МЕТОДИКА 2D, 3D+ВСП СОВМЕСТНЫХ СЕЙСМИЧЕСКИХ НАБЛЮДЕНИЙ НА ПОВЕРХНОСТИ И В СКВАЖИНЕ

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2D, 3D+VSP acquisition geometries combining surface and downhole measurements

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Summary

Two applications of combined surface and downhole acquisition geometries are described. They are called “2D+VSP” and “3D+VSP”. The advantages are based on the use of downhole arrival times and signatures to improve surface seismic data. The case stories approve the proclaimed features of proposed technology.

Аннотация

Рассмотрена технология совмещенных наземно-скважинных сейсмических наблюдений в вариантах «2D+ВСП» и «3D+ВСП». Преимущество этой технологии основано на использовании годографов первых вступлений и формы импульсов глубинного прибора для коррекции записей наземных сейсмоприемников. Приведенные примеры применения технологии подтверждают преимущества использования таких наблюдений.

Introduction

The basic geophysical methods used by prospecting and monitoring of oil and gas deposits, are logging (LOG), seismic prospecting on a surface (2D and 3D) and seismic prospecting in wells (VSP).

LOG methods possess high resolution by the depth, however that methods study only the most nearest area around a well. Seismic prospecting on a surface possesses an opportunity of receiving of the coherent image of the large objects, but such methods have insufficient resolution and accuracy to solve problems of high detail. In comparison with ground seismic prospecting VSP provides more detail studying of borehole environment, but in the limited range of distances from a well.

At production drilling on oil and gas frequently there is a need of detailed studying of productive layers on distances up to 1.5 – 2 km from a well, not achievable for prospecting by VSP method. Presence of a deep well can increase sharply accuracy of 2D and 3D seismic prospecting in vicinities of this well, if simultaneous supervision on a surface and in a well is used. This provides combination of advantages of seismic prospecting on a surface and VSP. The technique of the combined acquisition means that every shot of 2D or 3D survey is acquired by VSP geophone set located close the well bottom. As a matter of fact, this technology is based on three-dimensional acquisition geometry.

Method description

The technique of supervision by multipoint three-component VSP geophone is discussed. VSP geophone is positioned close to the well bottom. Using this technique it is possible to estimate the heterogeneity of the top part of well environment. Also it is possible to compensate variations of the shot signatures in surface seismograms [4].

In figure 1 the simplified scheme of supervision system and rays trajectory in section 2D for simplified double field CDP covering is presented.

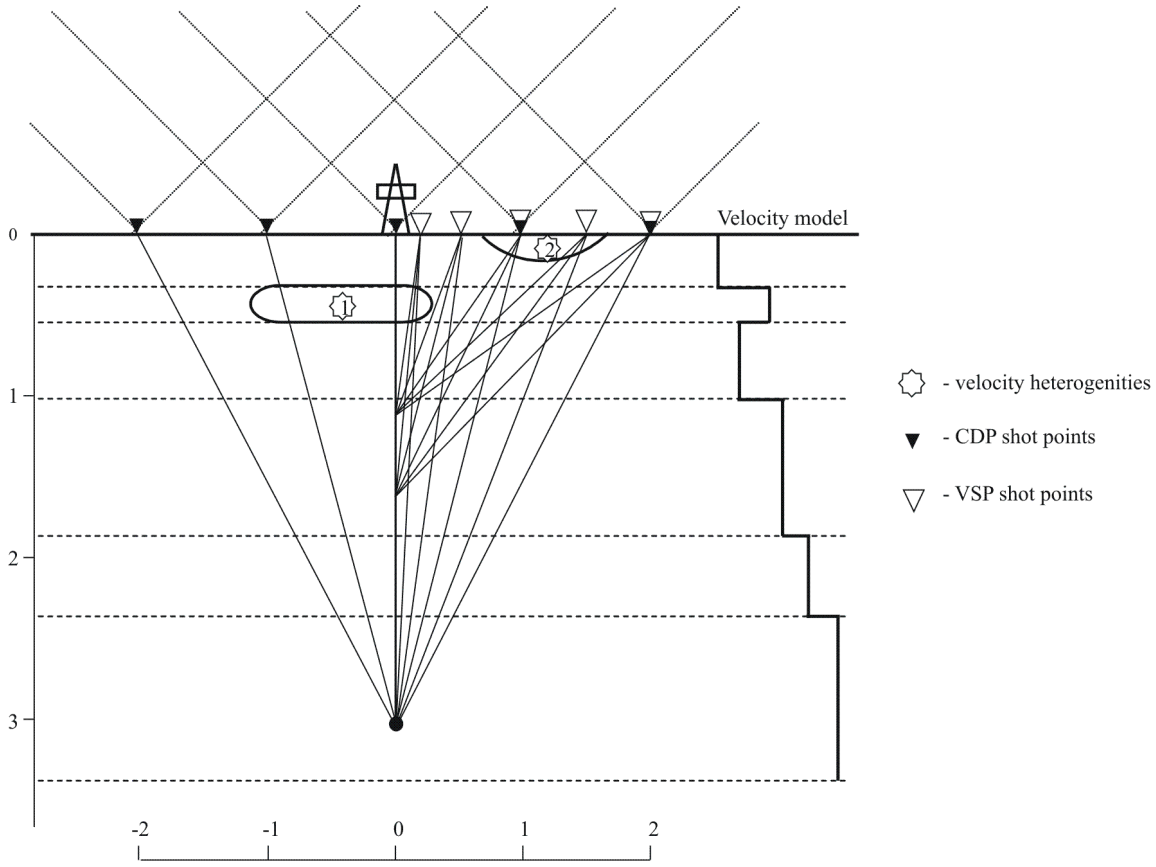

Fig. 1 Field measurement scheme by a technique "2D+VSP" or 3D survey

Each shot of 2D or 3D survey is registered by the multipoint three-component geophone located close to the well bottom, with step between receivers not less than 15 m. Using of a multipoint three-component geophone provides an opportunity of extraction of a direct P-wave for subsequent signature determination in surface geophones records.

Usual VSP zero and offset surveys are provided in the well. The data from the nearest shot point are used for correlation of surface reflections with lithologic section. Also this data are used to forecast a geological section lower than a well bottom, and also to increase the resolution of surface survey by applying to CDP sections additional deconvolution by the VSP primary reflections.

Carrying out of the VSP from several shot points provides accurate velocity model of environment (velocities, factors of anisotropy and inclinations of layers) in a well.

Processing description

Data processing of the combined acquisition consist of three stages. At the first stage data processing of the VSP from all shot points is carried out. The basic result of the first stage is the velocity model of environment [3].

Further processing of records of the VSP deep geophone is carried out. This includes kinematics and dynamic processing [1]. As a basis for kinematics processing serves first break hodograph of the VSP geophone records. It is supposed, that space hodograph is influenced by next factors:

- the environment, described by layered model;
- local variations of weathering layer;
- variations of shot conditions.

The difference between observed hodograph and synthetic hodograph, which designed using velocity model of environment, defines a field of static corrections. The smooth component of these corrections characterizes local variations of the weathering layer, and high-frequency component characterizes variations of shot conditions.

Dynamic processing of VSP records serves for equalizing the signatures of different shots. This processing consists of extraction of a downgoing wave and combining of a reference signal for calculation of the correcting operator. The reference signal is provided by stacking of traces of downgoing waves having close equal offset from the wellhead.

Results of this stage are corrections for anomalies of weathering model velocities and the operators compensating differences of signatures.

At the last stage surface seismograms are corrected before usual processing chain. In this processing results received at the previous stages are used.

Deconvolution CDP to VSP is applied to 3D cube or 2D profile to provide strictly zero phase signature[3].

Processing results

The basic specific results of combined acquisition technique, that provide some advantages compare to standard technique are obtained at the second stage of processing.

The first advantage proposed technique is exact estimation of weathering layer model, which is used for correction of mid-frequency static shifts in surface seismograms. The example of such map, constructed by "3D+VSP" geometry on productive field in Western Siberia, is presented in figure 2. The real river complex is depicted to show good correlation with defrozing zones which sharply declines velocities in weathering layer.

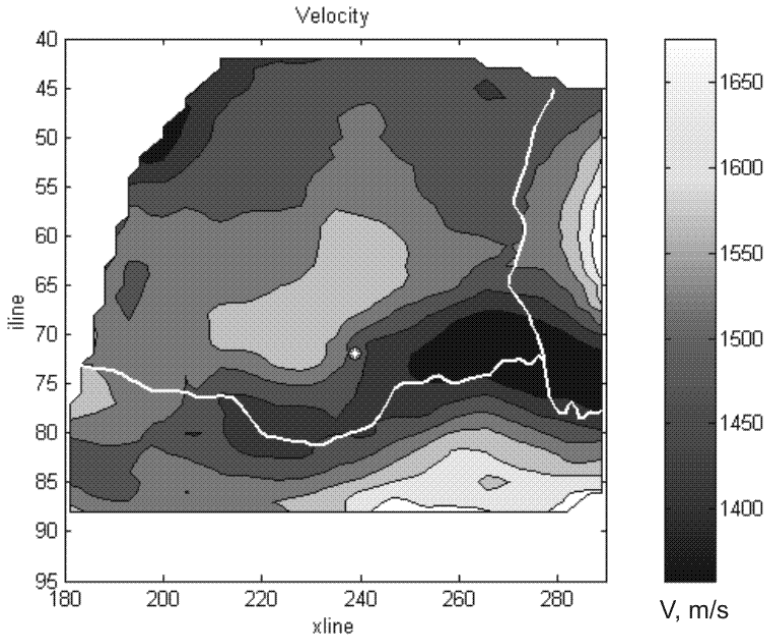

Fig. 2 Layer velocities map including a permafrost zone
(white point – well, white line – river complex)

Other advantage of such technique is the possibility to use operators, smoothing signatures in surface seismograms. In figure 3 initial records of one ground geophone from several explosions and result of correction of static shifts and signature differences are presented. Reflected waves correlation improvement is obvious. That confirms the possibility of using static corrections and operators, designed by VSP geophone set, to compensate influence of differences in shot conditions in ground geophones records.

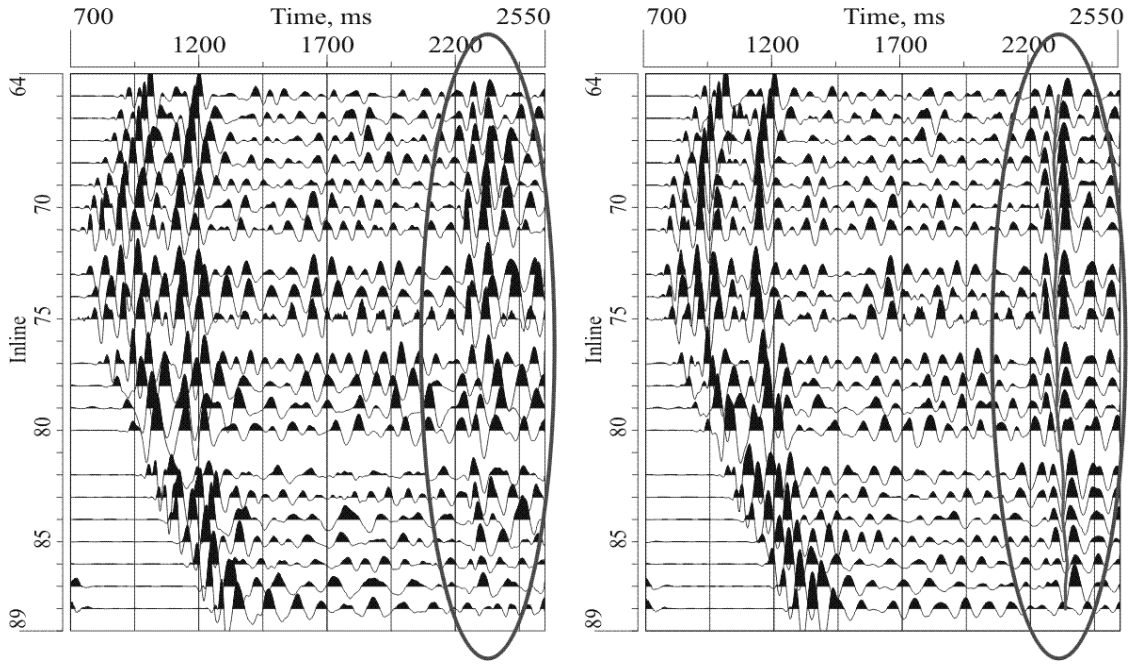

Fig. 3 Surface common receiver gathers for several shot points (at the left – before correction, on the right – after correction of the signatures and static corrections using downhole geophone records)

Conclusions

The combined acquisition technique allows to get advantages compared to seismic prospecting when the deep well is present on the prospect area [2].

The basic advantages of combined surface-well geometry can be formulated as follows:

- it is possible to compensate differences in shot conditions controlling signature of each shot and applying signature deconvolution,
- it is possible to use true static corrections,
- it is possible to use exact well velocity model according to the VSP, also it is possible to consider a horizontal gradient of weathering layer velocities. This gradient is estimated from the variation of the direct wave arrival times obtained for surface survey.

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