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Prestack Signal Enhancement by Multi-parameter Common Offset MultiFocusing

E. Landa* (Advisory Board of Geomage), M. Rauch-Davies (Geomage), K. Deev (Geomage) & A. Berkovitch (Geomage)

SUMMARY

Imaging in complex areas is of great importance in seismic imaging. First of all it is connected to the ability to extract valuable information from the raw seismic data and to use this information for constructing of a reliable velocity model, which is a crucial step in depth imaging. In such case, time processing is a necessary step to improve signal to noise ratio in the raw data. Moreover, results of time imaging can significantly help to create reliable velocity models and consequent depth images. Improving the quality of prestack data always stays in focus of intensive research.

In this paper we follow an approach presented by Berkovich et al. (2011) which proposes using a local COMF approximation for traveltimes stacking surface description. It allows for an arbitrary common offset adequately approximate

traveltimes of seismic events in the vicinity of a CMP position. The paper presents application of the proposed procedure on synthetic and real data including imaging using the improved seismic data.

Introduction

Imaging in complex areas is of great importance in seismic imaging. First of all it is connected to the ability to extract valuable information from the raw seismic data and to use this information for constructing of a reliable velocity model, which is a crucial step in depth imaging. In such case, time processing is a necessary step to improve signal to noise ratio in the raw data. Moreover, results of time imaging can significantly help to create reliable velocity models and consequent depth images. Improving the quality of prestack data always stays in focus of intensive research.

During the last decade, the MultiFocusing (MF) data analysis method has been successfully adopted for this purpose. The method is based on a local coherency summation of seismic signals around a specified point at the surface. The methods use a subset of arbitrary located traces around the imaging trace, rather than a single CMP gather. To achieve this goal the technique searches for each CMP location and each time sample a local travel-time surface which optimally fits the moveout across a collection of prestack traces. This local time surface can be adequately approximated by common offset multifocusing (COMF) correction. It is a multiparameter function which in two dimensions depends on 5 unknown parameters and in three dimensions depends on 13 parameters. The parameters are connected to three fundamental parameters of the paraxial approximations of the ray theory, namely, the radii of the normal (N) and normal-incidence-point (NIP) waves and the emergence angles.

The ability of the local stacking operator to improve the quality of prestack data is presented in Baykulov and Gajewski (2009), Berkovich et al. (2011) and Buzlukov and Landa (2013).

In this paper we follow an approach presented by Berkovich et al. (2011) which proposes using a local COMF approximation for traveltimes stacking surface description. It allows for an arbitrary common offset adequately approximate traveltimes of seismic events in the vicinity of a CMP position. The paper presents application of the proposed procedure on synthetic and real data including imaging using the improved seismic data.

Common-offset MultiFocusing correction

A limitation of the Zero-Offset MF (ZOMF) method in a complex environment is a quasi-hyperbolic approximation for actual travel-time surfaces. To overcome this limitation we introduce a local COMF time correction which accurately approximate traveltime surface in the vicinity of an arbitrary offset trace. Unlike zero-offset MF time approximation, it is valid for arbitrary source-receiver pairs in the vicinity of a non-zero offset trace. COMF traveltime formulas provide an adequate representation of arrival times for arbitrary offset and source-receiver configuration. The COMF correction formula is accurate even for strong curved reflectors and moderate lateral velocity variations. Implementation of the COMF requires estimation of five parameters for each time sample of the common-offset image. Analysis consists, as usual, of maximization of the semblance correlation measure. Outputs of the COMF provide enhanced prestack seismic records which can be used for velocity model construction and subsequent depth imaging.

Examples

We illustrate the proposed method on a real example taken from a known Benjamin Creek data set. Figure 1 shows shot gather before (*1.a*) and after data enhancement (*1.b* - ZOMF and *1.c* - after COMF). It can be seen that while zero-offset MF kinematics successfully used for data enhancement and amplitude preservation only around near offsets, the common-offset MF preserve non-hyperbolicity and amplitudes thru the full range of offsets. Figure 2 shows advantages of COMF vs. ZOMF data enhancement presented on PSTM fragment results. Circle 1 outlines better amplitude and dip preservation, circle 2 shows less artifacts and circle 3 reveals folded structure on the common offset MF-PSTM version.

Figure 1.a (original data).

Figure 1.b (zero-offset MF).

Figure 1.c (common-offset MF).

Figure 2.a (original PSTM).

Figure 2.b (ZO-MF PSTM).

Figure 2.c (CO-MF PSTM).

Conclusions

We have applied zero-offset and common-offset MultiFocusing imaging on highly structured data. Presented figures show limited efficiency of ZO-MF in comparison to CO-MF data enhancement in cases of complex geology and/or strong lateral velocity variations. In such cases, traveltimes of seismic events become non-hyperbolic and zero-offset operators starts to be inaccurate. The common offset MF based on approximation for locally coherent seismic events allows an evenly accurate estimation of the wavefield parameters within the full offset range. COMF technology is efficient and reliable tool for data enhancement, velocity estimation and amplitude-preserved accurate imaging.

References

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