O3-2

SEISMIC EXPLORATION: YESTERDAY, TODAY, TOMORROW

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This paper represents the history of development of principles on which the modern seismic is based.The main principle of seismic development was and is an extension of the recorded data dimensionality. The following below table reflected the process:

Table 1

Survey index	seismic record arguments	data dimensionality
1D	T	1D
2D	Lx, t	2D
3D	Lx, Ly, t	3D
4D	Lx, Ly, t, τ	4D
3D/3C	Lx, Ly, t, α_r, φ_r	5D
4D/3C	Lx, Ly, t, τ, α_r, φ_r	6D
3D/9C	Lx, Ly, t,α_s, φ_s, α_r, φ_r	7D
4D/9C	Lx, Ly, t, τ, α_s, φ_s, α_r, α_r	8D

Where: t - time, Lx – offset on õ, Ly – offset on y, τ - date of seismic survey, α_r – azimuth of a component recorded at a receiver point, φ_r – bearing of a component recorded at a receiver point, α_s – direction azimuth at a shot point , φ_s – direction bearing at a shot point.

It is assumed herewith that all the technical and theoretical capabilities of the seismic including number of used attributes for acquired data and development of theoretical base of seismic are going from data dimensionality extension.

Table 2

Periods of Seismic Development	Seismic Method Results	Seismic Field Image Types	Dimen-sions	Oil Industry Tasks	Economical Efficiency Sources
First Period: 1920 - 1960	Thick-Layered Velocity Model	First	1D	Prospecting	Survey, Refraction, Reflection+Drilling
Second Period: from 1960 to present	Thick-Layered Velocity Model, Seismic Image of Finely-Layered Medium	First, Second	2D(CDP) 3D	Prospecting, Exploration	Seismic Survey + Drilling
Third Period: Current to future	Thick-Layered Velocity Model, Seismic Image of Finely-Layered Medium Seismic Description of Reservoirs (Seismography)	First, Second, Third	4D 3D/3C=5D 4D/3C=6D 3D/9C=7D 4D/9C=8D . . .	Prospecting, Exploration, Production	Seismic Survey + Drilling + Production

The history of development of seismic theoretical principles may be subdivided into three stages:

1D seismic surveys of the first period may be characterized as seismic operations when information about geological section is based on seismic inversion. Seismic inversion has been accomplished using the radial image of seismic field represented by the first type in the table 2. Thick-layered velocity model was a result of such surveys.

During the second period of seismic development connected with transfer to the common midpoint method (CMP) (see table 1), almost all the information about geological section was taken from the seismic image. This image has been formed via automatic tracing of coherent lineups with stacking of 2D and 3D data on CDP (pre-stack migration) or CIP – stack on common image point (post-stack migration). Thus, wave image of seismic field (second – in the table 2) is with migration for all the events. A finely-layered geological medium image was a result of tracing of coherent lineups.

The third period is characterized by the sharply increased size of recorded data (see table 1). Besides, there is a transfer from structural solutions to solutions by seismography description (seismography – new author's term) which means more detailed description of geological medium on morphological specifications of seismic records as follows: identification of seismic facies, small tectonic faults, research of jointing, porosity, interpolation on acoustic logging data. Analytical image of the seismic field is not used. A solution is reached via determination of heuristic connections between geologic and logging data with neuronal nets (third type of seismic field image – table 2).
It`s quite difficult to evaluate accuracy of dynamic attributes (amplitude, frequency) of seismic image. However, from the geological point of view, the information of finely-layered seismic image more reliable than results of seismic inversion. Seismography solutions have much better geological information (description, monitoring of reservoirs through the form of seismic record), but physical model of medium i.e. functional connection between medium parameters and seismic field is not used. Therefore, accuracy of any obtained results cannot be estimated.

The figure 1 shows correlation between accuracy of determination (or error) and geological value of information for tasks solved with use of various attributes at the different stages of seismic development. This correlation corresponds to the complementarity principle for seismic data processing solutions (Nepomnjashchikh et.al, 1997). In practice such a theoretical correlation is reflected by correlation between value and economical efficiency of seismic at the different stages of its development (Figure 2). Thus, use of more informative attributes defined with less accuracy enables to get results that are more important for practice. Further increase of seismic efficiency may be expected via further development of its value with growth of dimensionality (more than 8D) considering deformation and rotation recorded.

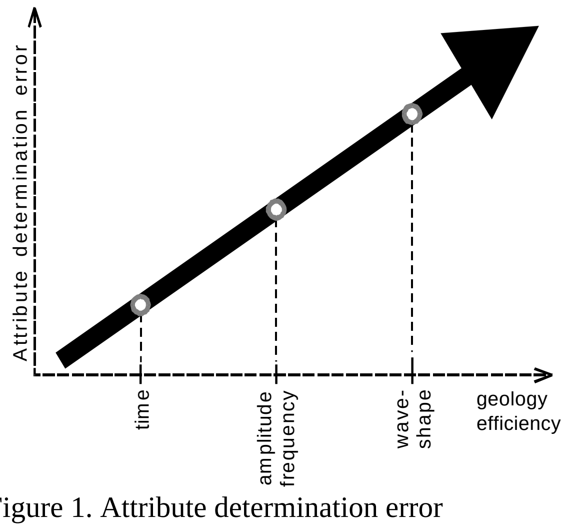

Figure 1. Attribute determination error and geology efficiency

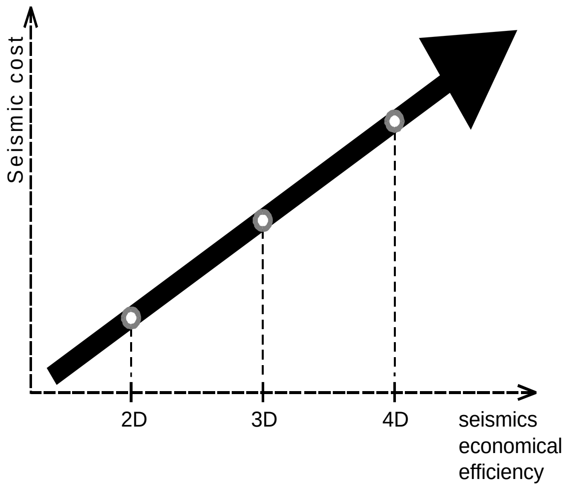

Figure 2. Seismic cost and seismic economical efficiency

Reference

Nepomnjashchikh I.A., Sydykov K.J., Bayandin A.N., 1997, Main Principle of Seismic Data Processing and Bohr's Complementarity Principle. International Geophysical Conference & Exposition, Istanbul, July 7-10, 1997, p. 24.