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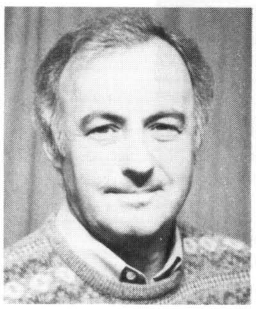

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Analysis and removal of spatial noise in 3D seismic surveys

G. Williams and A. Arnold

Current processing of 3D seismic surveys involves a mixture of 3D techniques and conventional 2D techniques. For example, velocity analysis, residual statics, stacking and migration use 3D methods but it is common practice to use conventional 2D programs for most other aspects of processing. Whilst this is satisfactory in itself, it is possible to use the three dimensional nature of the data to a greater extent than it is presently customary. This paper describes the improvements in data quality which can be obtained by one such technique. The process analyses the spatial properties of the data in order to discriminate between signal and noise and hence to suppress noise that cannot be removed by conventional 2D means.

It is standard practice in 2D surveys to perform frequency filtering to remove temporally random noise, FK filtering to remove coherent noise and to use various coherency enhancement techniques to remove spatially random noise. These techniques rely on being able to separate out the signal and noise components by one means or another. In a 3D survey, we have the further opportunity to separate signal and noise according to their spatial properties and hence to attenuate noise which cannot be separated out and removed in any 2D technique. Thus, for example, it is possible to suppress noise in the data which lies within the signal frequency bandwidth but which has spatial properties which differ from those of the signal.

A key feature of this technique is the analysis of what constitutes noise and what is signal. Careful analysis implies that there is no more risk of removing signal as well as noise than there is when performing conventional processing such as frequency filtering. In general, no particular model for the signal is used and each survey is analysed separately. However, it is possible to observe that geological structures usually have a considerable spatial extent, when viewed in a 3D manner. This is particularly true for stacked data when even a point scatterer has diffraction energy associated with it. Therefore, seismic

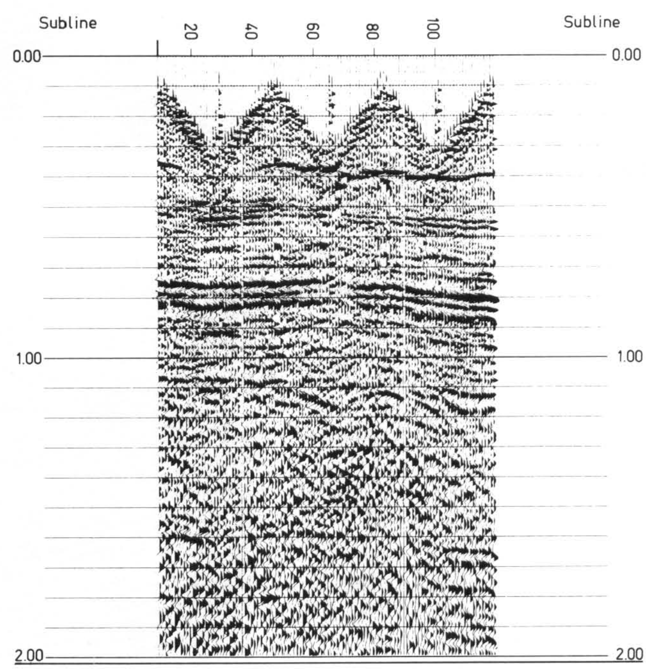


Fig 1 Crossline of initial stack showing poor continuity and resolution.

energy with high wavenumbers in both the x and y directions can usually be considered to be noise and removed from the data. The geological structure contained in the survey determines the exact portion of the kx–ky spectrum which can be removed. Reflections, fault planes and diffraction energy are not harmed by this technique and the spatial resolution of the signal is unchanged.

Figures 1 and 2 show a crossline from a 3D land survey before and after the removal of spatial noise. The dataset is particularly noisy and the noise cannot be attenuated with conventional processing such as frequency bandpass filtering. The major cause of the noise is a low fold which is also highly variable. Note that the curved diffraction energy at 1150 ms is enhanced. This will lead to a better migration and hence an improved final resolution. It should be noted that the section in Fig. 2 does not have a mixed appearance as would result from using a crude 2D runmix operator. Also, a runmix operation would tend to break up dipping events and diffraction energy.

Some results of using the technique on a high resolution (1 ms) land survey are shown in Figs 3 and 4. This dataset differs from that shown in the previous figures in that it contains steeply dipping events. The signal to noise has been improved without attenuating or breaking up the dipping events between 200 and 300 ms. The step-like nature of the data at 350 ms is already present in the data in Fig. 3. The data quality

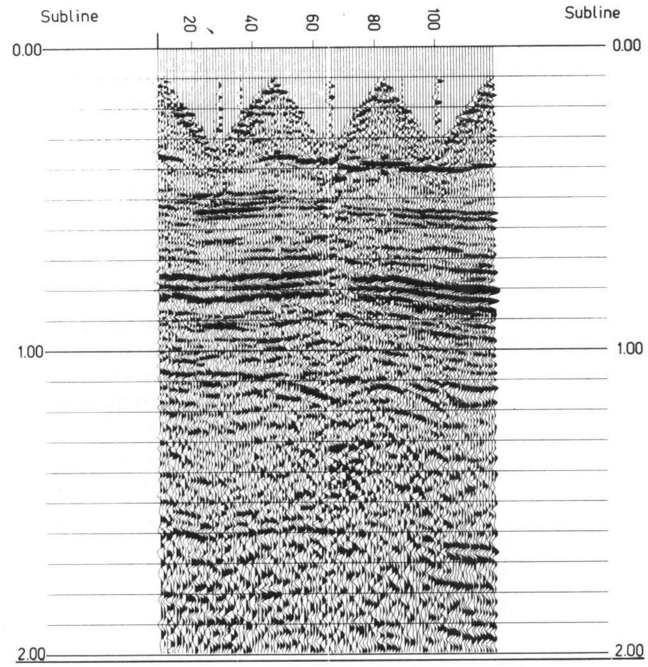


Fig 2 Crossline after analysis and removal of spatial noise. Note improved signal to noise, greater clarity of reflection and diffraction energy, plus increased fault resolution.

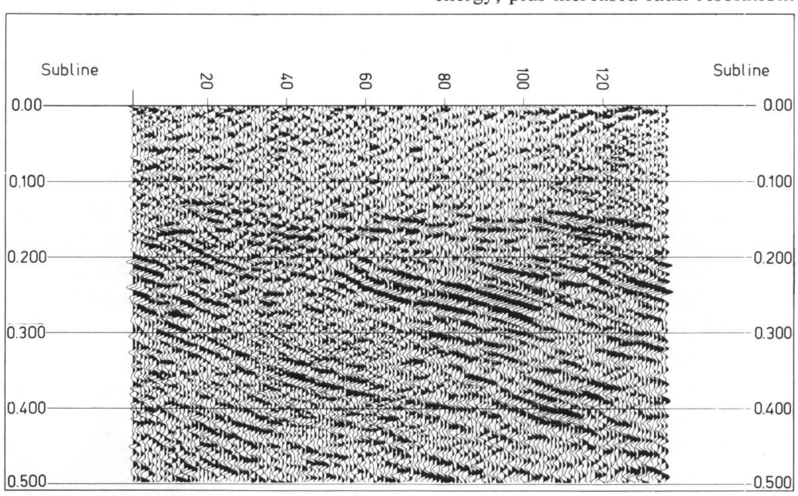


Fig 3 Crossline before spatial enhancement.

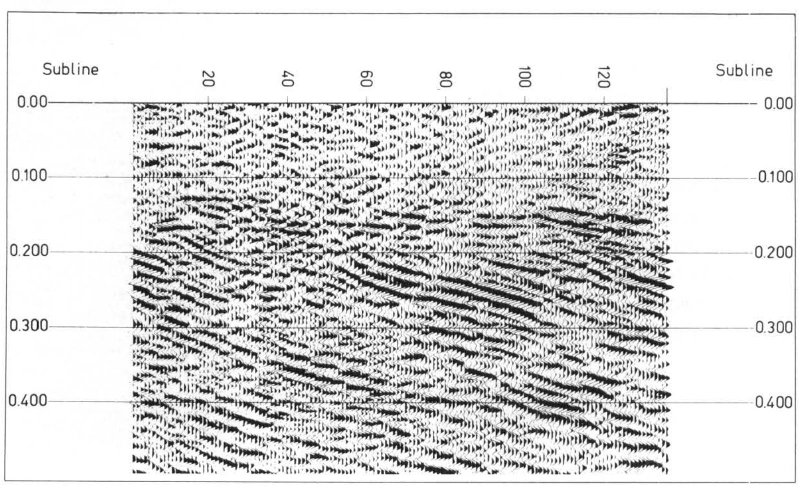


Fig 4 Crossline after spatial enhancement.

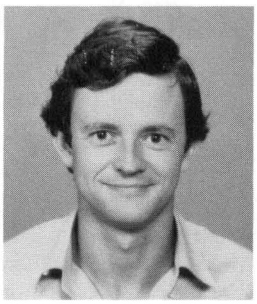
for this survey is better than that shown in Figs 1 and 2 and the improvements are consequently less dramatic. Nevertheless, there are significant improvements.

The process can be applied in either a time variant or time invariant manner. In both of the above surveys, the process was applied in a time invariant manner. In general, it is to be expected that a time variant application should be used for two main reasons. First, the spatial resolution of the data decreases with increasing two way time. Second, the geological structures will be time variant. Moreover, it may be economically desirable to use the technique only over a zone of interest or only on deeper data, where the signal to noise is often worst.

The process may be applied at any stage in the processing sequence after stack. Figures 1 and 2 are an example of applying it before migration, whereas the data in Figs 3 and 4 were migrated first. In view of the fact that migration operators act on noise as well as signal, the technique should usually be used pre-migration, i.e. as a means of better preparing the data for migration in order to obtain the optimum migration results.

Acknowledgments

The data in Figs 3 and 4 are courtesy of the National Coal Board of England.



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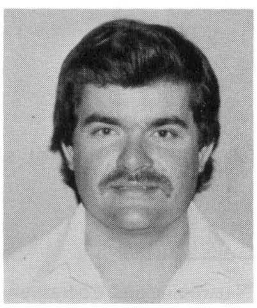

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Geophysical signature of gold and porphyry copper mineral deposits in the Lachlan Fold Belt, NSW

K. Tenison Woods and S. S. Webster

Introduction

Regional geophysical data of the Lachlan Fold Belt can be interpreted to supplement geological knowledge, especially as large areas within the Fold Belt are without outcrop. The data are:

(1) BMR aeromagnetic surveys (1960, 1961 and 1965) reprocessed by the Department of Mineral Resources (1983, 1984).

(2) Enhanced images and filtered enhanced images of the aeromagnetic data.

(3) BMR gravity surveys (11 km grid, 1959–67) and Department of Mineral Resources surveys (1984, 5.5 km grid, Forbes and Narromine sheets).

The extrapolated major geological structures and tectonic features reflected in the data of the study area (Forbes, Narromine and Cootamundra sheets, Fig. 1) are:

(a) Geology: (i) The Parkes Terrace. (ii) Ordovician sediments and granites. (iii) Volcanic units east of the Parkes Thrust Fault.

(b) Structure: (iv) The Parkes Thrust Fault system. (v) The Gilmore Suture. (vi) Transecting linear features.

Regional interpretation

THE PARKES TERRACE

This is recognized in the gravity data (Fig. 2) as a major, though discontinuous, ridge trending north–south, then swing-