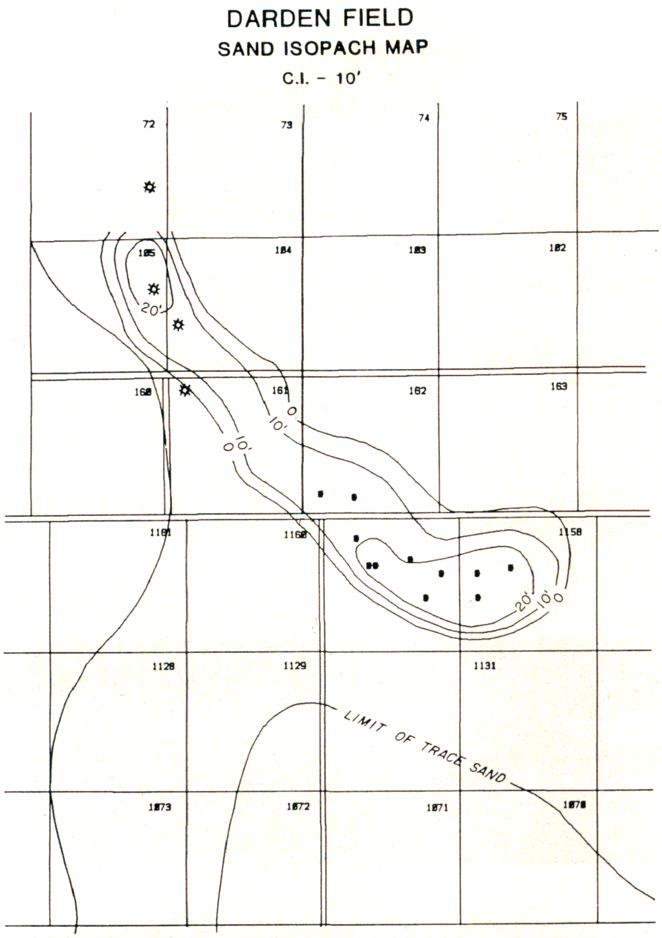

FIGURE 6
Sand Isopach Map, Darden Field.

An Integrated Approach to Interactive Seismic Interpretation

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Summary

The objective of seismic exploration is to image the earth's subsurface in order to improve the success rate of drilling wells. Since hydrocarbons are increasingly being found in subtle and complex traps, it is important to use all the information available for interpretation and to use it as accurately as possible. This implies combining all the surface seismic data with information from other sources, such as well logs and VSPs to provide an integrated interpretation. Moreover, this interpretation must usually be done within tight time constraints.

Interactive workstations organise and manipulate large quantities of data in a convenient and efficient manner, permitting either a faster interpretation, or more likely, a more detailed interpretation within a given time. The system described in this paper incorporates Landmark and Discovery workstations. It provides completely interactive structural interpretation, fault analysis, digitizing and final mapping. Well log, VSP processing and seismic attribute analysis may be performed on the workstations and the results incorporated in a detailed interpretation. Interactive modelling is also available. The complete system may be used for 2-D or 3-D datasets.

Integrated seismic interpretation

An integrated seismic interpretation is no longer an option, but a necessity. The giant hydrocarbon fields have long since been delineated and our exploration objectives are now directed towards the more subtle accumulations. It has become mandatory that a geophysical prospect be supported geologically and vice versa. Source rock, maturation and depositional environment all have to be established along with the correct group spacing, sampling interval and migration velocity in order to generate a prospect that is both geophysically and geologically viable. Information from both disciplines must first be researched, organized and integrated.

Geological information forms the basis for most exploration prospects. Source rock potential, reservoir sands and tectonic environment are factors which inevitably help to determine the nature and type of hydrocarbon traps that the exploration program should attempt to delineate (Fig. 1). Synthesis of this type of information into the seismic interpretation can, however, often prove to be difficult and time consuming. In many cases well log surveys provide the necessary geological information that is required to determine source rock potential, primary and secondary objectives and maturation properties.

The generation of synthetic seismograms from the sonic and density well logs has proved to be a useful interpretation tool for determining time depth correlations and seismic character responses. The introduction of vertical seismic profiling methods has enabled us to generate synthetic seismic sections that should provide a more accurate reproduction of the seismic data. Attribute analysis has enabled us to analyse the seismic trace in terms of frequency, phase and reflection strength. Detailed stratigraphic analysis can be directly correlated with seismic information through acoustic impedance sections. Seismic, attribute and acoustic impedance sections can utilize colour to enhance the visual display, thus allowing subtle geological variations to be identified (Fig. 2).

Interpretation provides a geological model of the subsurface. Integration of data from various sources allows the interpreter to test the geological model for consistency. For example, an initial structural hypothesis can be combined with the interval velocities from well logs to provide a model for ray tracing, using a modelling package. The results produced may then be compared to the seismic. Similarly, 3-D map migration can be performed interactively to test the areal consistency of a 2-D interpretation.

Interactive Interpretation

Seismic interpretation has always been time consuming and the large volume of data and huge number of paper sections have presented severe organisational problems. When coupled with the problems associated with displays of data from different sources and vintages, these practical difficulties have often inhibited an integrated interpretation. All the data needs to be available in various display formats and accessible during any part of the interpretation. The recent development of interactive interpretation systems has removed many of these problems that have hindered interpretation

TYPE OF INFORMATION	FORMAT	METHOD OF INTEGRATION
Porosity, Permeability Lithology Source / Seal potential Density Velocity information Time - depth information	Well logs	Modelling, attribute analysis, direct well log - seismic comparison Generate synthetic seismogram
Regional geological data	Documentation, Well correlations	Input through geologic modelling
Seismic stratigraphic response	Vertical Seismic Profiles (VSP), Acoustic Impedance sections	Direct comparison with seismic data

FIGURE 1
Integrated geologic information.

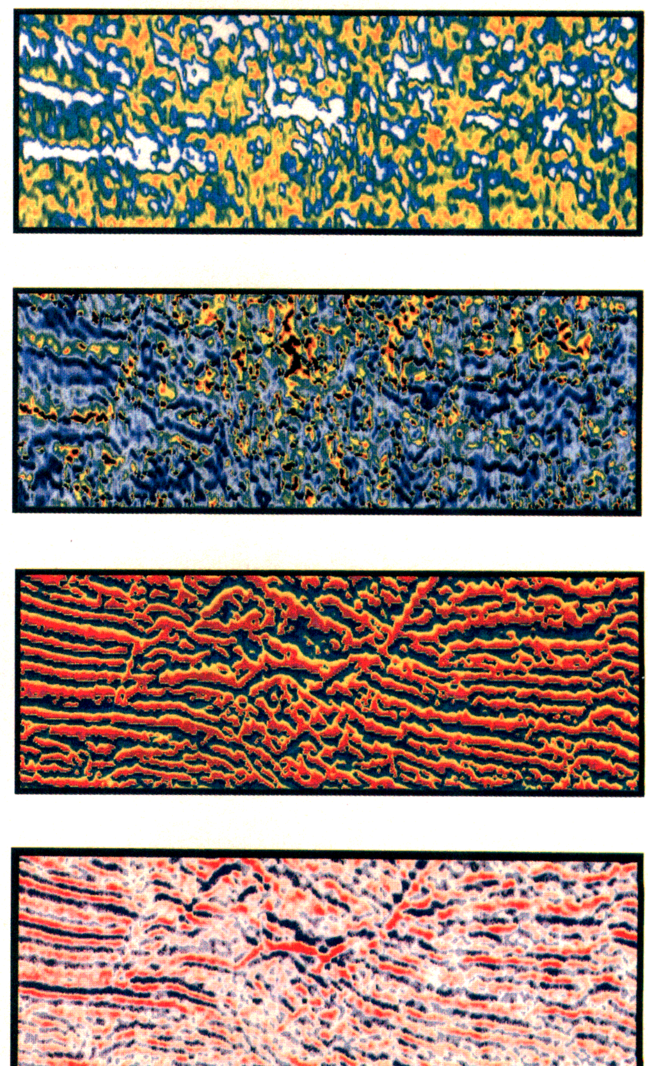

FIGURE 2
Colour enhanced seismic and attribute sections.

geophysicists. Interpretation, correlation and manipulation of both geological and geophysical data can be accomplished efficiently and quickly using the system described in this paper. A basic interactive interpretation flowchart (Fig. 3) allows all the geological and geophysical data to be reviewed throughout the interpretation.

Post-stack processing such as scaling and filtering may be performed on the system, allowing for example, 2-D seismic datasets of differing vintages to be viewed with the same display parameters. Data may be displayed as wiggle traces or it may be colour coded thus enhancing amplitude information (Fig. 4). Well logs and VSPs may be processed by the interpreter, so that surface seismic sections, synthetic seismograms and VSP information can be viewed simultaneously and at various scales and colours.

Seismic attribute and acoustic impedance sections may be generated so that interpretation using conventional seismic sections, seismic attributes and acoustic impedance sections is possible on the system. Digitizing and map generation are performed on the system as the interpretation is progressing.

Preliminary or final interpretation can be performed in much less time than it would normally take using conventional paper sections. This time saving then allows detailed hypothesis testing and revision of the interpretation. Geological and geophysical data are stored on magnetic disk with the interpretation and can be accessed during any stage of the interpretation for revisions or correlations. Software developments include fault analysis (Fig. 5) and horizon mapping. Geological theories and models can be generated and tested quickly and easily using all available data. The massive volume of geological and geophysical data required for a complete seismic interpretation can be integrated more efficiently and effectively and in a manner that affords the geophysicist the time to investigate the subtle details of an evaluation.

Data and interpretation models may be permanently stored on laser disk or tape and reloaded at a later date when further information, from for example, either new wells or new seismic, becomes available. The interpretation may then be updated with a minimum of effort.

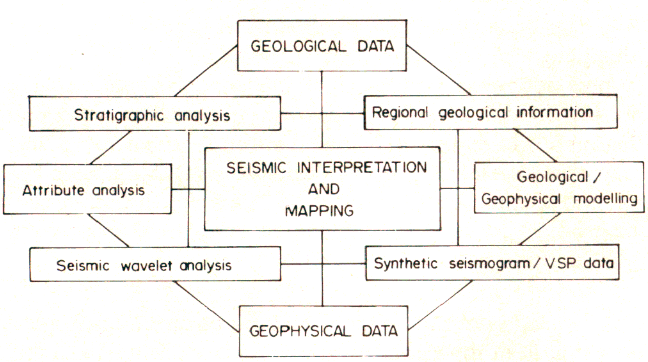

FIGURE 3
Interactive interpretation flowchart.

Conclusion

The amount of geological and geophysical information required for a complete seismic interpretation of a prospect area creates a volume of data that is difficult to analyse thoroughly by conventional means. Data transfer from seismic sections to contour maps and the subsequent revisions become time consuming and may lead to an inaccurate and generalised appraisal. The interactive system described in this paper handles manipulation of large data volumes efficiently. Data transfer and time structure mapping are performed in unison with the seismic interpretation allowing additional time for detailed stratigraphic or fault pattern analysis.

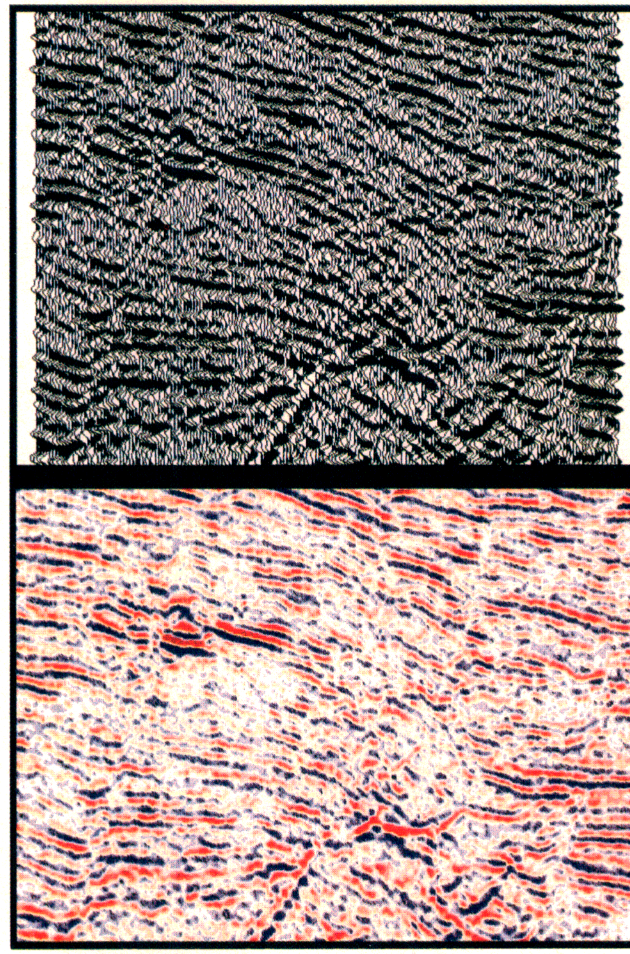

FIGURE 4
Comparison of wiggle and colour enhanced seismic section.

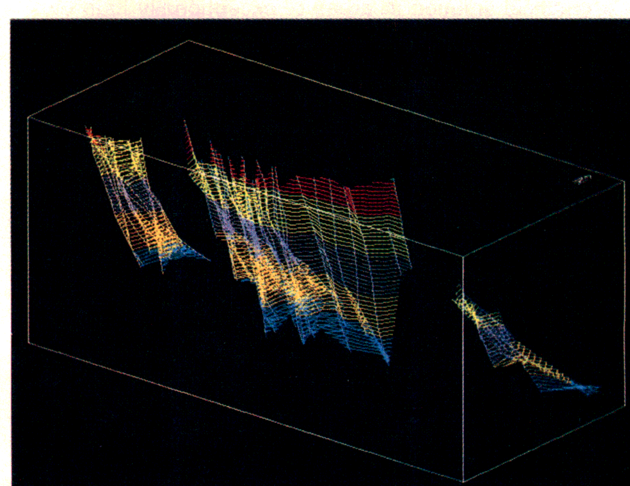

FIGURE 5
Interactive fault analysis.