content. Two case histories are commented on; in a third one, spurious effects due to well casings are shown.

It is obvious that neither the depth, nor the lateral extent, of hydrocarbon deposits can be inferred from the observed Transiel, induced polarisation anomalies. However, the effectiveness of the method to select the seismic prospects which correspond to hydrocarbon accumulations can be evaluated by statistical analysis of the results of all Transiel surveys carried out over areas drilled before or afterwards. It is clear that the degree of correlation between Transiel anomalies and oil and gas occurrences may vary depending on the way the parameters of evaluation are taken into account. In any case, a high degree of correlation is found (50 to 85%).

Preparation of geophysical data for interpretation

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Introduction

Geophysical interpretation is being based on three-dimensional (3-D) analysis these days, as more interpretation tools become available. However, the interpreter is often restricted in his interpretation because of: (a) a lack of a complete geophysical signal; (b) the style of data presentation to work with; (c) processing which may reduce rather than enhance the signal quality; (d) a lack of time to adequately develop and confirm 3-D models.

The geophysical signal, irrespective of technique, is a signal which contains a broad spectrum of frequencies. To obtain a good 3-D interpretation, the complete signal needs to be available, initially to present the interpreter with a complete and accurate presentation; then to allow the interpreter to decide which styles of presentation are required; to decide if parts of the signal need to be enhanced or subdued; and to enhance different parts of the spectrum if required.

Three-dimensional interpretation is generally performed on gridded data because:

(1) The grid is uniformly spread across the area of interest irrespective of the original data set.

(2) Data from different techniques can be more readily compared or combined when they have a common geographic base.

(3) The spatial distribution and areal extent of anomalies can be more readily defined.

(4) Grid operations, including fast Fourier transform techniques, are faster by an order of magnitude than operations on original data.

(5) Map presentation from gridded data is generally an ideal form of presentation.

Presentation

Can a contour map adequately present the broad spectrum of a geophysical signal?

A contour map is merely the presentation vehicle of a grid. Thus the question is better phrased 'Can a grid adequately represent a broad band geophysical signal, especially the higher frequencies?' A grid can easily represent the same spectrum present in the signal if the mesh size used is less than or equal to the sample interval. However, because the geophysical data is usually irregularly spaced there has to be a compromise. The compromise takes a different course depending on the type of gridding routine used: random gridding for irregularly spaced data, or, bi-cubic spline techniques for data in parallel or sub-parallel lines.

The random gridding technique uses a modified growth method to generate mesh values, with both interpolation and extrapolation. High frequency anomalies tend not to be joined at all unless they are within two wavelengths of the next anomaly. The result is the familiar egg pattern.

The bi-cubic spline technique will carry higher frequencies between lines, provided the lines are less than three wavelengths apart and the anomaly trend is almost normal to line direction.

A technique of auto-correlation, introduced by Exploration Computer Services (ECS), allows for high frequency trends to be continuous when oblique to the line direction. The auto-correlation technique does not force trends into a map, but rather searches, within limits, for anomalies on adjacent lines of equivalent wavelength and amplitude. If the anomalies are matched then the trend is created. No other trends influence the formation of the trend, with the exception of a trend connecting stronger anomalies and passing through the same zone. This refinement ensures that there is a continuous anomaly which the interpreter can use for 3-D interpretation, rather than a series of discontinuous anomalies.

Compromises required for gridding are: (a) an almost square mesh to prevent introduction of distortions; (b) for broad spaced surveys, not more than 13 mesh points between lines. In the example of regional aeromagnetic surveys, this means reducing the mesh to sample ratio from 1:1 to 1:3.

Contour interval

It appears from published maps that the minimum contour interval used relates to mesh size rather than the type of signal to be presented, i.e. for large mesh sizes, small contour intervals are not used. This practice not only eliminates medium and high frequency anomalies, but also reduces the definition and resolution of all but the high amplitude anomalies on a map.

The minimum contour interval relates directly to the accuracy at which the data is recorded. Thus two fundamental steps will ensure that the interpreter has a grid, and hence contour maps, which accurately reflect the geophysical signal: (1) choose a mesh size as small as the data distribution will allow, but consistent with data spacing (2) choose a minimum contour interval consistent with the accuracy of the data.

Processing

Eighty percent of processing is routine and does not require manual interference at any stage. Manual input is required for three types of noise: (a) one point (spikes); (b) residual misclosure noise; (c) large noise envelopes on the signal.

The old style approach was to filter the signal until an acceptable product was achieved, at the expense of high and even moderate frequencies in the signal. The current approach is to remove noise spikes individually and correct the cause of misclosures, rather than mask them by filtering. To reduce abnormal noise envelopes, a non-linear filter with both amplitude and wavelength cut-offs is used. These filters reduce the noise without affecting a signal of the same frequency.

Speed of operations is also an important consideration. Thus data is stored and processed in data base systems utilising random access files. These data bases can have restricted access for processing to ensure the integrity of the stored data.

Interpretation

The interpreter can improve the confidence level of interpretation by employing multiple techniques or by multiple presentation of a single technique. For example, in the latter case, the use of the fast Fourier transform technique on gridded data sets can provide: spectral plots; low, high or band pass filtered data; derivative maps; upward and downward continuations; reduction to pole.

These maps can all be created on today's minicomputers and even on some microcomputers. Thus where the data warrants the effort, these maps can be available for the interpreter or created by him.

The eventual aim of the interpreter is a geological interpretation. Structural interpretation is a necessary element, and features such as trends and faults can also be added to relevant data sets during the gridding process to enhance the presentation.

Conclusions

Contour maps can be a vital feature of an interpreter's array of tools if the gridded data set is created to represent the entire spectrum of the geophysical signal. Two important parameters will ensure that the gridded data reflects the full spectrum: (1) as small a mesh size, consistent with data spacing, that data distribution will allow; and (2) a minimum contour interval consistent with the accuracy of the data.

A correct grid will then allow the interpreter to utilise other techniques, such as fast Fourier transform operations, to provide other perspective views of the data set.

First break refraction methods to calculate statics

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The methods which calculate weathering statics from first break refraction data often involve the determination of the intercept time T_i and an estimate of the velocity of the consolidated formation V_1, with the weathering velocity obtained from an uphole or Low Velocity Layer (LVL) survey. It is erroneous to extract the intercept time T_i on the x-t graph for determination of the delay time T_d (from $T_d = 1/2\ T_i$), or to estimate the consolidated formation velocity V_1 from the gradient of the line of best fit through the x, t points, on the basis of refraction first breaks obtained from individual seismic shot records. However, the iterative method minimises the error in estimation of the intercept time T_1 for the calculation of weathering statics, and obtains the consolidated formation velocity as a by-product, which is then used to compute the elevation statics.

The determination of weathering statics using the redundant refraction data from reflection seismic records has the inherent advantage of deriving the statics and applying the corrections on the same data set, and therefore under identical physical conditions (cf. statics calculated from an LVL survey and applied on seismic data). In a typical 12-fold or 24-fold coverage survey using a 96 trace split-spread configuration with 50-70 m station interval, the relevant refraction first breaks achieve at least fourfold redundancy at each station. This statistical advantage is the primary basis on which the iterative process can provide effective statics control.

Description of the iterative process

Only those first break arrivals which pertain to refraction energy from beneath the weathered layer are included for computation in the iterative process. The first break picks, within a defined offset interval of typically from 200 to 800 m, are ordered into common shot and common receiver sets, and a preliminary refraction velocity V_1 is determined by a linear regression algorithm.

In each iteration, the V_1 values from each station are smoothed with a broad triangular filter of 100-150 points, i.e. approximately 1-1.5 times the cable spread length. Each smoothed V_1 is then fitted through the corresponding mean point $(\bar{x},\bar{t})$ of the ordered first break picks to obtain the intercept time T_i at $x = 0$. Half the intercept time, i.e. the delay time T_d, is assigned to the respective shot or receiver station; the total time delay from shot and receiver is then computed and subtracted from each first break pick corresponding to that relevant shot and receiver combination.

The entire procedure is repeated for three iterations, updating V_1 and then obtaining the intercept time T_i with each iteration. The standard deviation of the linear regression fit of the picks will decrease as the estimation improves with each iteration. After the final corrections the intercept time for the line of best fit should be zero.

At the end of the last iteration, the consolidated formation velocity V_1 is accepted for subsequent calculation. The delay time T_d at each station is obtained by summing the intermediate values of each iteration.

Finally, the datum static at each station is calculated from the usual formula:

$T_g = T_e + T_w = -\dfrac{E}{V_1} - k\,T_d$, where E = elevation above datum, and $k = [(V_1 - V_0)/(V_1 + V_0)]^{½}$

The Gardner-Leclerc method of computing static corrections using a desk-top computer*

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Introduction

Since the introduction of surface and near-surface sources, there has been difficulty in obtaining information about the vertical velocity through the weathering, so accurate static corrections have been difficult to estimate.

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