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Exploring SS waves in conventional onshore multicomponent data

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Summary

In conventional seismic surveys *SS* reflections are overlooked and even have been hardly identified. However pure S-wave generation has been predicted for theoretical models, such as impulse sources on the free surface (Miller and Pursey, 1954) or explosive sources inside a borehole (Lee and Balch, 1982), and the literature presents real experiments that confirm them (e.g. Hardage, 2014, Lash, 1985). This work addresses the possible presence of pure *S* wave reflections (*SS*-waves) generated by explosive sources in a land conventional multicomponent survey. Such a kind of reflected events would provide an additional image of the terrain, at minor additional cost for a multicomponent survey, which, together with the *PP* and *PS* images, can allow for better processing of the *S* data and more reliable information about the elastic properties of the medium.

Data from the Hussar 2011 3C survey were used to this purpose (Margrave et al., 2012). After estimating the *SS* waves arrival time and its NMO curves from well-logs velocity information, it was found that the feasible *SS*-waves arrivals are embedded inside the ground roll cone. Consequently strategies to enhance the *SS* events and cut down surface waves were addressed. Since S-wave static corrections are challenging (e.g. Anno, 1986), it was explored a method to obtain independent static corrections for the source (Guevara and Trad, 2019).

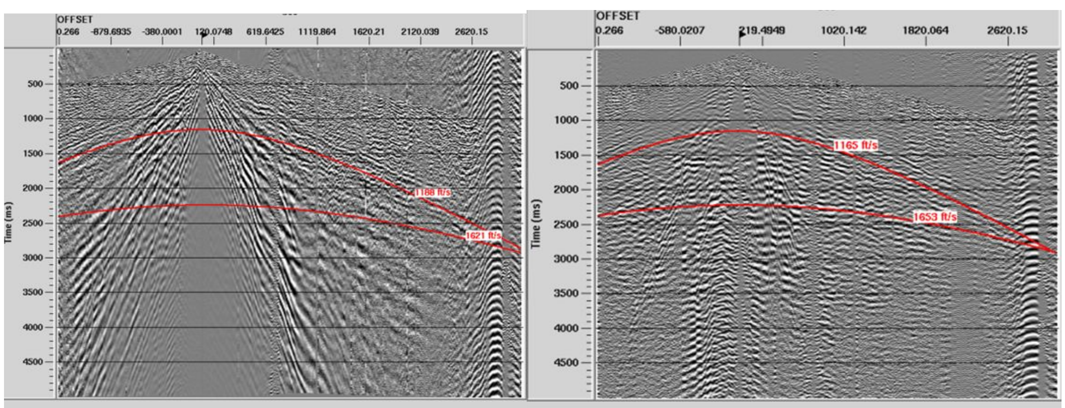
The resulting data after filtering show energy with the expected *SS*-events arrival time in both radial and transversal components. After a simple velocity analysis it was obtained an *SS* stack section, which shows events corresponding to the *PS* stack section at the expected arrival time. The method appears promising to obtain additional information from land multicomponent data.

Theory and method

Since *SS* reflections are not recognized in conventional multicomponent data, modeling of these events appears as a convenient strategy to understand their behavior. Reliable information about velocity from well logs is advisable to this purpose. On the other hand, it is expected the presence of noise and perhaps low energy affecting these events. Ground Roll (GR), the noise cone common in field records, composed by energetic surface waves and other coherent events, should be taken into account. As a consequence, to obtain information on the *SS*-reflections it is required filtering or attenuation,, preserving as much as possible the expected *SS*-waves. There is also a significant effect of the heterogeneous near-surface layer (NSL) on *S*-waves (e.g. Anno, 1986). Static corrections intended to overcome this delay on seismic reflections recorded at the surface, is already partially solved for the receiver side by the static corrections of PS waves, in an asymmetrical way, since the explosive sources are located some meters deep inside the NSL. However the source static corrections appear as an issue without a known solution available yet. Finally, after such filtering and corrections, NMO and stacking are the steps to follow to obtain an image, without much differences compared with the conventional method for *PP* reflections.

Results and discussion

For this experiment is was selected a 4.5 Km length seismic line, whose energy was provided by 257 dynamite shots buried in boreholes at 15 m depth. More information about the Hussar 2011 3C survey is in CREWES reports and in Margrave et al., 2012. Firstly we estimated the *SS* waves arrival time and NMO curves by modeling from the well-logs velocity data of the zone, and relating these curves to the field records. It was found that the feasible *SS* reflections are embedded inside the ground-roll cone, as shown in Fig. 1(a) by the transversal component before filtering together with *SS* expected NMO arrival time curves (the red lines) for a couple of reflections. Consequently it is required filtering of these energetic events. Processes useful to this purpose in ProMAX include surface wave noise attenuation, noise burst edition and bandpass filtering. In addition it was useful applying the Time Fourier Transform filter. Figure 1(b) shows the same transversal component after filtering. Notice that many linear events have been attenuated, and some events that follows the *SS*-wave NMO curves can be identified.



a b

Figure 1: A record of the transversal component (a) before filtering the noise cone (b) after filtering. The red lines show the estimated NMO curves for SS-waves according to the velocity model.

An approximation to the source statics was obtained from interpolation of the receiver statics used for the *PS* wave processing. After filtering and such a source and receiver static corrections applied, a conventional velocity analysis was carried out, guided in principle by the modeling data. No additional filtering or process was applied. As a result it was possible to obtain an *SS* stacked sections for the transversal and radial components. It is illustrated by Fig. 2(a) for the radial component.

Figure 2 shows a comparison of the *SS* radial component stack section (Figure 2(a)) with a previous *PS* section (Figure 2(b)), obtained from processing by the CREWES project (Cova et al., 2018). Both figures have the same vertical and horizontal scales (time and CDP surface location). The red arrows show probable analogous events in both sections, coming from the same geological interface. The stacked section of Fig. 2(a) shows reliable *SS* reflection events, since they show the expected arrival time and with NMO velocities that also agree with the expectations for these wave mode.

This result show reliable SS events obtained from a conventional multicomponent land survey. Issues that demand attention for future work are the source statics correction and the surface waves noise attenuation.

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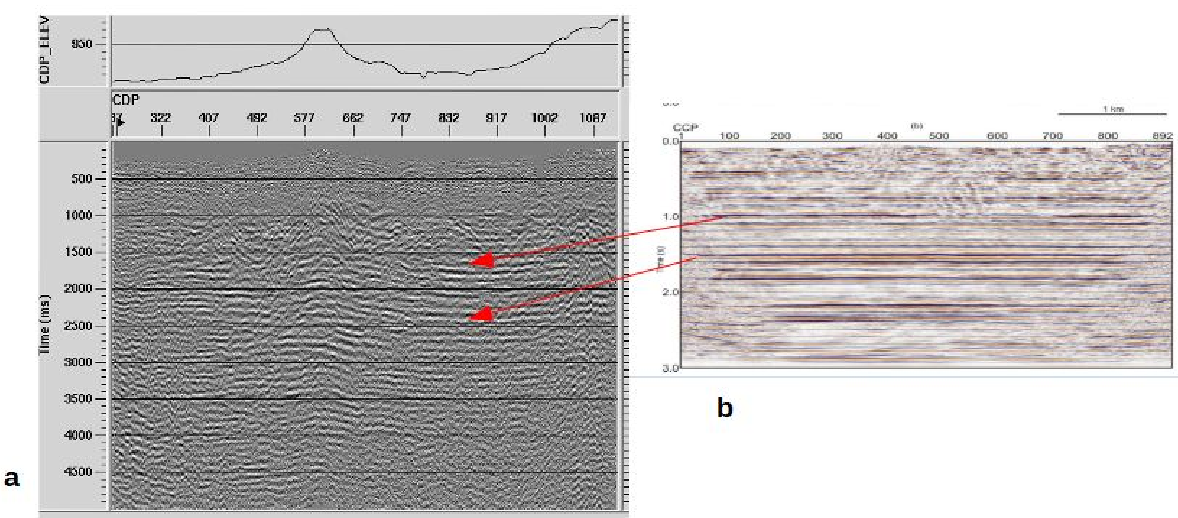

Figure 2. Comparison of the events of the (a) SS stack section from the radial component and (b) the PS stack section. Both have the same time and space scales. The red arrows identifies analogous events.