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A CRS-based Heterogeneity Attribute

J.H. Faccipieri* (CEPETRO-UNICAMP), T.A. Coimbra (CEPETRO-UNICAMP), L. J. Gelius (UiO) & M. Tygel (IMECC-UNICAMP)

SUMMARY

An attribute describing heterogeneity is proposed based on the diffracted-wave contribution. In areas of complex geology the amount of diffracted energy will increase relative the specular reflections. By use of the modified CRS technique, a reliable measure of the diffractions can be obtained. Proper scaling with the output from a conventional CRS stack gives a normalized measure of the complexity of the geology. The new attribute has possible use both in seismic texture analysis and as a weight factor employed to combine CRS based reflection- and diffraction-enhanced stacks. The potential of the heterogeneity attribute is demonstrated using seismic data from offshore Brazil.

Introduction

Based on the Common-reflection-Surface (CRS) method (Jäger et al., 2001), we derive an attribute describing the heterogeneity or complexity of a seismic stacked section or an image. Generally speaking, seismic data are normally processed in ways that do not honour properly the varying characteristics of the recorded wavefield across the area of investigation. In areas of complex geology the amount of diffracted energy will increase relative the specular reflections. However, in many cases these diffractions will be weaker in amplitude because of being distributed over a large range of scattering angles. The more complex geology the more scattered energy is to be expected. Thus, if proper velocity models and images should be obtained in areas with high heterogeneity, such diffractions should be properly utilized.

Honouring heterogeneity by use of CRS

Primarily designed as reflection enhancement technique, the standard use of CRS is bound, in many cases, to attenuate the diffracted wave contributions present in the seismic data. However, a modified version can be constructed that better approximates diffractions than reflections. Successful use of the diffraction-modified moveouts for a number of purposes has been already demonstrated in the literature (see f.ex. Asgedom et al., 2012). Enhancement of reflections and diffractions based on CRS has been mostly carried out as two separate processes with two independent outputs. Faccipieri et al. (2013) were the first to propose to combine the two enhanced stacks to make further use of the full potential of the CRS technique. The idea is that such a combination will ensure a stack with enhanced signal-to-noise ratio and also with the finer details of the complex geology better preserved due to the diffractions.

In this previous work, a rather naive approach was followed by adding the two enhanced sections together without any scaling. The study presented here can be regarded as a further refinement. The idea is to introduce a simple attribute that can describe the degree of heterogeneity associated with the various seismic responses recorded. We define this attribute as:

$$\chi = \frac{a_{dif,RMS}}{a_{dif,RMS} + a_{ref,RMS}} \tag{1}$$

i.e. the relative ratio between the RMS-amplitudes of respectively the diffracted-enhanced and the combined reflection-enhanced plus diffraction-enhanced events computed at every data sample point after proper thresholding of the amplitudes to minimize the contribution from noisy areas. In case both amplitudes are set to zero after thresholding, the attribute is set to zero as well. By using this attribute as a weight, a combined seismic section can be constructed according to

$$ST_{com} = \chi \cdot ST_{dif} + (1-\chi) \cdot ST_{ref} \tag{2}$$

with ST_{dif} and ST_{ref} representing respectively the CRS diffraction-enhanced stack and the CRS reflection-enhanced (conventional) stack.

Field data example

In order to demonstrate the basics of the proposed approach, a selected part of a seismic line from the Jequitinhonha Basin offshore Brazil was considered. Figure 1 show the heterogeneity attribute calculated for this section. Several areas of heterogeneity are highlighted by this attribute, which correlate well with zones of complex geology. Next, we selected one target zone of the seismic line where the heterogeneity attribute is overall fairly high (cf. rectangular box in Figure 1). The left image in Figure 2 represents the conventional CRS stack computed within this target area. Correspondingly, the right image in Figure 2 shows the combined CRS stack computed employing Eq.(2). Direct comparison shows that the attribute-weighted CRS stack gives an improved representation of the zones of complex geology with the corresponding diffractions now being well recovered.

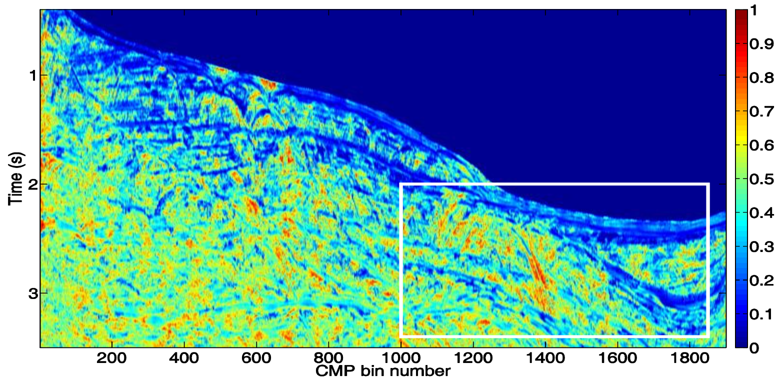

Figure 1 *Heterogeneity attribute computed for selected seismic line.*

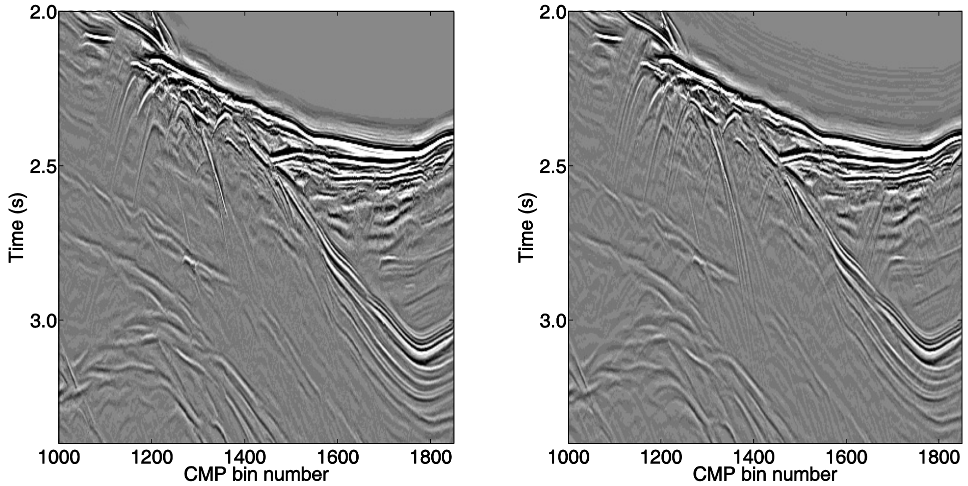

Figure 2 *CRS-stack (left) and combined CRS-stack (right) from target area in Fig.1.*

Concluding remarks

Based on the concept of CRS, an attribute representing heterogeneity has been introduced. The attribute itself can be employed in image analysis to characterize the seismic texture and with applications within image segmentation. It can be regarded as a more physical attribute than f.ex. the chaos attribute frequently employed in seismic interpretation. We also propose to use this attribute as a weight function when forming a combined CRS section based on both diffraction- and reflection-enhanced events. The work presented here discusses only the post-stack case. Future work will include the application of pre-stack type CRS with constant-offset reference ray. Within such a formulation, improved CMP-gathers can be formed which can lead to more accurate velocity information. Constant-offset migration of CRS-combined data can also lead to improved images directly (without going via the stacked section).

References

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