ISBN 90-73781-03-5

EUROPEAN ASSOCIATION OF EXPLORATION GEOPHYSICICISTS

53rd Meeting and Technical Exhibition
Florence, Italy
26 May - 30 May 1991

Technical Programme and
Abstracts of Papers
(Oral and Poster Presentations)

C030 EVALUATION OF THE AMBIGUITIES OF SEISMIC INVERSION

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The problem of acoustic and elastic inversion has been studied by several authors; however, there is still the need to understand completely the ambiguities of the inversion, i.e. to determine the reliability of the solution. The wavefield obtained insonifying the medium that results from the inversion will match the data, but there is no guarantee that the solution proposed is the real one. Besides, another interesting problem, not yet completely solved, is the determination of the resolution of velocity analyses, in presence of an unknown AVO.

Aim of this paper is a statistical analysis of these problems. We first derive the covariance matrix of the data corresponding to a time window of a Common Midpoint Gather in a layered medium, either in the time space domain or in transformed domains.

Each event is characterized by a residual (not completely corrected yet) NMO, as usual, but also by an AVO behavior, a priori unknown deterministically but characterized by a known statistical distribution.

In this way we can model the a priori information that we have relative to the data in this window. We can suppose to have, for instance, an uniform distribution of residual Normal Moveouts, and a uniform distribution of the parameter that determines the parabolic behaviour of the AVO. From the covariance matrix that expresses this a priori information, we measure the number N of degrees of freedom (the number of its non negligible eigenvalues).

The eigenvectors of the matrix relative to these eigenvalues span the data space. They are then expanded on a nonorthogonal basis built with $K \leq N$ vectors that correspond each to events characterized by a residual NMO and an AVO or by a residual NMO only.

Thus, the minimal number is found of the geophysically plausible events that combined together could reproduce the data.

Analytically, calling $\mathbf{R}$ the covariance matrix and $\mathbf{x_k}$ a vector corresponding to the k-th of the K events that we wish to use to represent the data space, we determine the matrix $\mathbf{P}$ corresponding to the projection onto the space spanned by the $\mathbf{x_k}$'s. In order to take into account the effects of a limited signal to noise ratio, we limit to 30 dB the spread of the eigenvalues of the matrix obtained from the K vectors $\mathbf{x_k}$ that correspond to the eigenvectors used for the matrix $\mathbf{P}$. Then, we evaluate the rms residual ϵ^2 obtained representing all possible events with a linear combination of the vectors $\mathbf{x_k}$.

This residual is given by the equation:

$$\epsilon^2 = Tr(\mathrm{I} - \mathrm{P})\mathrm{R}(\mathrm{I} - \mathrm{P}) \tag{1}$$

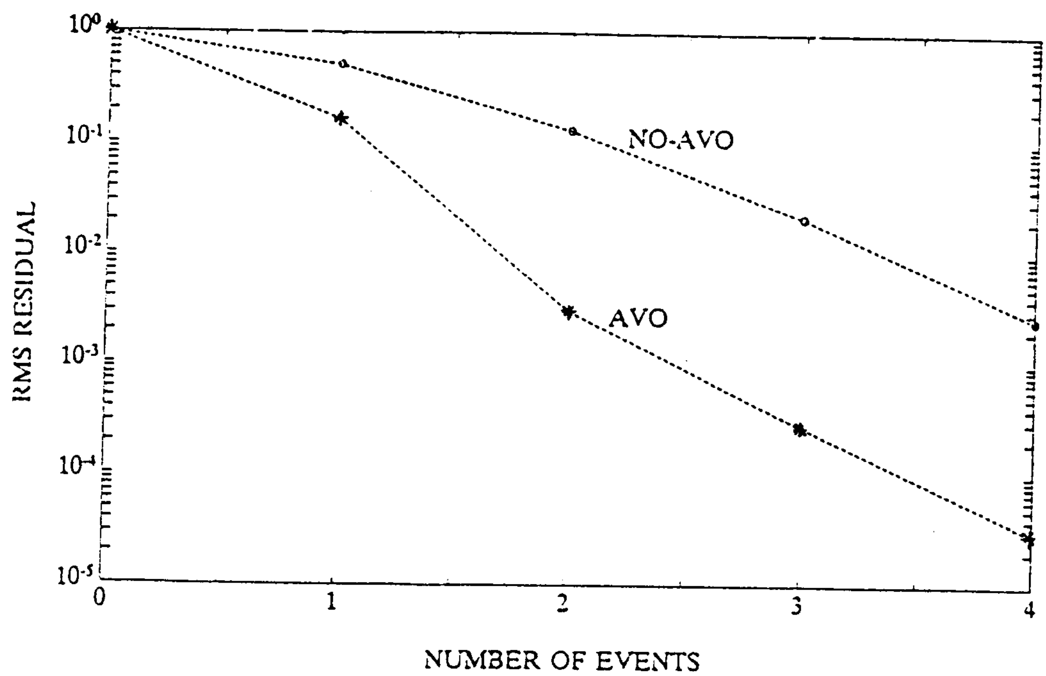
Finally, an optimization stage determines the RNMO's of the events $\mathbf{x}_k$, so that the rms residual is minimized. Thus, the optimum sampling in the velocity space is found, for events with AVO.

As an example, we show in the figure the residual as a function of the number of events with AVO that would span a data space correspondent to a distribution of velocities and AVO. In the same figure we see also the number of events without AVO that would span the same space. It can be seen that any distribution of events pertaining to the data set characterized by R could be described as well either with 2 events with AVO or with 4 events without AVO. Obviously, the descriptions would correspond to different media but no inversion technique could differentiate them without further information, since in both cases the residuals would be small enough.

The paper will discuss some possible ways to identify the impact of this a priori information in conditioning the ambiguities thus found.

Acknowledgments

I wish to express my gratitude to Prof. F.Rocca for many helpful advices throughout the development of this work. This work has been partially funded by AGIP SpA (Italy) within the framework of the Project Geoscience sponsored by the CEC, DG XII, Contract JOUF 0037.



RMS Residual as a function of the number of events representing the data set. Events with AVO (*) yield the residual with respect to the NO AVO case (o).