Application of High Definition Seismic technology in severe nearsurface seismogeologic surroundings

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Annotation

Complex near surface conditions sometimes provide unacceptable challenge to traditional seismic processing. This kind of conditions may take place for example if high level of noises is combined with high amplitude variations of velocities in the upper part of section. This may be often met in permafrost areas with thawing zones and in mountain areas.

Two main specific procedures from High Definition Seismic (HDS) technology are applied to fit these challenges. One is iterative wave field analysis instead of usually applied detection of signals among noises and the other is “Polycor” static correction method with high resistance to noises. The examples are shown for low frequency static shifts for mountain relief and midi frequency static shifts for thawing zones in permafrost surroundings. In the first case static shifts with period of 2O km were determined and in the second one amplitude of static shifts with period of about 0.5 km was about 60 ms. As the results of wave field analysis with iterative adjustment of different types of noises and useful signals reliable reflections were detected in original seismograms with high level of noises and high amplitude midi frequency static shifts were reliably determined. Coherent velocity analysis showed that signal to noise ration was increased more than ten times.

The HDS section obtained compared to traditional processing technology showed better correlation of reflection boundaries in full time range, reliable structural positioning of productive well and reasonable positioning of projected well.

Аннотация

Сложные поверхностные сейсмологические условия иногда представляют неразрешимые сложности при обработке данных сейсморазведки. Такая ситуация имеет место, например, при комбинации высокого уровня помех и высокоамплитудных вариаций скоростей в верхней части разреза, характерных, в частности, для многолетнемерзлых зон с растеплениями и предгорных участков.

Для этих условий из арсенала технологий Сейсморазведки Высокой Четкости (СВЧ) применяются специфические процедуры итеративного анализа первичных волновых полей вместо преимущественно используемых методов выделения полезных сигналов на фоне помех и метод «Поликор» с высокой помехоустойчивостью для коррекции статических поправок. В работе приведены примеры определения статических поправок в условиях высокоамплитудных низкочастотных вариаций, связанных с горным рельефом и среднечастотных вариаций, связанных с зонами растепления. В первом случае выделены статические поправки с периодом порядка 20 км, во втором – амплитуда поправок с периодом порядка 0,5 км достигала 60 мс. В результате анализа волновых полей с итеративным уточнением помех различного типа и полезных волн в первичных волновых полях с

высокоамплитудными среднечастотными статистическими сдвигами и высоким уровнем шумов выделены достоверные полезные отражения. По результатам когерентного анализа скоростей достигнутое улучшение отношения сигнал/помеха в первичных сейсмограммах составляет более десяти.

На полученном временном разрезе СВЧ в сопоставлении с результатами традиционной обработки улучшена прослеживаемость отражений во всем диапазоне времен, уточнено структурное положение продуктивной скважины и определена перспективная точка для заложения проектируемой глубокой скважины.

Introduction

Many technical innovations were applied to seismic prospecting in last years: azimutally isotropic, multicoverage 3D geometries with small space increments, multicomponent acquisition, multinode processing clusters, parallel high speed processing, etc. But the progress in efficiency of seismic prospecting is not so impressive especially under complex seismogeologic conditions. For on land surveys frequency band usually doesn't exceed 3.5 octaves and this means that neither law frequency (vertical gradient for example) nor high frequency features of geological sections are available for investigation by seismic methods. No sufficient results were still obtained from shear waves in spite of many investments. These disadvantages are due to some traditional simplifications in acquisition and processing.

- 3D surveys are really 2D geometries which are not adequate to 3D geological media;
- Geophones are not clamped to the earth providing resonances on high frequencies;
- Static and dynamic corrections do not describe real time graphs of reflections if upper part of section is complicated.
- Velocity estimates obtained from hyperbolic scans are very far from real;
- Procedures of detection the useful reflections are not based on fundamental approaches.
- There are no technologies of reasonable application of shear waves in surface seismic.

High Definition Seismic approach [1] combines some improvements which provide correct solutions of the problems and is aimed to achieve not less than 7 octaves.

- 3D + VSP as 3D acquisition system;
- Clamping of geophones to the earth;
- Application of "Polycor" method [2] to determine more reliable estimate of smoothing static corrections;
- Iterative wavefield analysis [3] instead of detection of signals;
- Restoration of true time graphs of reflections using static and dynamic shifts as temporary smoothing factors in process of wavefield analysis;
- Vector migration combining P and PS waves for better inversion.

HDS processing case story

Separate parts of HDS approach may be applied to improve efficiency of seismic prospecting. Presented case story illustrates advantage of "Polycor" static corrections and HDS wavefield analysis in subarctic areas of Eastern and Western Syberia. Fig.1. shows that reliable shot and receiver statics including low frequency component (20 km) may be obtained and they are similar to each other and relief configuration. The other example (Fig. 2) illustrates determination of shot and receiver statics with strong static anomalies due to thawing zones beneath the rivers. Amplitude of static variations is approximately 60 ms. These severe static variations are combined with pure signal to noise ration (Fig.3.).

Wavefield analysis was applied to raw seismograms. The method used was iterative determination and adjustment of different noises and useful reflections. The last wavefield was used for calculation of 4 factor statistically consistent prediction error deconvolution operators which were applied to all components of wavefield. Final result is full deconvolved wavefields minus all determined noises. Coherent velocity analysis confirms that signal to noise ration increased more than 10 times.

CDP section obtained without any additional processing (Fig. 4, Fig. 5) compared to results of traditional processing with the use of top rank software showed sufficient advantages of HDS processing. Reliable correlation of reflections is achieved for the full time range. Structural position of productive well is determined. Reasonable criteria are obtained for positioning of projected well.

Conclusions

Application of HDS approach to processing of seismic data with severe variations of static shifts combined with extremely law signal to noise ration provides satisfactory results compared to negative results of traditional processing.

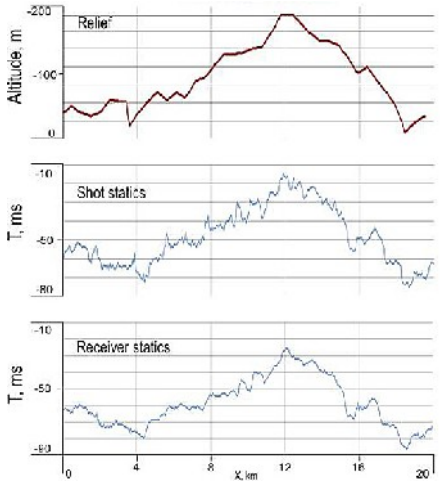


Fig. 1. Shot-based, receiver-based statics and relief (Eastern Siberia).

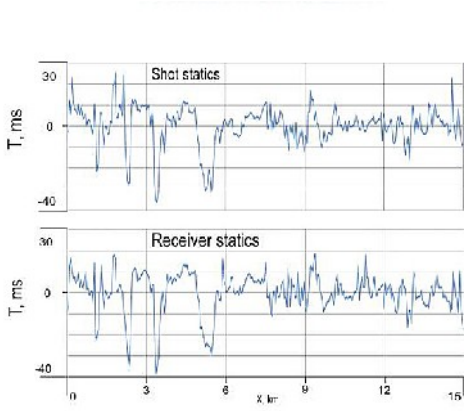
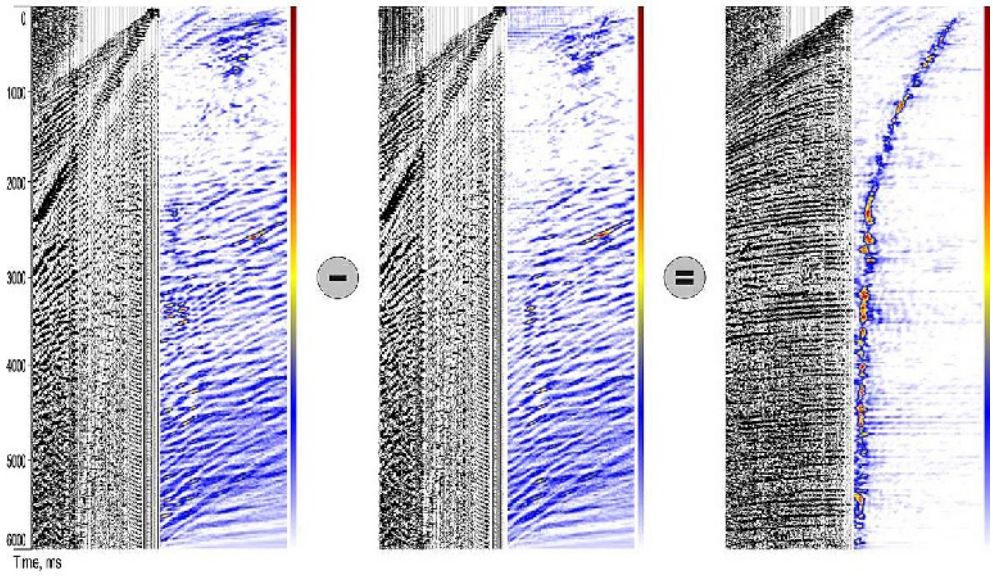
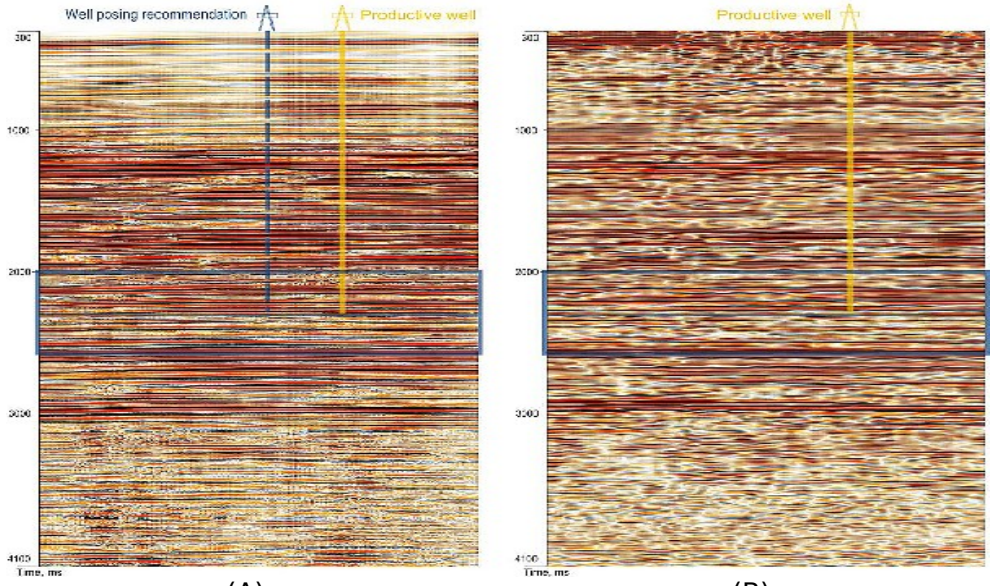


Fig. 2. Shot-based and receiver-based statics (Permafrost Western Siberia).



(A) (B) (C)

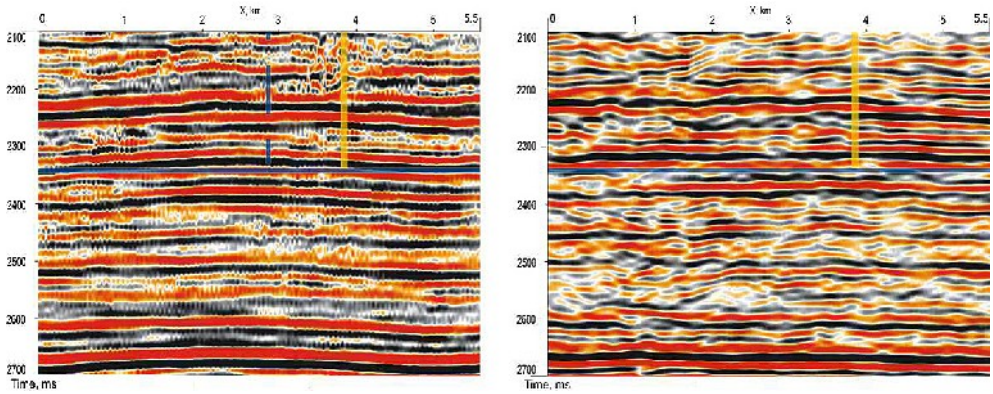
Fig. 3. Wavefield analysis (A - raw seismogram, B - noises, C – residuals).



(A) (B)

Fig. 4. CDP sections (A - HDS processing, B - top brand software

processing).



(A) (B)

Fig. 5. CDP sections fragment (A- HDS processing, B - top brand software processing).

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