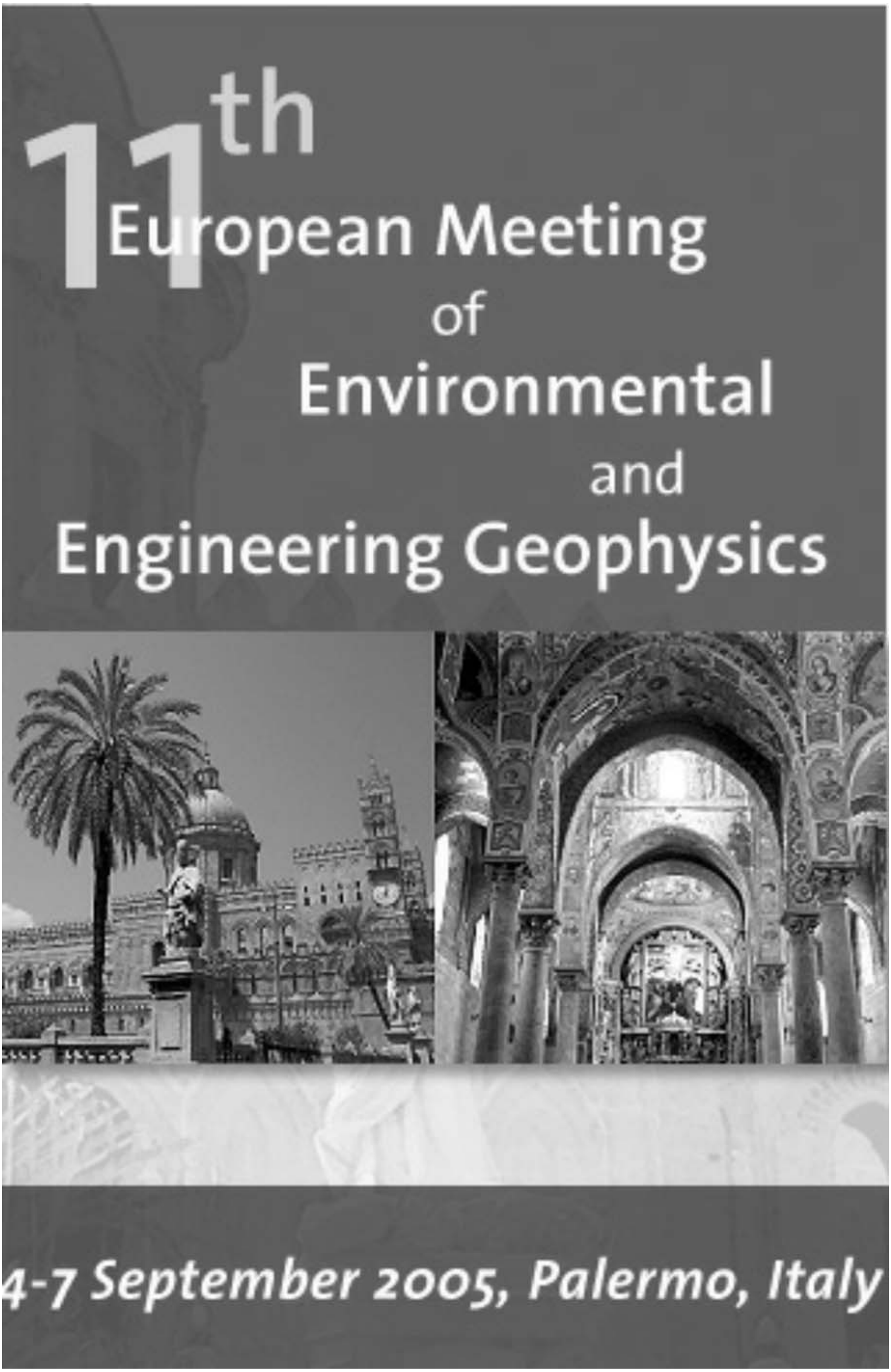
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A053 S/N enhancement by radon transformation in ultra shallow SH-wave reflection investigations

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Abstract

Summary.

A short shear (SH) wave profile was collected as a part of a wider experiment involving P- and S-wave reflection and refraction measurements for further processing. The purpose of the experiment was to examine the efficiency of ultra shallow bedrock surface by SH reflection imaging commonly implemented in engineering applications. The original SH data suffer from direct, refracted, guided and surface waves interference. In some Common Shot Gathers the presence of significant P wave energy is also obvious, despite the use of special designed SH-wave detectors and the use of a pure horizontal energy source, i.e. a hydraulic seismic generator device.

We tested the efficiency of successive processing steps focusing on multiple energy attenuation, followed by the implementation of a technique for reducing the source generated noise, both based on forward and reverse linear and parabolic Radon transformations. The proposed scheme was applied on the data collected along a 49-shot records SH wave reflection profile.

Data Acquisition

SH wave reflection data were acquired using the standard common midpoint (CMP) method. The profile consists of forty-nine shot records by shooting end-on source-receiver geometry with 2 m minimum offset, 0.5 m geophone spacing and 0.5 shot interval. A maximum of 12-fold cover attained with the aforementioned configuration.
Focusing on the minimization of labour involved we used an efficient and portable horizontal energy source and a series of special designed SH-wave detectors. The source (figure 1) was a 9cm diameter air-driven piston mounted to a 10 Kgr metal plate with a thin rubber base attached to it for better ground surface coupling.

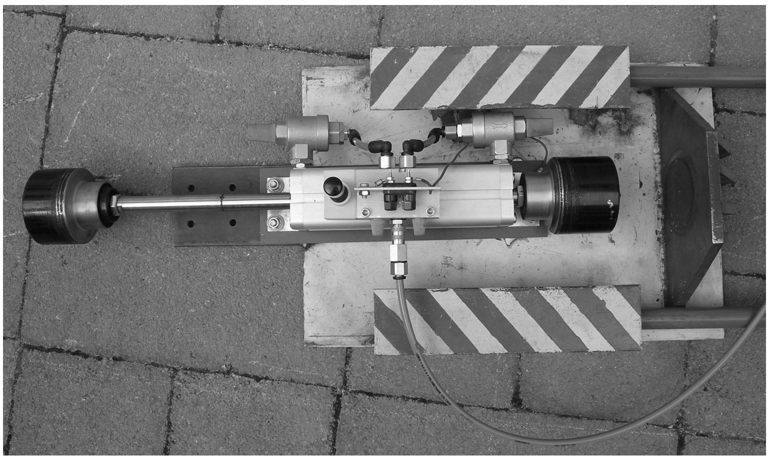

Figure 1. The seismic source.

The piston was fully charged by a 130-145 psi (9-10 bars) pump within 5 seconds, providing a theoretical ability of 10-15 blows per minute. In fact due to the limited number of detectors (24) the real time increment was 2 minutes. The detectors used were designed by

Sambuelli and Deida. According to Sambuelli and Deida (1998) pairs of conventional vertical geophones are mounted on common supporting stems and the axes of each pair of geophones are inclined in opposite directions and are electrically connected. Sambuelli and Deida (1999) proved that this detector configuration is more sensitive to SH-waves than the traditional horizontal geophones and is getting the better over the other techniques since it is not needed to strike the sledgehammer on both sides of the loaded plank or to activate the air-driven piston in two opposite directions. A 24-channel EG&G Geometrics SmartSeis 18-bit engineering seismograph was used to record seismic data. The record length was 0.512 s and the sampling interval 0.5 ms.

Data Processing

Data were processed on a P4 1.7 MHz computer running Seismic Unix on a Linux platform. The original data are of low quality, mainly due to dry unconsolidated overburden material, presenting no obvious SH wave reflected energy. Pre-gained records are dominated by direct waves (figure 2). A dramatic improvement in signal to noise ratio is obtained with the application of AGC of 0.25 s window length, followed by the implementation of an offset

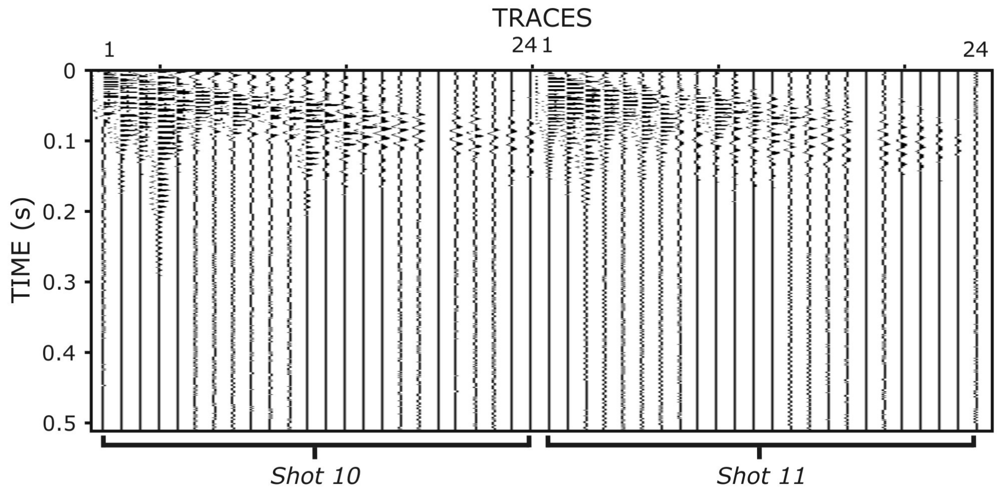

Figure 2. Initial Common Shot Gathers.

based weighting trace factor (figure 3). In order to preserve the most useful energy recorded, which lies above 20 Hz, a trapezoidal (10-20-90-120Hz) band-pass filter was applied. Inspecting the records after the removal of the high frequency random noise it follows that the main energy components are of low frequency guided waves along with a large amount of

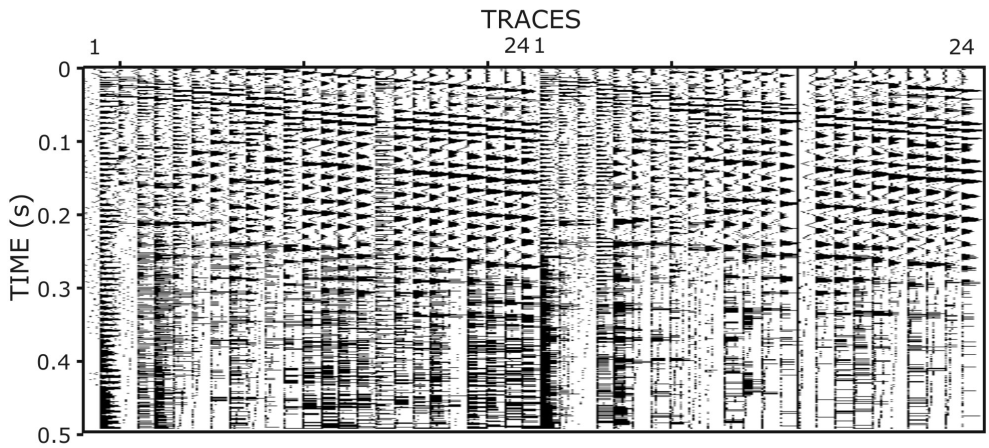

Figure 3. Common Shot Gathers after AGC and offset based weighting factor.

back-scattered noise due to subsurface irregularities The filtered data are corrected for statics, CMP sorted, NMO corrected and finally stacked (figure 4).

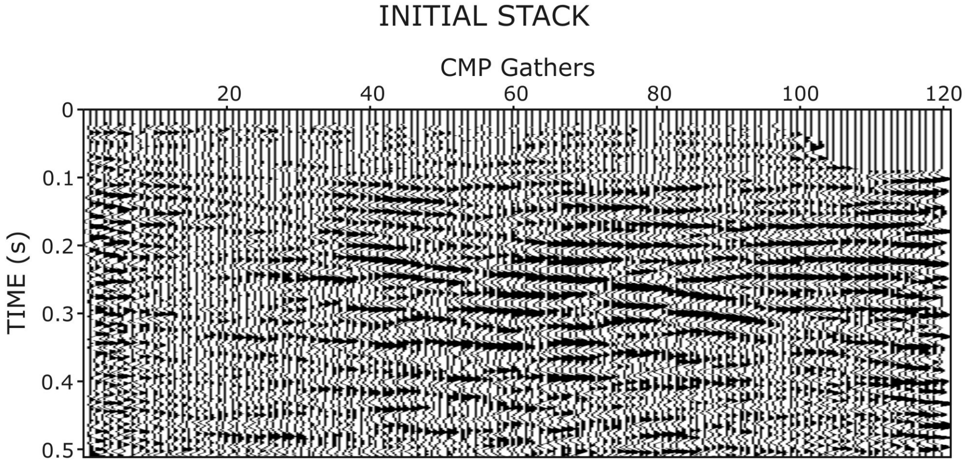

Figure 4. Initial stack.

Radon transformations

One of the most effective 2-D filtering techniques applied is the generalized radon transformation. The usefulness of this transformation lies, among the others, in its ability to eliminate multiple reflection energy and reduce the source generated noise. Linear radon transformation converts linear and hyperbolic events in the t-x domain to points and ellipses respectively in τ-p domain. In order to enhance ultra shallow reflections and attenuate source generated noise, the first part of the procedure proposed by Spitzer et al. 2001 was used. According to this procedure the next steps were followed are:

- Conversion of shot gathers to reduced travel time format by using the velocity of 180 m/s, as the average apparent near surface SH-wave velocity
- Linear τ-p transformation (figure 5)
- Definition of τ-p domain regions dominated by source-generated noise and their mutation, with 5-ms taper in τ direction
- Inverse linear τ-p transformation
- Removal of the linear move-out terms

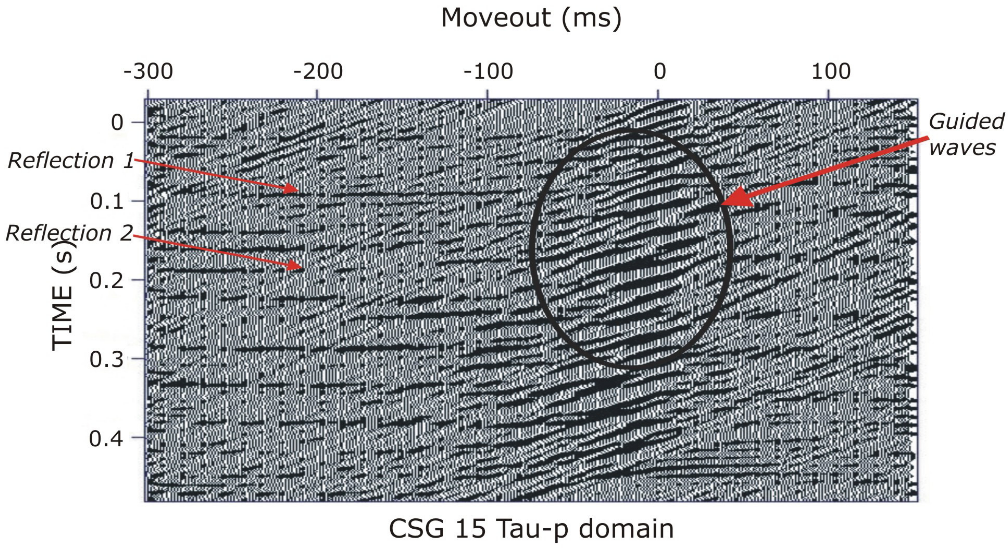

Figure 5. Common Shot Gather in tau-p domain.

The records were shifted by 30ms downwards in time scale to avoid possible over-corrections due to lateral velocity variation. After the removal of the direct arrivals and most of the guided waves the records were subsequently radon transformed (forward and inverse) in parabolic mode to attenuate multiples. The final stack is shown in figure 6.

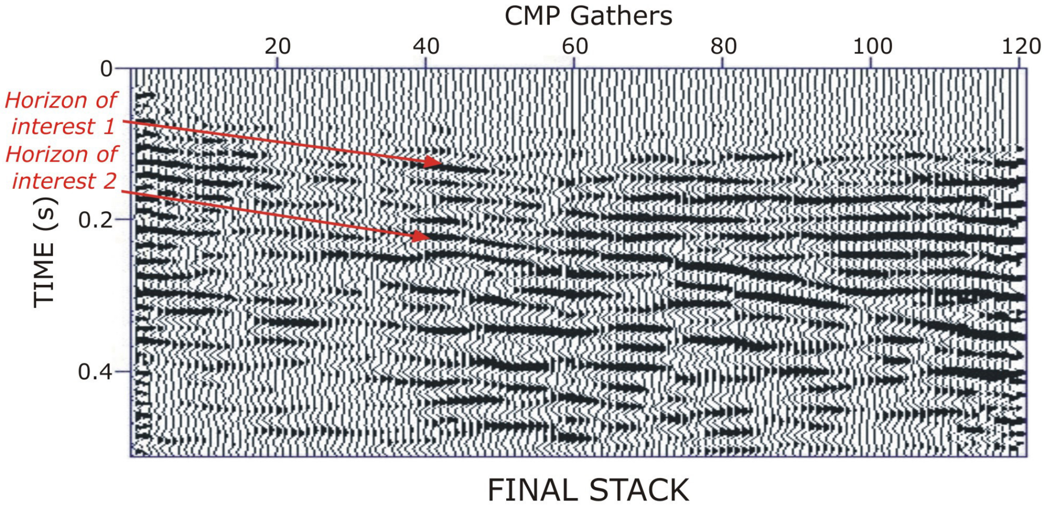

Figure 6. Final stack.

Conclusions

Preliminary data analysis revealed that very shallow SH-wave reflections are masked by high amplitude guided waves (strong reverberations). The reflected energy, at early stages, is obvious only in some of the recorded CMP`s.

The suggested procedure seems to be promising as it attenuates significantly the guided wave energy, although it involves a “dangerous” muting phase at the tau-p domain. It is also time consuming as it requires a single CMP processing procedure, due to very poor reflection quality. Proper *p* value range selection results to the minimization of direct P-wave energy.

References

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