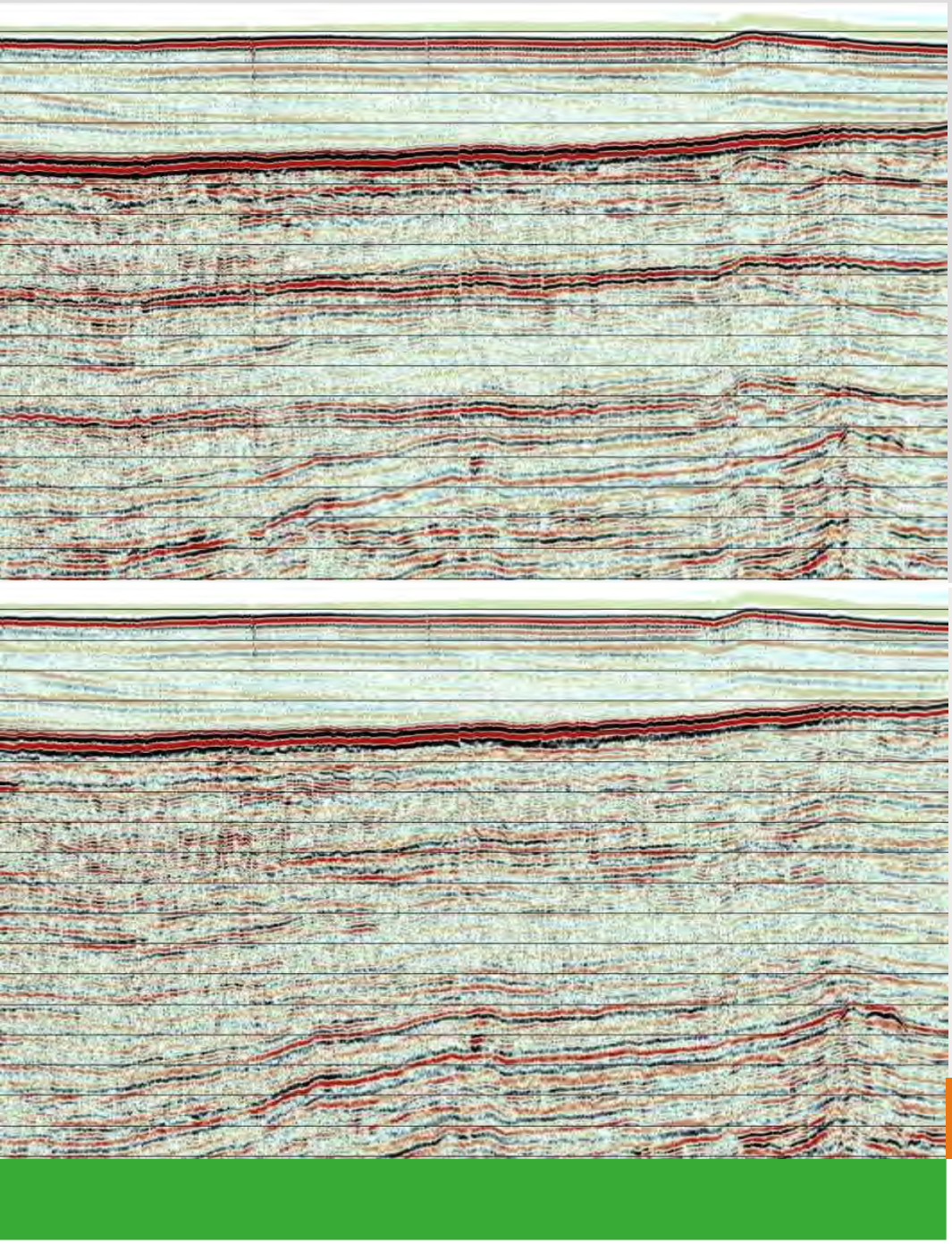


1 – Marine seismic section with multiples
2 – Marine seismic section after SRME

ATTENUATION OF MULTIPLE REFLECTIONS

TECHNIQUES TAILORED TO GEOLOGY

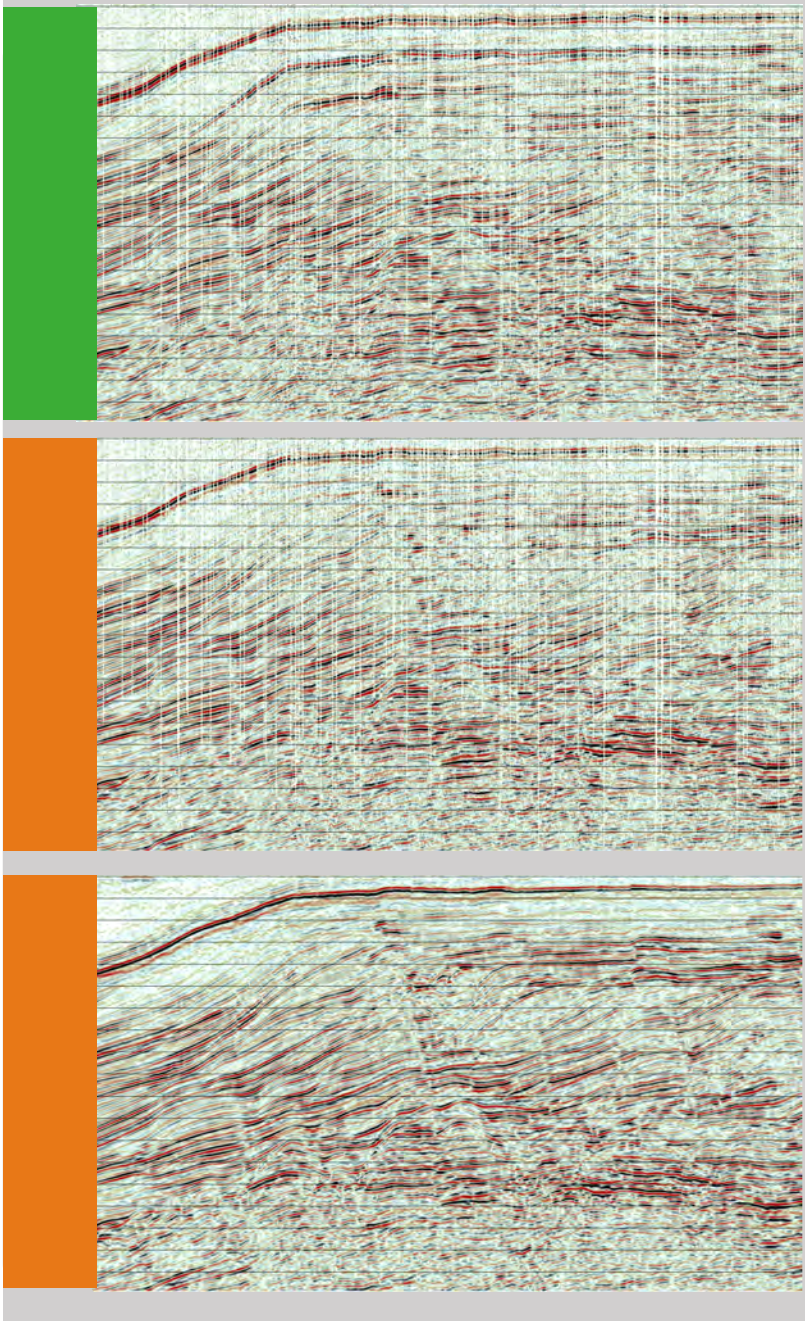
GEOFIZYKA TORUŃ
GRUPA PGNiG

METHODS TO ATTENUATE MULTIPLES

2D/3D SRME MODELLING, ADAPTIVE SUBTRACTION AND INTERPOLATION

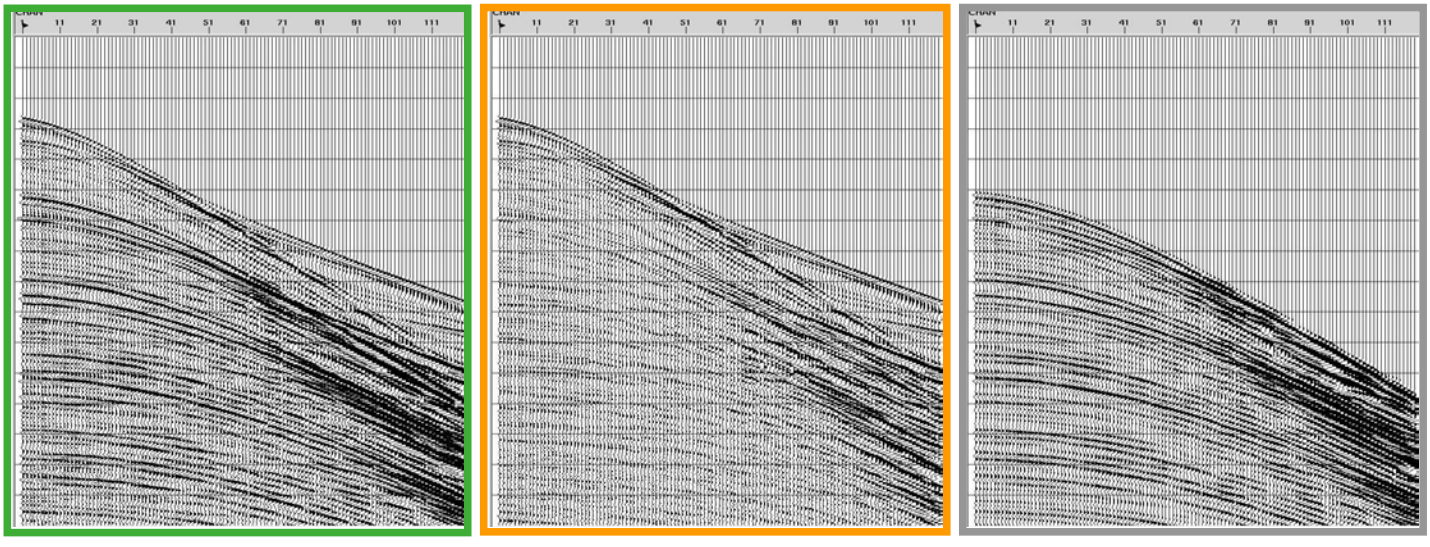
τ- p DECONVOLUTION / TARGETED DECONVOLUTION

Both, in land and marine seismic surveys, multiple reflections are frequently the strongest ones.
Definition, modeling, and elimination of multiple reflections involves various techniques, such as the application of 2D/3D SRME, deconvolution in τ-p domain, multiples' elimination based on moveout and dip discrimination, hybrid/cascade, and deterministic approach to the modeling of multiples, adaptive techniques and the usage of other subtraction methods.

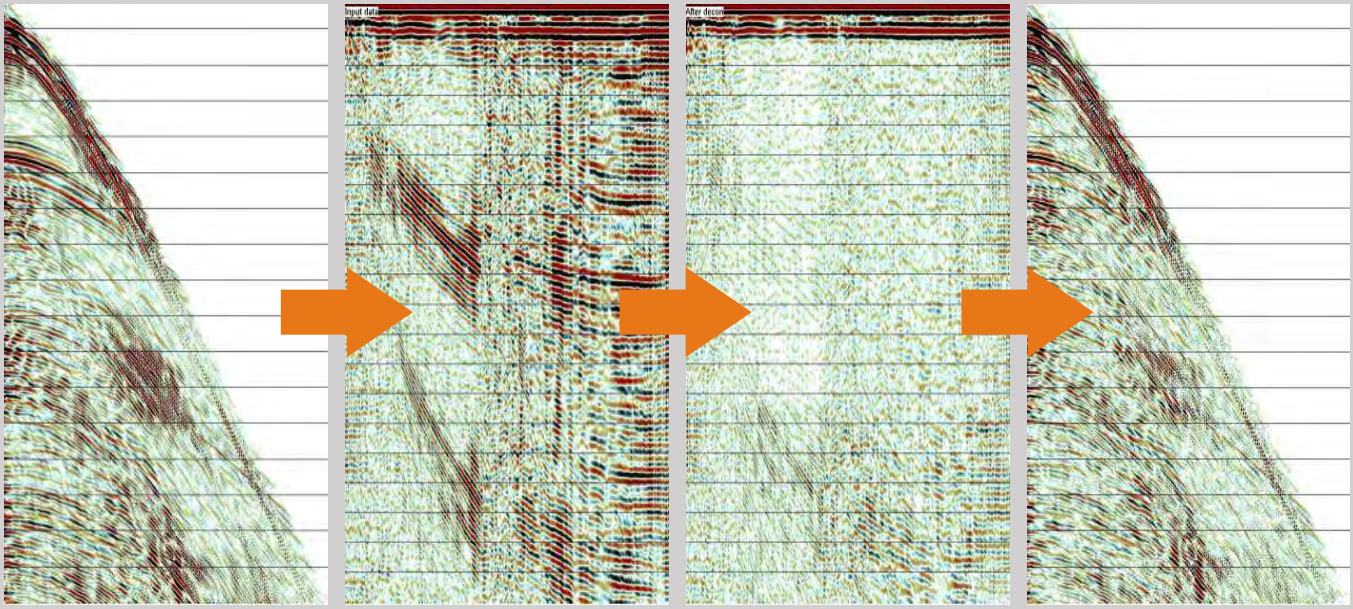


1 – Marine seismic section with multiples
2 – Marine seismic section after 3D SRME and adaptive subtraction
3 – Marine seismic section after 3D interpolation with 3D SRME

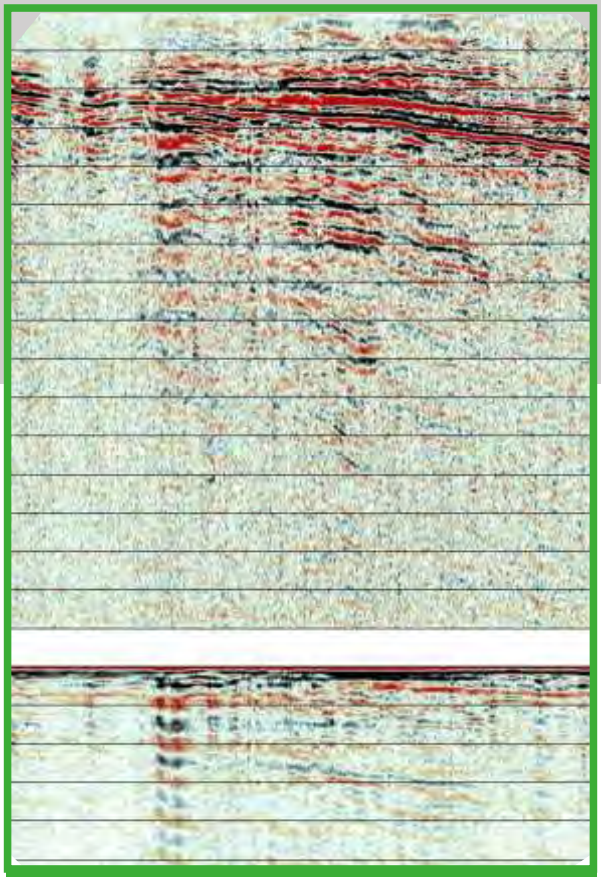
1 – Marine source gather with strong water bottom multiples,
2 – Marine source gather after 2D SRME,
3 – Difference between data before and after 2D SRME



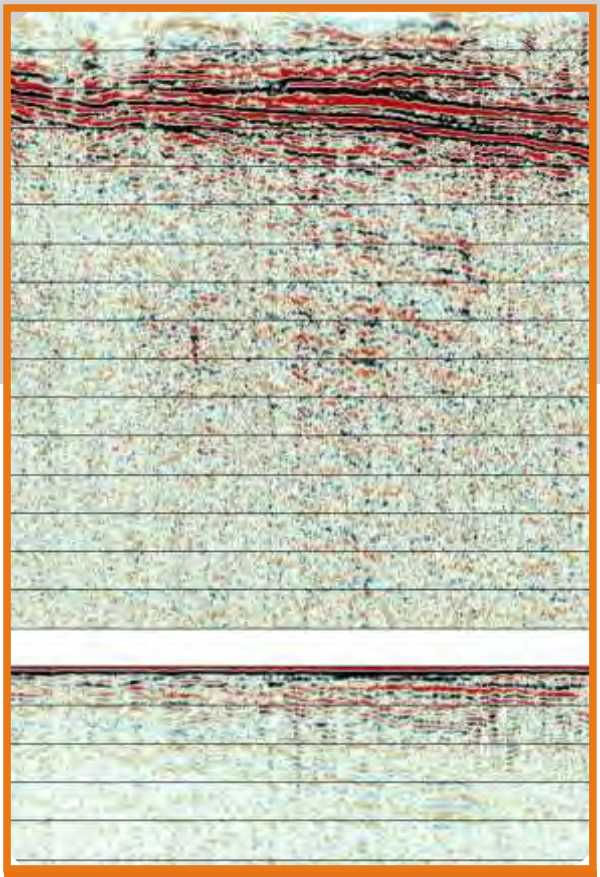
Surface related multiple elimination (SRME) method does not need subsurface information to predict and remove multiples from seismic image. It is used at the initial step of the processing so subsequent procedures are free of these distortions and from multiples-based wavelet.



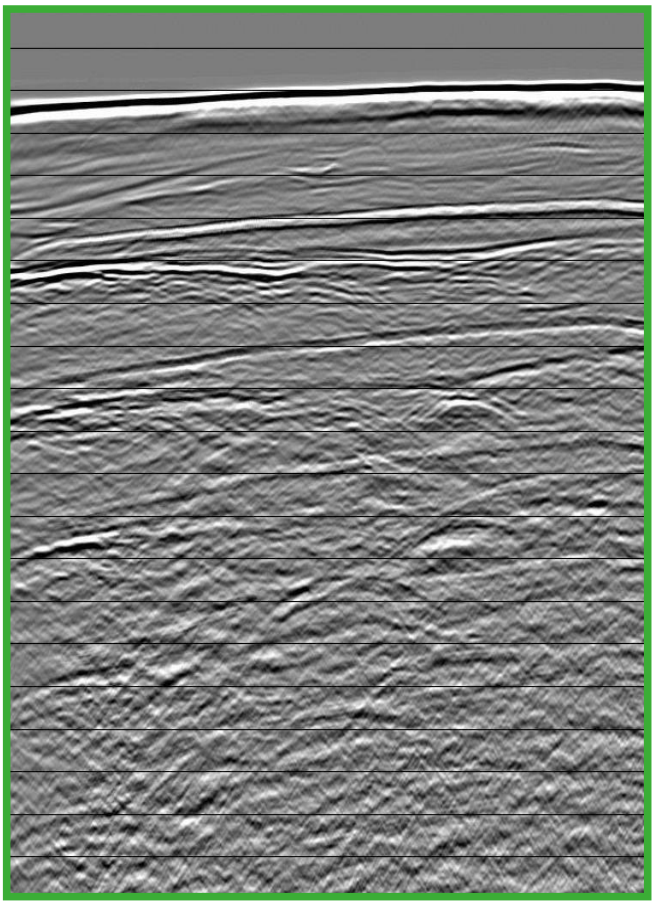
Land source gather: 1 – Original data; 2 – Autocorrelation in τ-p domain; 3 – Autocorrelation in τ-p domain after predictive deconvolution in τ-p domain; 4 – Data after attenuation of multiples.



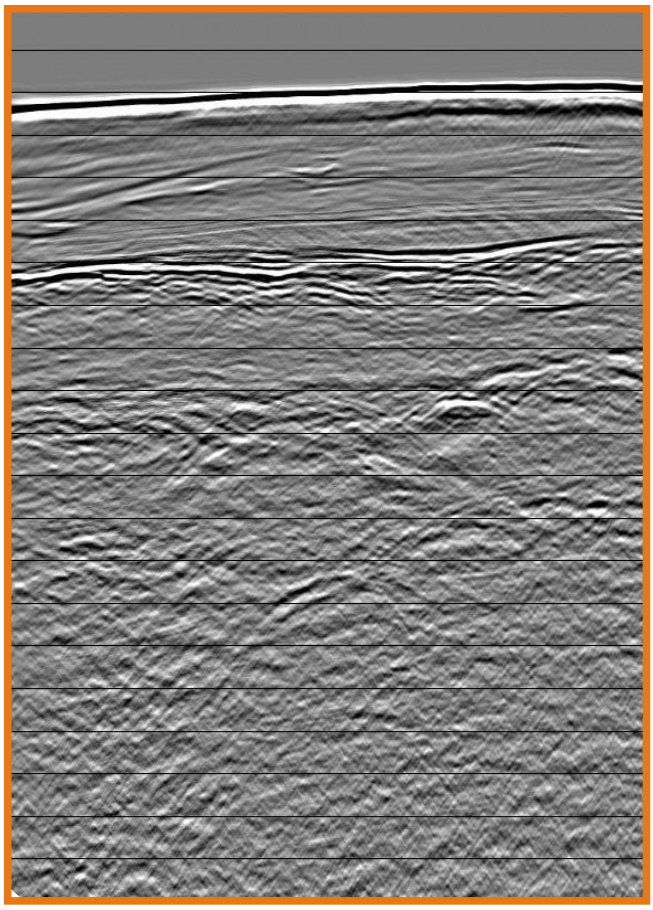
Transition zone seismic section with autocorrelation before multiples' attenuation



Transition zone section with autocorrelation after predictive deconvolution in τ-p

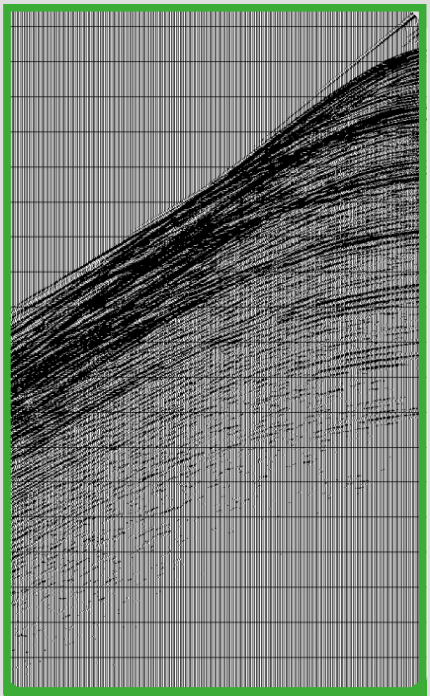


Marine seismic section before multiples' attenuation

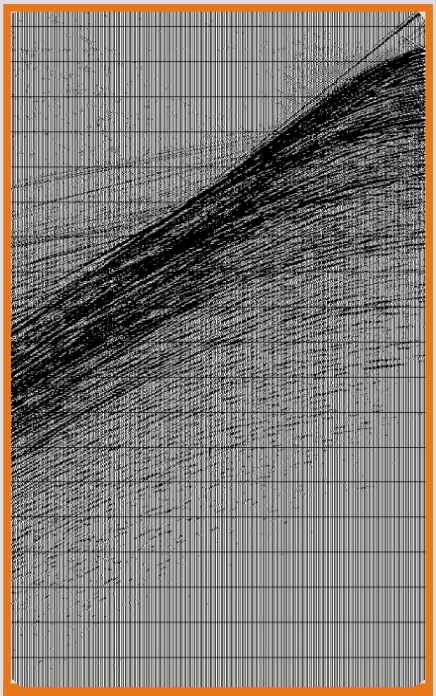


Marine seismic section after targeted predictive deconvolution in τ-p

Predictive deconvolution in τ-p domain gives the best results if the periodicity and predictability of the multiple is conditioned through GT solutions dedicated to land seismic. Modification of the prediction distance with the offset is key to efficiency of this method. Selection of prediction distance and length of the deconvolution operator set this method to the selective (long or short period) multiple elimination.



CDP gather before multiple's attenuation



CDP gather after deconvolution in τ-p domain

METHODS TO ATTENUATE MULTIPLES

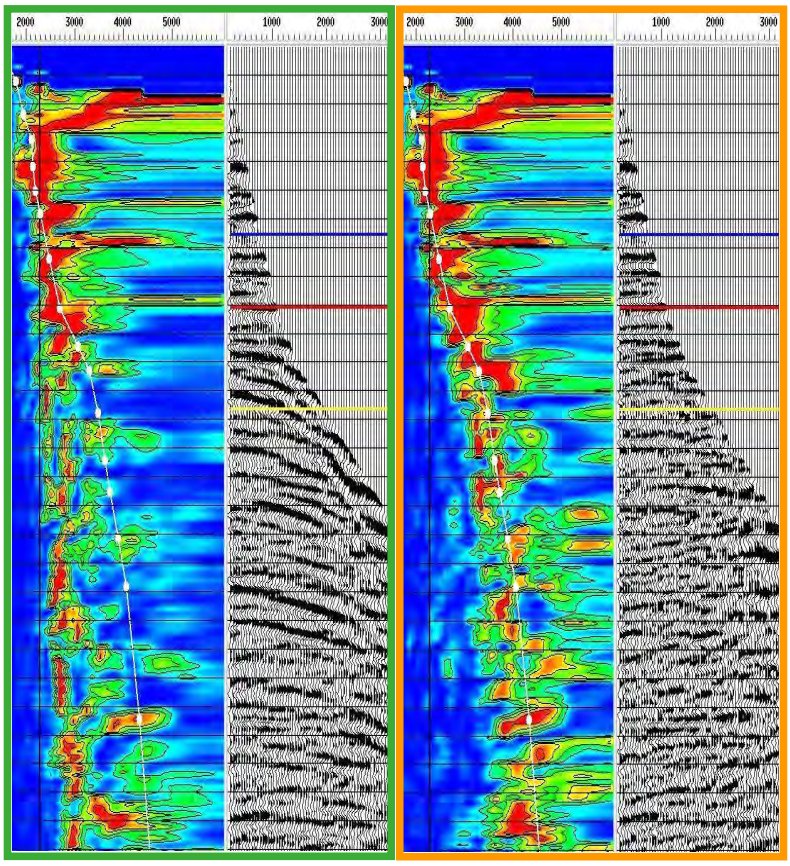
HR RADON FILTERING

HYBRID / CASCADE MULTIPLES' ATTENUATION

DETERMINISTIC MULTIPLES' ELIMINATION

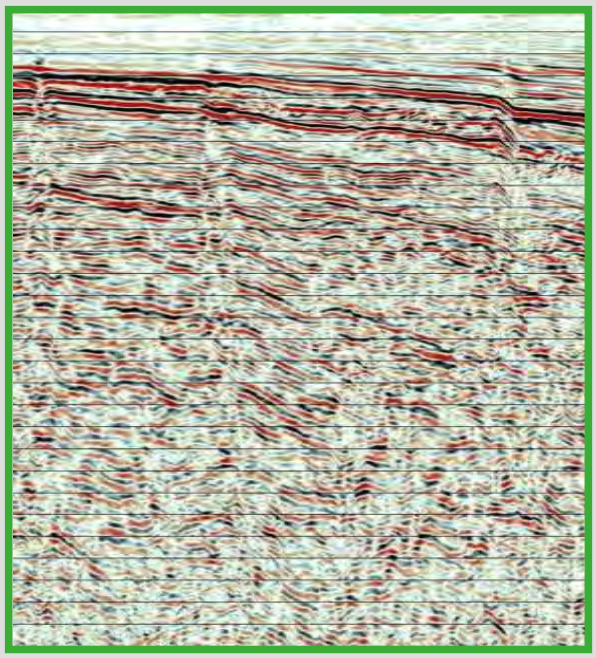
Methods based on a difference in spatial behavior of the primaries and multiples are commonly used for long-period multiple elimination.

Application of high resolution Radon filter reduces smearing of the seismic data and allows to remove multiples with higher precision, and with secure signal resolution. HR Radon filtering additionally well preserves amplitude relations. HR Radon transformation can be used in various sorting domain and can be space and time variant.

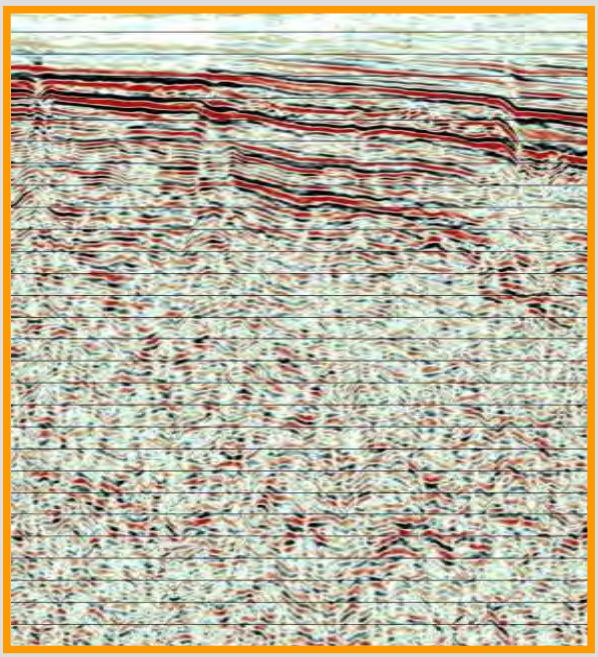


Velocity analysis on the land seismic data before multiple attenuation

Velocity analysis on the land seismic data after HR Radon filter



Land seismic section before multiple attenuation



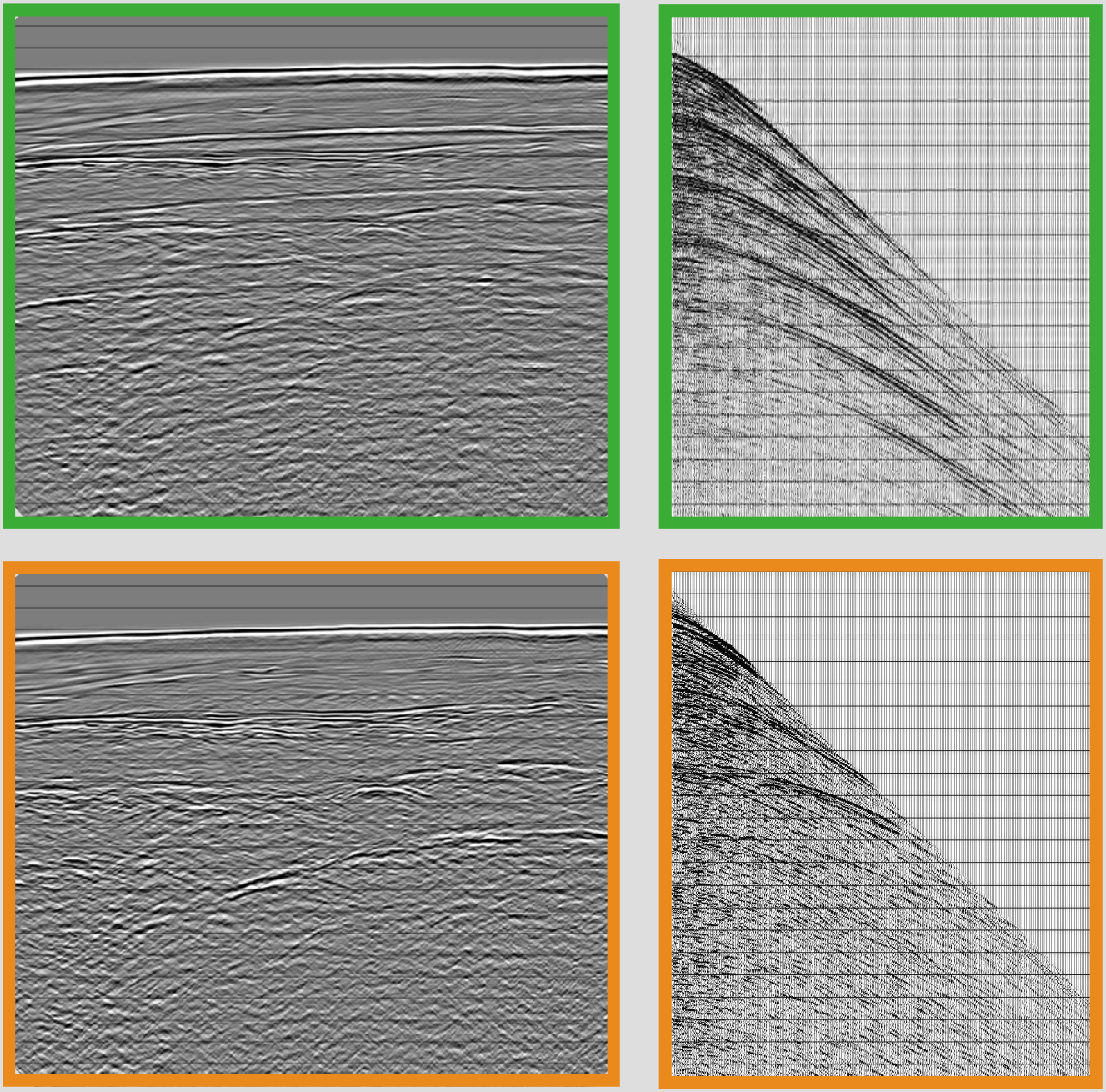
Land seismic section after HR Radon filter

Due to specific local geology, and occurrence of strong multiple events in the seismic data, sometimes an ambiguity occurs as to positions of multiples and localization of primaries. Strong problems with multiple prediction and elimination are often faced in such cases. Especially for near offsets, where the multiple events interfere with real reflections. Specific approach based on deterministic methods is applied to overcome this problem.

Deterministic methods are based on:

- estimation of the multiples' periods,
- finding space/time/depth ranges of the multiples' occurrences,
- modelling multiples with velocities of multiples,
- subtracting models from the input data.

Usually, modelling is being performed cascaded in both, the CDP and common offset domains.

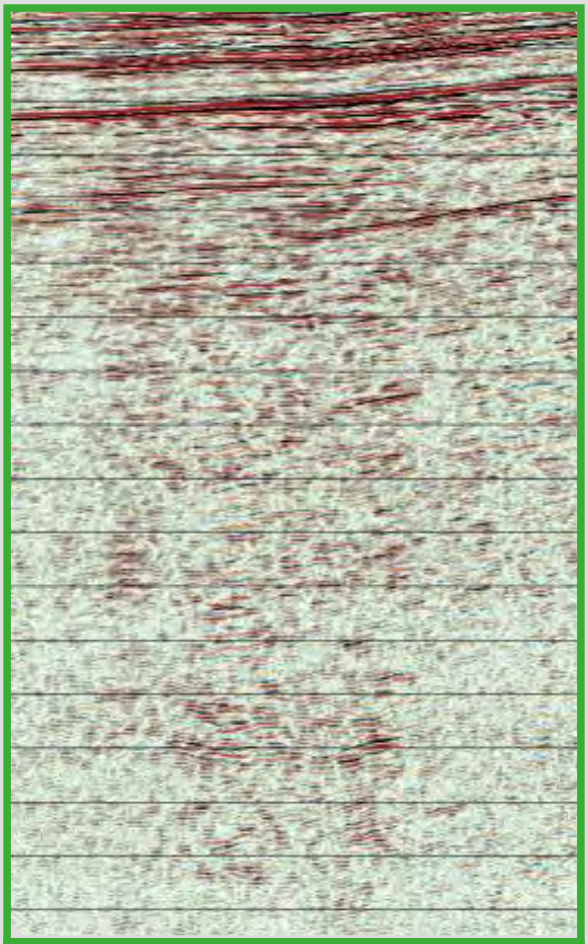


1 – Original marine stacked section;
2 – Original marine CDP gather; 3 – Marine stacked section after HR Radon filtration;
4 – Marine CDP gather after multiples attenuation with HR Radon.

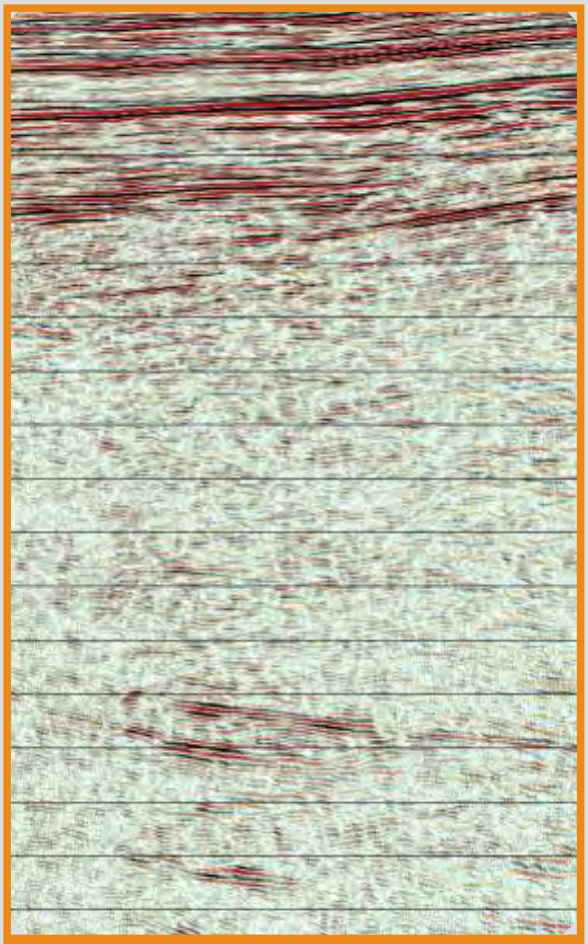
Methods based only on the moveout and dip discrimination are not sufficient for multiple attenuation if these events occur in the nearest offsets or when short-period multiples are present in the seismic image.

Solution in this case is to apply hybrid or cascade methods using series of procedures for multiples' estimation and elimination. Frequently models of multiple reflections are created iteratively, then adaptively subtracted from seismic data. Final models of multiple events are commonly generated by summation of partially extracted multiple signals.

Interbed and intrabed multiples' elimination based on deterministic approach is effective and efficient. Extraction of models and their adaptive subtraction from seismic data protects against destruction of primaries. That could happen if only direct procedures were applied and if primaries are mixed with multiples, crossing with each other and have similar direction in the data.

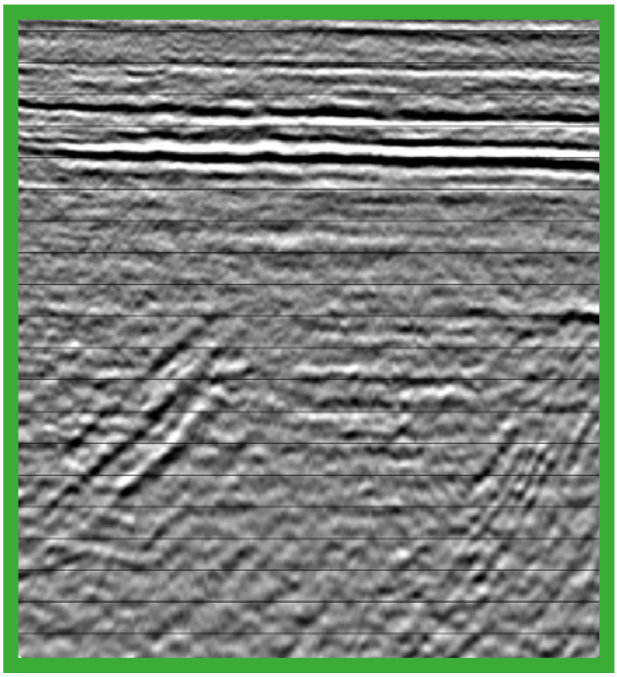


Land stacked section before multiples' attenuation

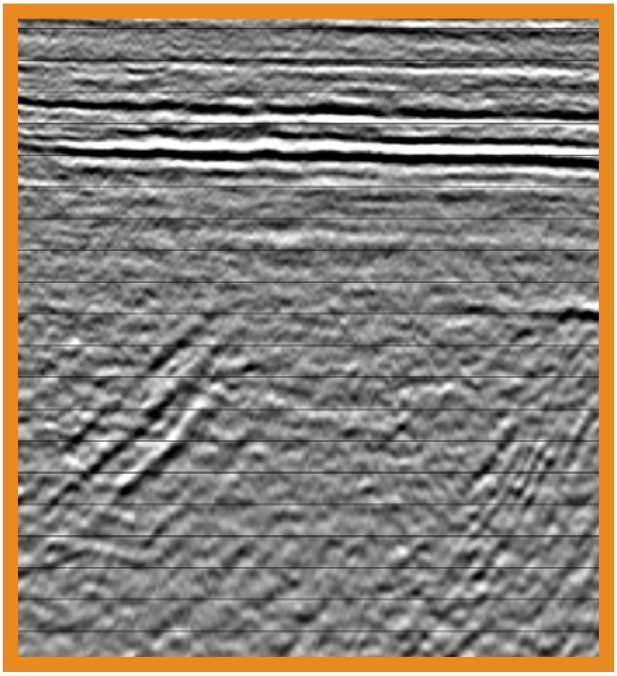


Land stacked section after deterministic multiples' attenuation

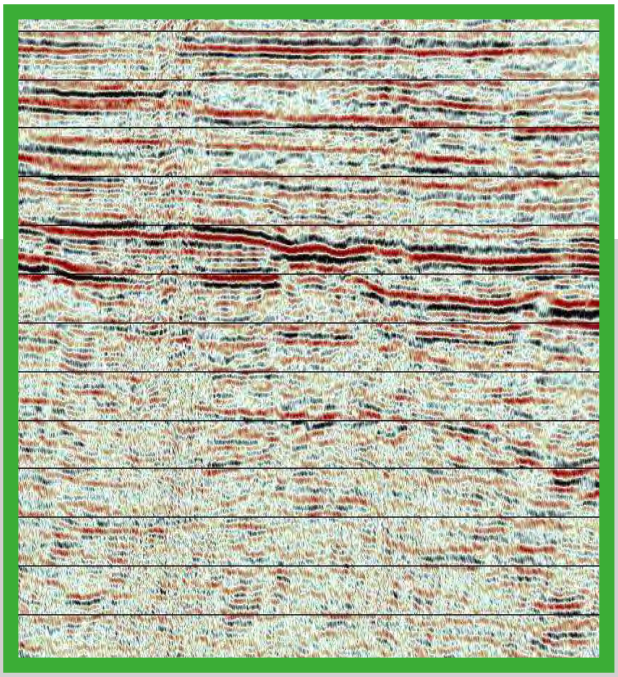
Deterministic approach frequently includes nonstandard processing procedures to create models of multiples. These procedures, such as GT ECP, hybrid modelling, or extraction of post-stack models are crucial when standard procedures fail.



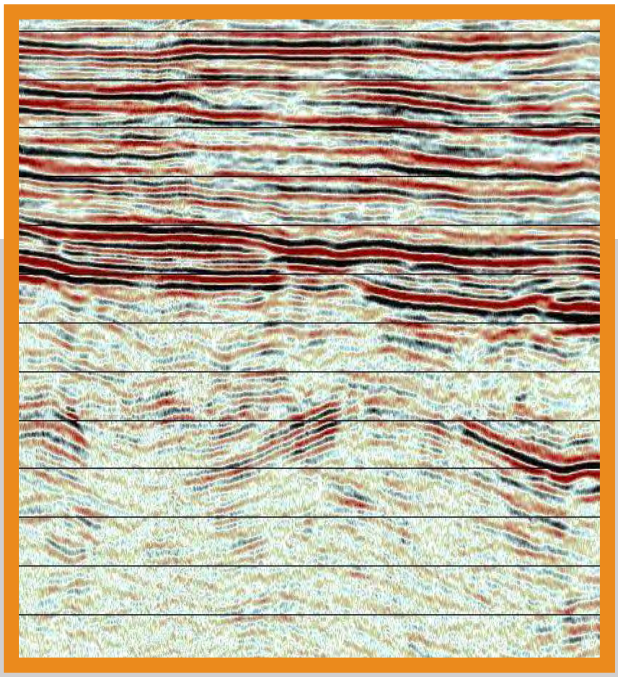
Marine stacked section before multiples' attenuation



Marine stacked section after deterministic interbed or intrabed multiples' attenuation



Land stacked section before multiples' attenuation



Land stacked section after deterministic multiples' attenuation

A practical approach to defining and modelling multiple reflections, and their removal, is an important component of marine and land seismic data processing. Multiple reflections, because of their high energy, frequently mask primaries, and strongly deteriorate correct image of geology. Advanced tools of suppressing multiples: SRME, deconvolution in τ- p, HR Radon filtering, and deterministic iterative and interactive methods are often the only way to eliminate these events form recorded seismic data.