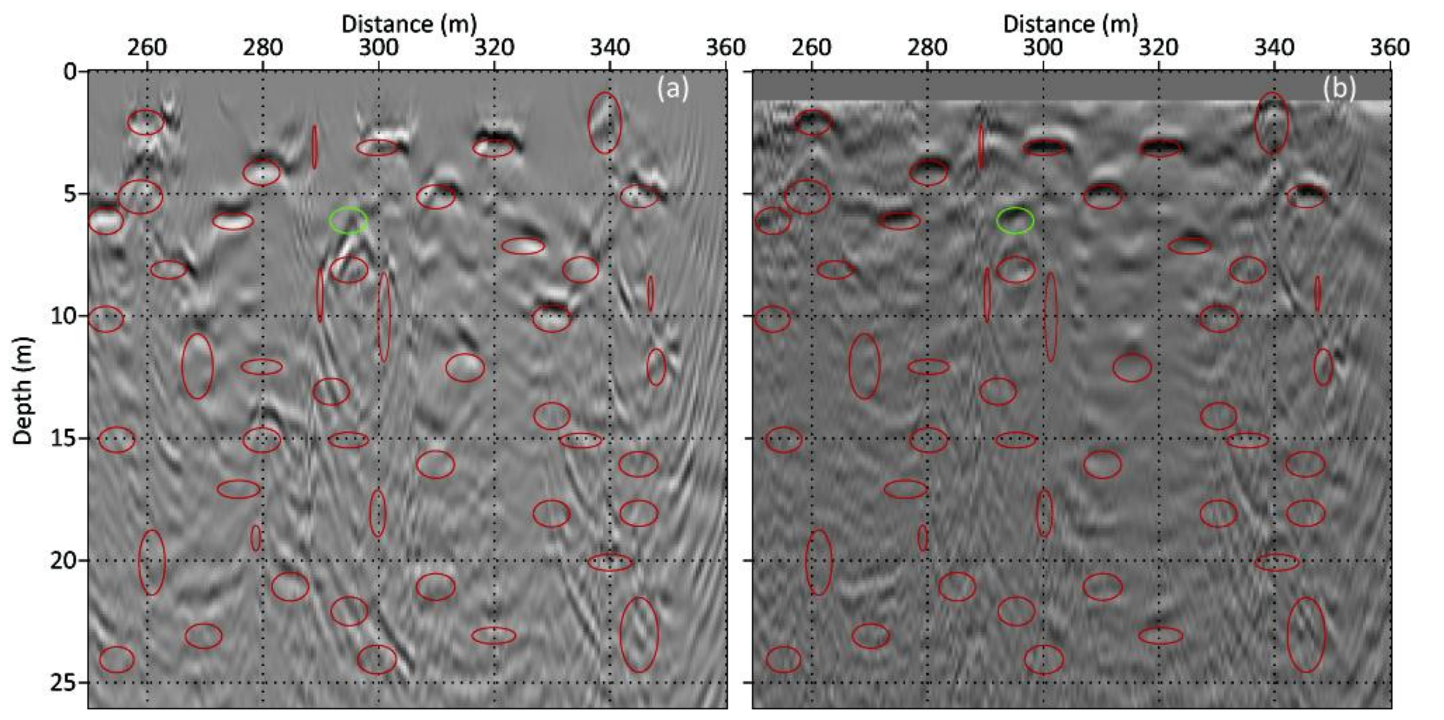


Figure 3: Comparison between CRS (a) and SI (b). The green ellipse shows an example of better depth resolution in the case of SI.

2. Comparison between split-spread and roll-along geometry (Figure 4). Split-spread geometry images the subsurface with less artifacts.

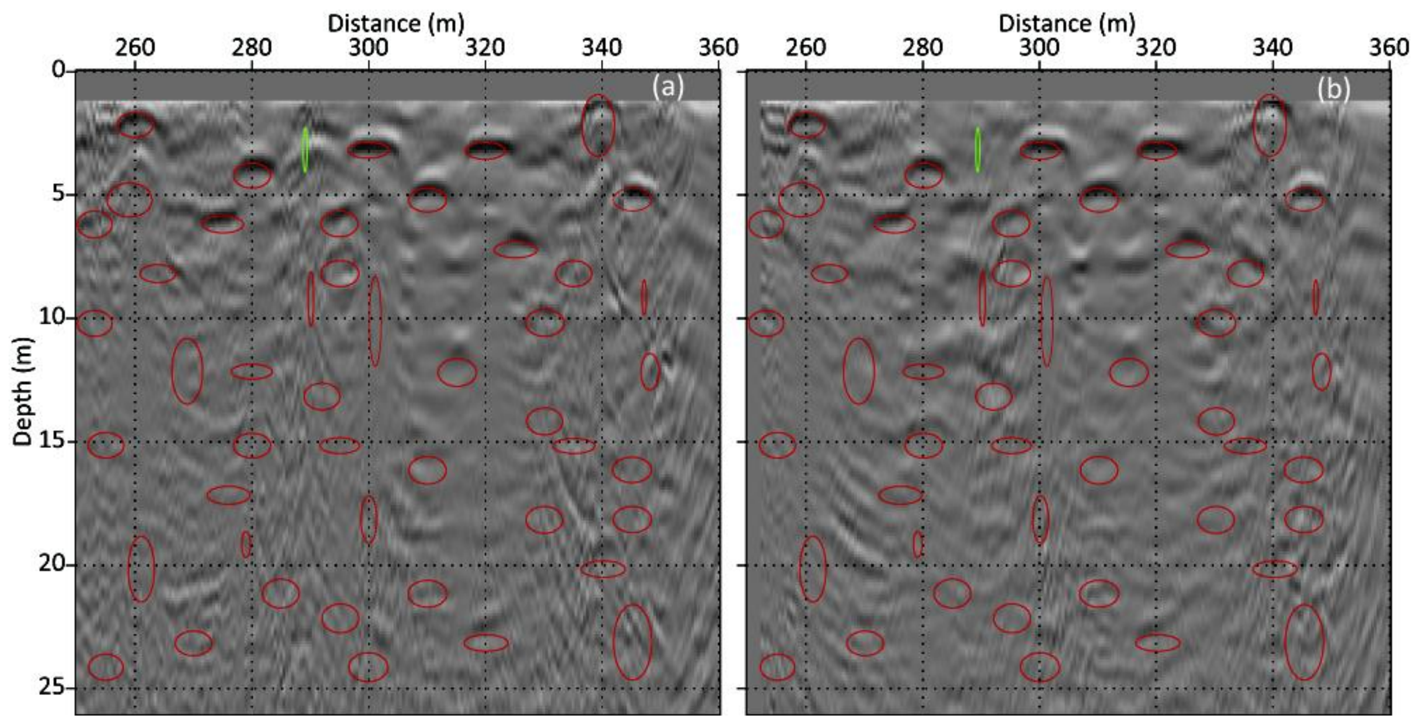


Figure 4: Comparison between split-spread SI (a) and roll-along SI (b). The green ellipse shows an example of better imaging in the case of split-spread geometry.

Results - Conclusions

3. Sensitivity tests. First of all, we included an error in the source position to test the time-lapse non-repeatability of CRS and SI (Figure 5). Secondly, we added a 5 % error in the migration velocity (Figure 6) and finally, we applied automatic muting to understand the effect an error in the muting procedure would have on our images (Figure 7). In all cases, SI proved to be less sensitive to the errors than CRS. To support our results we computed the normalized root mean square value (NRMS) (Mehta et al., 2007) for the first and third case and the result was 89,5 % for CRS and 31,8 % for SI for the time-lapse error, and 70 % for CRS and 27,5 % for SI for the muting errror.

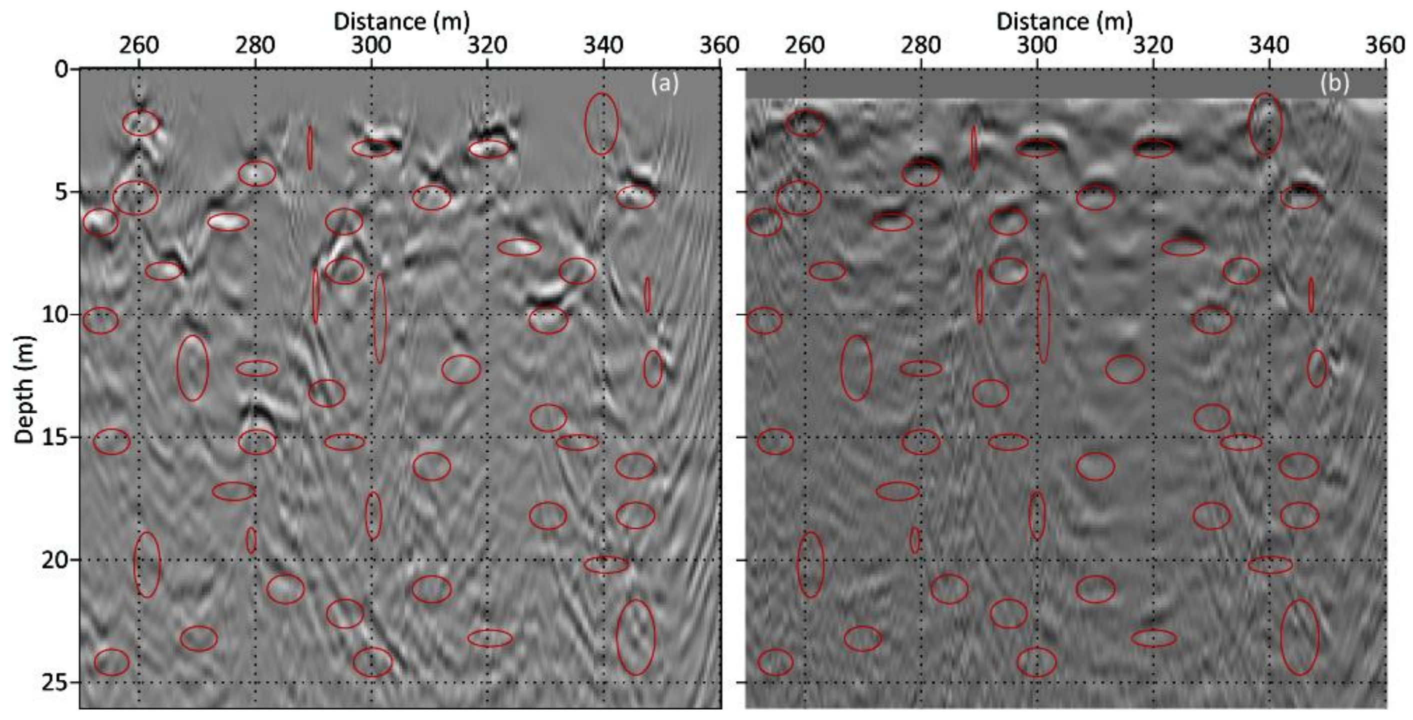


Figure 5: (a) CRS and (b) SI with non-repeatability errors in the source. Comparing this image with Figure 3, the advantage of SI is clearly visible.

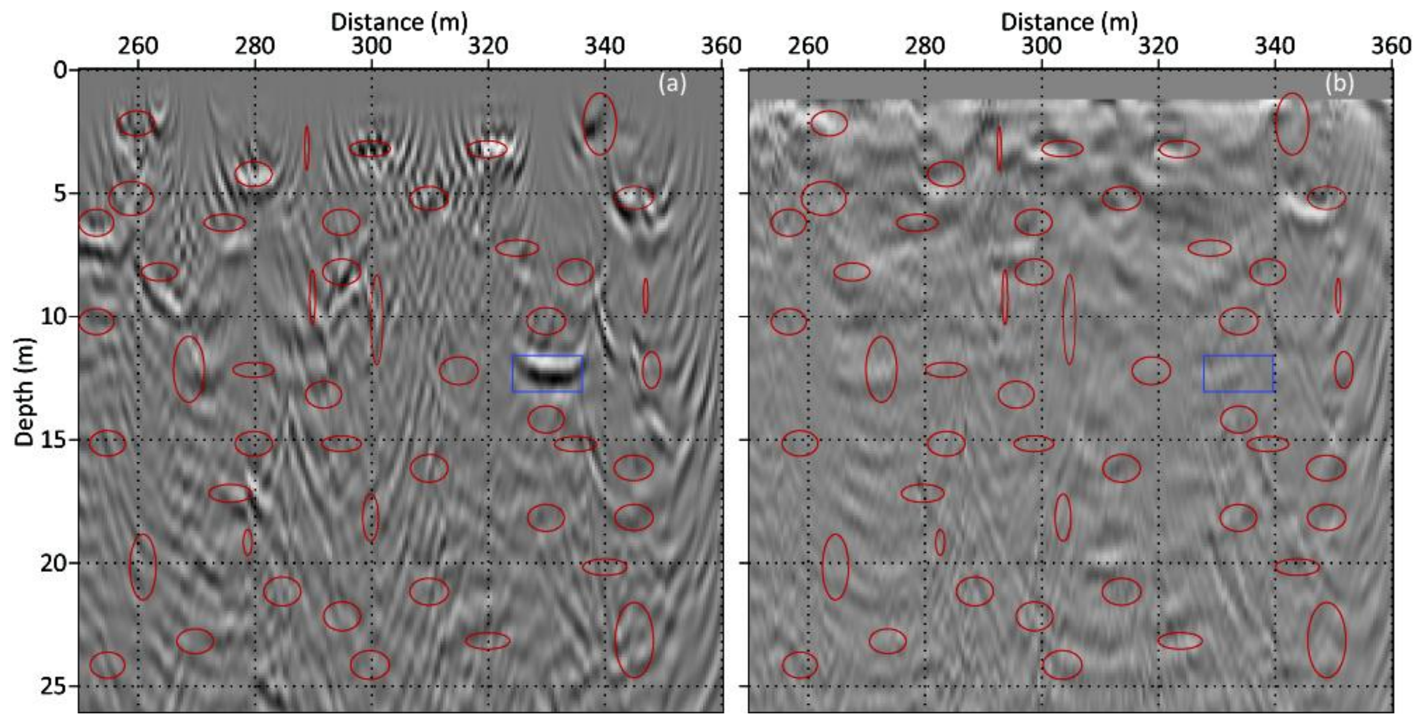


Figure 6: (a) CRS and (b) SI with a 5% velocity error. Comparing this image with Figure 3, it is visible that although both are affected by the error, SI shows less artifacts (e.g., blue rectangle).

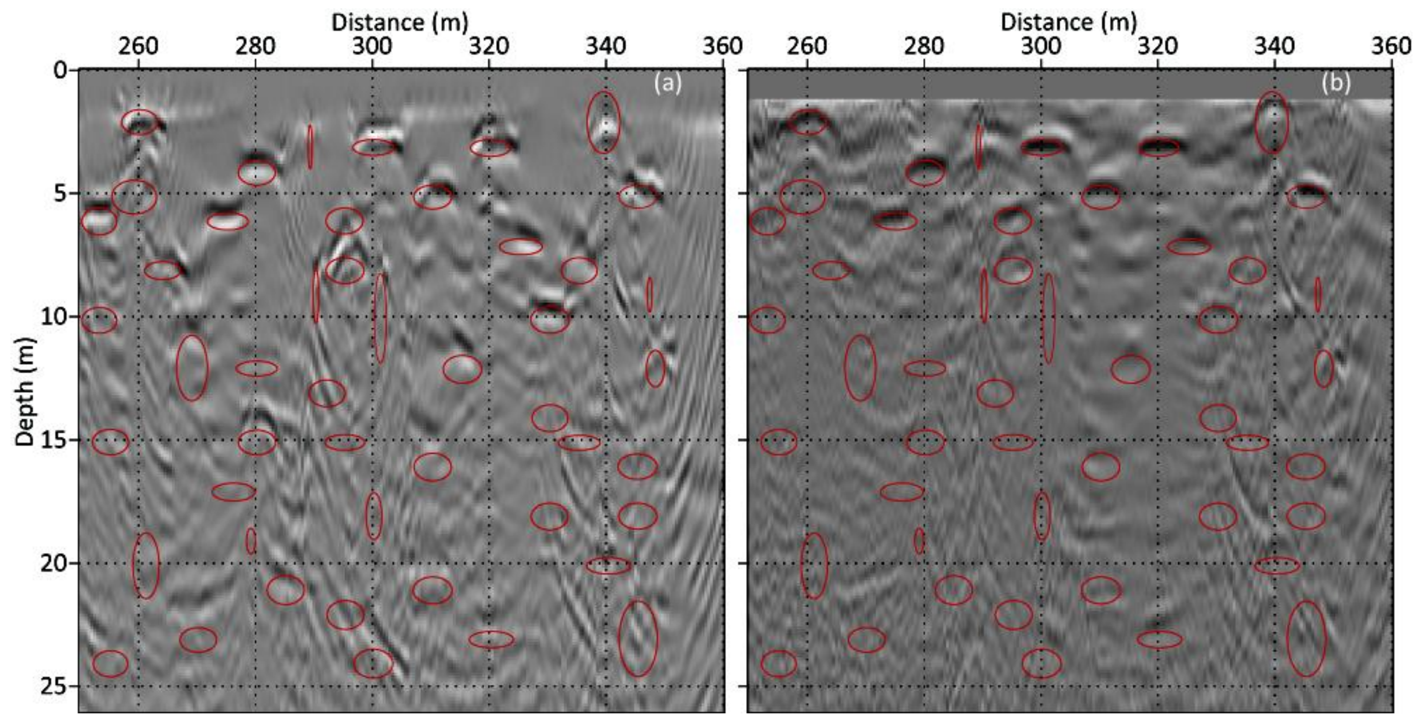


Figure 7: (a) CRS and (b) SI with automatic muting. Comparing this image with Figure 3, the advantage of SI is clearly visible.

References

- Mehta, K., J. Sheiman, R. Snieder, and R. Calvert, 2007. The virtual source method applied to Mars field OBC data for time-lapse monitoring: SEG Annual Meeting, 2914-2918.
- Snieder, R., K. Wapenaar, and K. Larner, 2006. Spurious multiples in seismic interferometry of primaries: *Geophysics* ,v. 71, p. SI111-S124.
- Thorbecke, J. W., and D. Draganov, 2011. Finite-difference modeling experiments for seismic interferometry: *Geophysics* , v. 76, p. H1-H18.
- van Wijk, K., 2006. On estimating the impulse response between receivers in a controlled ultrasonic experiment: *Geophysics* , v.71, p. SI79-SI84.
- Wapenaar, K., 2006. Green's function retrieval by cross-correlation in case of one-sided illumination: *Geophysical Research Letters,* v. 33, L19304.

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