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COMPUTER PROCESSING OF SEISMIC REFRACTION DATA

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In the generalised reciprocal method (GRM) of seismic refraction interpretation described by Palmer (1974, in prep.), the data processing and interpretation stages may be separated. The data processing stage is relatively simple but as it may involve handling considerable amounts of data, the use of a computer is desirable. In this paper some methods for the computer processing of seismic refraction data are discussed.

The data processing stage may be broken up into four main areas which involve:

1. Picking first arrival times
2. Making up hole and reciprocal time corrections
3. Calculation of time depth and velocity analysis terms
4. Calculation of a depth section from the interpreted time section.

A suite of Fortran programs have been developed to automatically process the seismic data in each of these stages. Field data is written onto magnetic tape using an S.I.E. RS49R seismic system and these tapes are then read, and the data processed and plotted using a PDP11/45 computer and Calcomp 563 and 745 plotters.

First Arrival Times

The first arrival time is usually defined by the first noticeable onset of seismic energy. Two complementary methods have been developed which pick this time very accurately. The methods are applied to individual traces and use the statistical properties of the noise prior to the shot instant to identify the noise after the shot. The seismic event is recognised as it has different statistical properties to the noise. Events may be picked even if their amplitudes are less than those of the noise. Such very early events can not be picked on a conventional seismogram and it has been found that the automatically picked arrival times are much more accurate than hand picked times.

Computer program SFA picks the seismic first arrivals which are plotted and stored in disc files. Up to 6% of the automatically picked times may be in error through crossfeed between the traces, geophones being disconnected, there being insufficient signal or through a failing in the automatic picking method. A program has been written for editing these bad picks.

Up Hole and Reciprocal Time Corrections

As in most interpretation methods, up hole corrections are made in the GRM. These can be simply made through using the time to an up hole geophone or by assigning a velocity to the surface layers.

The reciprocal time is the travel time between pairs of shots. In theory the two times between shot points should be equal but often this is not the case. The times may not be equal because of:

(1) The ground near the shot points being disturbed by previous shooting
(2) Delays in either the shooting system or in the detonator.
(3) Poorly picked arrival times
(4) Errors in the up hole corrections.

Ground factors such as anisotropy may also be a source of error.

Constant corrections are made to the times from each shot so that the reciprocal times agree in a least squares sense. The sum of the corrections is minimised and usually these corrections will be less than 2 milliseconds per shot. Both the up hole and reciprocal time corrections are made by program ADJUST.

The Velocity Analysis and Time Section

For nominated pairs of shots, computer program SEISSF (Hatherly, 1976) calculates velocity analysis terms and time depths using various XY spacings. Together with the travel time curves, these data represent all that is needed for the geophysicist to make an interpretation using the GRM. For convenience, these data are plotted at a useful scale beneath the travel time curves.

The Depth Section

For the conversion of time depths to depths an adaptation of the formula given by Dobrin (1976) is used. However, the depths calculated are not vertical depths but are instead the layer thickness measured perpendicular to the underlying refractor. For undulating or dipping refractors, the layer thickness is different from the vertical thickness and a migrated depth section should be constructed.

Computer program DSECTN (Hatherly, 1979) calculates and plots the depth section. It establishes arcs of radius equal to the layer thickness and the evelope of these arcs defines the refracting surface. The program uses the tangents between neighbouring arcs to give this envelope.

Often it is found that successive arcs do not intersect or give most unrealistic refractor surfaces. These unlikely arcs indicate the presence of errors in either the time depths or the seismic velocities of the layers. Usually the source of these errors is in the surface layer where the seismic velocity is low and often varies laterally. Reconsideration of the time section so as to give a well behaved depth section will improve the refraction interpretation.

Conclusion

With digital seismic data, automatic processing using the generalised reciprocal method can be achieved. Arrival times may be accurately picked and the problems associated with handling large amounts of data are minimised. Not only can the required interpretation be quickly made after the completion of a field survey, it will also be improved through the accuracy and thoroughness of the processing methods.

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HIGH RESOLUTION SEISMIC REFLECTION EXPERIMENTS IN REGIONS OF PRECAMBRIAN SEDIMENTS

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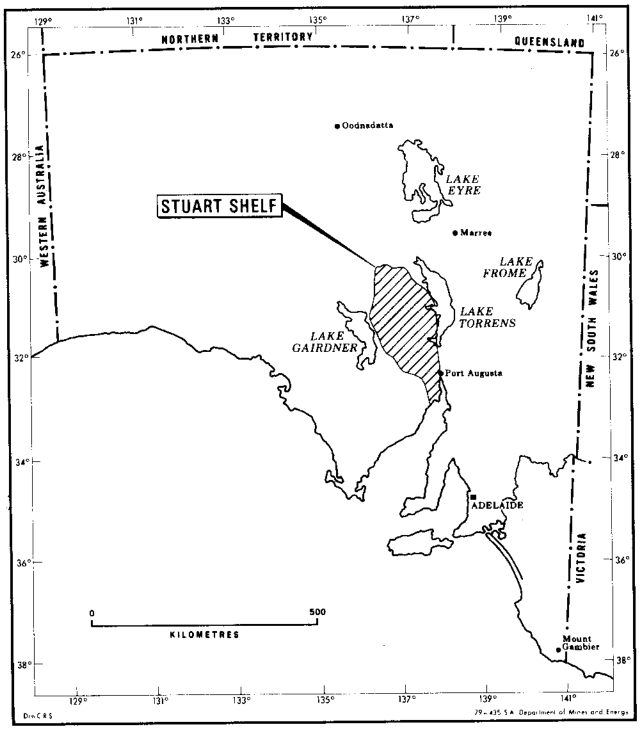
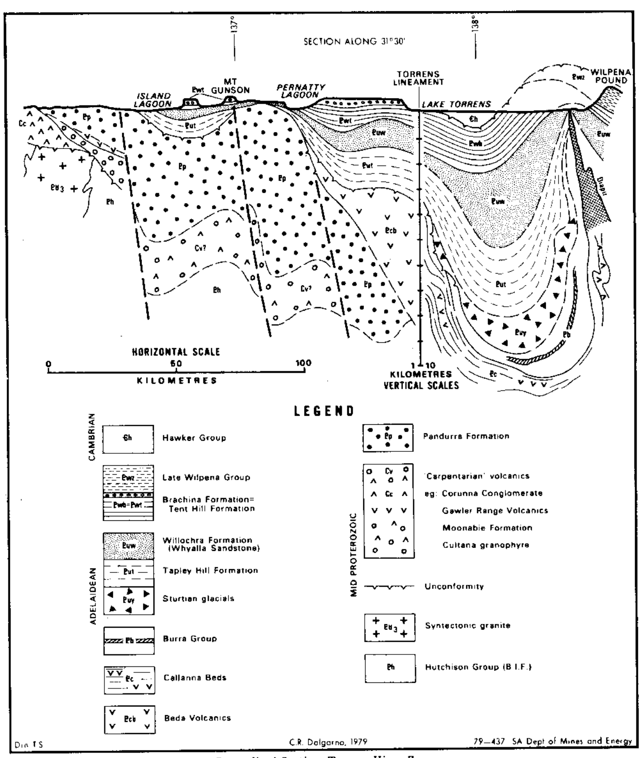
The thick sedimentary sequence that forms the Adelaide Geosyncline in South Australia accumulated in a subsiding trough east of the Gawler Craton, which is part of the Australian Precambrian shield. Between the mobile Torrens Hinge Zone on the western edge of this trough and the crystalline basement of the Gawler Craton, a gently dipping shelf facies was deposited over an irregular and gently undulating basement surface. This stable shelf zone is known as the Stuart Stable Shelf (see Fig. 1) and it has become an area of intensive exploration for base metals since the discovery of the Cattle Grid orebody at Mount Gunson in 1972 and the Olympic Dam copper-uranium orebody in 1975.

The Upper Proterozoic sedimentary sequence constituting the Stuart Shelf contains a wide range of lithologies, including sandstones, dolomitic shales, siltstones and quartzites, with extensive and thick volcanic flows near the base (see Fig. 2). In contrast to the intensive folding noted in the Adelaide Geosyncline, sediments in the Shelf have responded to earth movements by epeirogenic block faulting and gentle warping.

The Olympic Dam deposit was discovered by reconnaissance drilling of coincident magnetic and gravity highs and it has followed that most other exploratory drilling has been sited on such anomalies. Drilling to depths of up to 999 m in these hard Precambrian rocks is costly and it has become apparent that more direct control is needed. This has given





Generalised Section, Torrens Hinge Zone