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DATA PROCESSING REPORT

GLEN EDITH, WEST GLEN EDITH, AREYONGA AND HARAJICA SEISMIC SURVEYS

AMADEUS BASIN

NORTHERN TERRITORY

OCTOBER, 1984

FOR

PANCONTINENTAL PETROLEUM LIMITED,
9TH FLOOR, 50 MARGARET STREET,
SYDNEY, N.S.W., 2000.

BY

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GENERAL DISCUSSION

Detailing seismic surveys were carried out in the Glen Edith, West Glen Edith, Areyonga and Harajica areas of the Amadeus Basin, Northern Territory, for Pancontinental Petroleum Limited in 1983 and 1984. The areas form part of Oil Permits 175 and 178. The Location Map is shown as Plate 1.

The 2000% data were aquired by Geosource Party 6824 using MDS10-120 recording instruments. The geophone group interval was 20 metres and the source interval 60 metres. The recording spread was 120 trace symmetrical split wih 11 group gap, using 12 MD79-10Hz geophones per trace at 6 metre intervals. The data were recorded in SEGB format at 2 millisecond sample rate on 9 track digital tape at 1600 byte per inch density.

The energy source was four vibrators with 12 metre inline pad spacing. There were 12 sweeps per vibrator point with 4 metre move-up between sweeps. Sweep frequency was 12-90 Hz logarithmic. On Glen Edith line P83-GE48, 23 source points were recorded using 8 kg. of dynamite in 15 metre holes where the vibrators could not be used.

In addition to the above, refraction data were recorded using dynamite in 6 metre holes at a nominal interval of twenty-four stations for near-surface correction purposes.

Field tapes and support data were forwarded to Digital Exploration Limited (a Digicon Company) at their Brisbane processing centre.

The following data were received for processing :-

Glen Edith (including West Glen Edith)
Lines P83-GE44 to 55 inclusive

Harajica
Lines P83-HJ1 to 4 inclusive

Areyonga
Lines P83-A1, A3 and A4

The final products were seismic cross-section films in variable area, wiggle trace mode with horizontal scale of 10 traces per centimetre and vertical scale of 10 centimetres per second.

DATA PROCESSING GENERAL

A flow chart of the processing sequence is shown in Plate 2. This shows a conventional assembly of processing operations as performed on the subject data. Except for some proprietary programs, those used form part of DIGICON'S basic "DISCO" seismic processing system developed for use with the Digital Equipment Corporation's VAX 11/780 computer.

PARAMETER TESTING

Based on experience gained in processing data in this region from the 1981 and 1982 surveys, testing was aimed at extracting the maximum quality from the data whilst at the same time maintaining compatability between the projects.

(1) DECONVOLUTION

A suite of deconvolution before stack (DBS) tests was run on representative shot records of line P83-GE55. These tests compared spiking deconvolution, statistical wavelet deconvolution and various predictive deconvolutions of single and two gate designs. The predictive parameters examined included 8, 16, 20 and 24 millisecond gap lengths.

From these tests a single predictive deconvolution operator was selected utilizing a gap length of 24ms. and an operator length of 200 milliseconds designed over a window of 400 to 4000ms at the near offset and 800 to 4000ms at the far offset.

(2) DATUM STATICS

Various solutions of datum statics were tested due to the variable nature of the near-surface layers in the Amadeus Basin. Various offset ranges and weathering velocities from production Vibroseis records and dynamite refraction records from line P83-GE55 were tested. Both hand digitizing and machine picked first break routines were attempted. These first break times were input to Digicon's STATICSG program, a description of which follows in processing discussions. Also, for comparison, statics were hand computed using single and multilayer weathering models.

Of the nine examples forwarded, that using machine picked breaks with all offsets from the production records input to the STATICSG routine with variable weathering velocities was selected.

(3) POST STACK FILTER TESTS

Tests were made on the following lines representing the three areas, P83-GE54, P83-A1 and P83-HJ2. Two formats are employed, namely consecutive 10 Hz slices from 0 to 120 Hz and octave slices 7-14, 15-30, 20-40, 30-60, 40-80, 50-100 and 60-120 Hz. Both are displayed with and without AGC after filter to demonstrate the bandwidth occupied by various coherent events, their relative amplitudes within and between the filter slices and character variations which may be imposed in differing pass-band applications.

From the displays forwarded the following time variant final filters were advised.

a. Glen Edith and West Glen Edith

0.0-1.5 seconds	12-15 low cut	50-55 high cut
1.5-5.0 seconds	12-15 low cut	45-50 high cut

b. Harajica

0.0-2.3 seconds	12-15 low cut	55-60 high cut
2.3-5.0 seconds	12-15 low cut	45-50 high cut

c. Areyonga

0.0-1.8 seconds	12-15 low cut	55-65 high cut
1.8-5.0 seconds	12-15 low cut	45-55 high cut

EXTRA PROCESSING REQUIRED

(1) ADDITIONAL VELOCITY ANALYSIS

The basic processing sequence evolved for these data included two passes of resiual statics computation and application with a run of velocity analysis preceding each. Because of the complexity of the velocity patterns encountered over much of the Amadeus Basin further refinement of velocities after the second pass residual statics was requested for most lines.

The additional analyses were in the form of Constant Velocity Stacks, a description of which occurs in the following discussions on processing operations.

DATA PROCESSING OPERATIONS

1. DEMULTIPLEX AND CORRELATION

The multiplexed, uncorrelated field data are decoded, correlated and converted to an internal 9 track, trace sequential correlogram format for subsequent processing.

In addition 23 dynamite records were demultiplexed for shotpoints 250-316 on Glen Edith line P83-GE48, where the vibrator energy source could not be utilised. These records were dephased by application of a filter derived from manufacturer's phase response curves for the recording instruments.

2. TRUE AMPLITUDE RECOVERY

True amplitude recovery phase of seismic data processing includes the following steps :-

i. Removal of binary gain (non-linear) which is applied to the data during recording.

ii. Correction for amplitude loss due to spherical spreading of the wave-front as it is propagated downwards through the earth and reflected back to the surface. To correct for this each trace is multiplied by $V^2 T$, where V is the seismic wave velocity and T is the two-way record time.

3. EDIT

This option is used on some records to zero noisy or wild traces which would not make a useful contribution to the stack. Information from the displayed demultiplexed records, field monitor records and observers logs is combined to determine the editing table.

4. COMMON DEPTH POINT GATHER

The seismic traces along a line are gathered into data sets on the basis of common reflection point. The offsets, surface and sub-surface co-ordinates and shot sequence numbers are annotated in the trace headers for use in the subsequent processing.

5. DECONVOLUTION

Deconvolution is the process of designing and applying an inverse filter to remove the effects on the recorded data of the earths filtering characteristics.

The design parameters are usually determined for an area during the preliminary testing phase. As discussed previously a predictive (gapped) deconvolution filter was chosen because of the improvement it made in the poorer data areas.

6. DATUM STATICS COMPUTATION

The statics were computed using computer picked first breaks from the 120 trace production records. The first break information was input to DIGICON's STATICSG program, using offsets from 300 to 1300 metres.

The function of this program is to compute datum statics following standard refraction techniques. The input first-break picks may be hand picked, digitized or computer picked.

Line information is drawn from the data base and used with input elevation listings to fully define the profile. Details of shot and receiver offsets, instrument delay corrections, weathering velocities and the selected datum elevation are also provided, together with a table of uphole times for sub-surface energy sources.

Near surface velocities were calculated from the direct arrival times on the near four or five traces. The area is characterised by high contrasts in near surface velocities. Values generally were in the range 1000 to 2500 metres per second but figures down to 700 metres per second were observed in Glen Edith and in excess of 3000 metres per second in Harajica.

The routine is iterative and progressively adjusted first break times are submitted for updating of sub-weathering velocities and delay times at each group location. Both of these are constrained by suitable smoothing filters to inhibit erratic variations.

Three iterations were specified for this project after which the geophone static was computed as an elevation correction plus a weathering correction.

Refraction velocities computed by the STATICSG program were also highly variable, ranging between 2000 and 4500 metres per second.

The line printer output lists the resultant statics, elevations and weathering thickness, sub-weathering velocities, delay times and standard deviation at each station. Also output are two plots, the first being the input first-breaks after adjustment for shot and geophone offsets and instrument delay and the second is of the first-breaks after final delay time removal. This latter plot also includes the elevation, weathering and delay time profiles.

The complete output is written to tape for later plotting of section headers and the statics are held in the data base for subsequent application.

7. FLOATING DATUM APPLICATION

FDATUM will calculate statics associated with a floating datum from previously computed but not applied shot and geophone datum statics. The datum itself is specified as a static which is the sum of shot and geophone statics for one or more CDP's divided by the number of live traces in the CDP range. Residual shot and geophone statics are applied to each trace pre stack while the float datum correction is applied to each CDP post stack to return data to computed datum.

This procedure is particularly helpful in proper velocity determination and the preservation of shallow data.

8. VELOCITY ANALYSIS

Two forms of velocity analysis were used during the processing of these data. Prior to each of the two passes of residual statics the fan velocity program SVELFAN was applied. Subsequent to the second pass residuals a further analysis was requested to determine final stacking velociy functions. For this run Constant Velocity Stacks (CVS) were used. Details of the two methods are as follows :-

A. SVELFAN velocity analysis is an automatic production oriented technique designed to obtain RMS velociy information from seismic data in CDP gathered form.

Based on preliminary CVS tests to determine the stacking velocities which might be expected in an area a set of velocity ranges versus two-way reflection time is input to the program together with a number of consecutive CDP gathers for each location where a velocity study is required. Also input is a number, n, (usually 7-11) of velocity functions to be applied to the gathers.

The program takes the maximum and minimum functions as specified by the ranges and times above and intersperses n-2 other functions between them. It then applies these functions, stacks and filters the data.

The SVELFAN display consists of six parts.

a. The uncorrected central gather of the input group.

b. The central gather NMO corrected by each of the n velocity functions.

c. The stacks formed by NMO correcting, stacking and filtering the set of CDP gathers using the n functions.

d. A display of velocity versus reflection time showing the n functions and points of high coherence at preselected intervals, e.g.: 50 milliseconds.

e. A plot of relative coherence amplitude versus time.

f. A listing of velocities versus time for up to three velocities at any time level, based on coherence measurements.

For this survey the analyses were run over 20 depth points with 10 velocity functions forming the fan.

B. CVS takes a group (e.g.: 50) of consecutive CDP gathers and corrects them for Normal Moveout using a single velocity. The gathers are then stacked and displayed. Those events in the gather traces which have been correctly moved by that velocity will stack together successfully, whilst those not correctly moved will undergo partial mutual cancellation. The process is repeated using numerous single velocities (usually 16-20 or more), the actual number required and the velocity increments being determined by prior investigation. The CVS analyses are run at selected locations on all lines.

In either case interpretation involves selecting a set of Time-Velocity pairs according to the observed stacking response maxima in the set of displays.

9. RESIDUAL STATICS

The routine assumes that the static variation from trace to trace is caused by velocity and thickness variations in the low-velocity weathering layer. It further assumes that refined static corrections, based on statistics computed from the reflection data itself, are desirable.

The automated statics analysis routine is conducted on NMO corrected gather records by utilizing all possible cross correlations between traces within and from adjacent depth points.

A dip model, representing the observed structure on one or more events within a specified gate or gates, is input to the program to facilitate dip correction within the set of CDP gathers being operated on. The model is interpreted from the previous stacked section in the processing sequence.

The process iterates automatically and makes separate estimations of residual normal moveout and dip, then computes a set of surface consistent residual statics for all shot and receiver locations. The appropriate residuals may be output on tape for application at a later stage, or stored in the data-base.

The following correlation processing controls are generally followed while estimating residual statics and have some data dependence :-

a. Static limits (+/- 16 msec. for first pass and +/- 8 msec. for second pass for these data).

b. Damping factor to prevent matrix instability.

c. Number of iterations (3 for these data).

d. The number of depth-points in the cross correlations. This may be constant or variable through the iterations. For these data 11 were used in first pass and 5 in second pass.

e. Inverse filtering controls for low frequency static estimation.

Residual geophone statics are applied in accordance with receiver surface location and residual shot statics with record or shot input sequence. Both are recorded in the appropriate trace headers.

10. NORMAL MOVEOUT (NMO) CORRECTION

This operation is performed assuming that the energy travels in a straight ray path and utilizes the following equation :-

$$T \text{ recorded} = \sqrt{T^2 \text{ corrected} + \left(\frac{X \times 1000}{VRMS}\right)^2}$$

A space-varying velocity function is utilized and the program computes a new space-varying function for each trace, by making floating point cubic interpolations between input control points, to produce a high fidelity NMO output.

11. PRESTACK MUTING

The function of this process is to mute or scale down the very shallow long offset traces where the signal to noise ratio is extremely poor.

In particular, the disproportionate stretching of traces with decreasing velocity and increasing offset, by NMO correction, contributes significantly to the poor S/N ratio. An effective muting system, which is both offset and velocity dependant, is achieved by measuring the percentage of NMO stretch of the trace and zeroing those parts stretched beyond a predetermined value. For this project a 40% value was used.

12. AGC BEFORE STACK

At this final stage of preparation of the trace it is assumed that each has been statics and NMO corrected to a simulated zero offset condition, on the datum plane, for the particular CDP. So that each may contribute equally over its full length, to the summed trace, a short gate (500 millisecond) Automatic Gain Control was applied, before stacking, to ensure that all were at optimum level.

13. COMMON DEPTH POINT STACK

After the completion of prestack muting and balancing the CDP data sets, which are corrected for the final velocity and residual statics, are summed algebraically. The resultant amplitude is divided by the number of live samples contributing to the summation to produce the final unfiltered stacked sample.

14. FILTERING

Zero-phase digital filters were used in the filtering of stacked data. A time constant band-pass filter having a low-cut of 15Hz and a high-cut of 60Hz was used for intermediate stacks. Time variant final filters were designed from filter tests carried out for the various areas as discussed in the section on parameter testing.

15. TIME VARIANT EQUALIZATION

An equalization gate length of 1000 milliseconds was applied to the data. The gate slides along each trace one sample at a time. The average absolute value (AABS) of the gate is computed and a scalar is applied to the centre point of the gate such that the AABS of the gate is now at a pre-determined level.

The gate then moves to the next location and the process is repeated. Thus a time variant scalar is determined which brings the trace to the desired amplitude level.

16. DISPLAY

The final display films were in a horizontal scale of 1:10000 (10 traces per cm with the trace interval representing 10 metres on the ground). The vertical scale was 10cm per second.

The films were fitted with a side panel on the right hand side with a comprehensive tabulation of line, field and processing information. Along the top of the films data relating to actual location along the line is displayed. This includes datum statics, residual statics, line intersection details, surface elevation and R.M.S. velocity tables with their points of application. All films were in the wiggle trace-variable area mode, with timing lines every 100 milliseconds.

ADDITIONAL PROCESSES

FINITE DIFFERENCE WAVE EQUATION MIGRATION

The program MIGRATX was used to time-migrate the data after stack. In this process events in the stacked seismic section are migrated to more nearly correct spatial locations, using an improved version of the finite difference wave equation technique. The input parameters to the migration program consist of stacking velocities, sub-surface trace interval and layer thickness which is a function of interval velocity and dip. The fundamental effects of migration on the stack are :-

a. Lateral displacement of dipping events.

b. Collapsing of diffraction patterns.

c. Uncovering buried foci.

d. More distinct fault resolution.

e. Signal to noise ratio improvement for coherent events in areas where most of the noise consists of diffraction arrivals.

Some limitations to the migration process which should be considered are :-

a. Where the migration is done in two dimensions only, some apparently attractive structures may correspond to reflections from out of the plane of the section. Thus some events may not tie on two cross lines which have been migrated.

b. If lines are not shot along the true dip or true strike, the migration routine can only migrate data in relationship to the apparent dip or apparent strike.

c. The selection of the layer thickness parameter is controlled by the maximum amount of dip suspected in the section and the ability to define the velocity adequately. For this project a 20 millisecond layer was used.

Migration was helpful in collapsing diffraction patterns, which were obscuring the flanks of the anticlines, thereby improving the information on the spatial configuration of these features.

THE DATA PROCESSING SYSTEM

DIGICON's installation in Brisbane is based on two Digital Equipment Corporation VAX 11/780 computers, coupled with DIGICON's DISCO seismic data processing system.

The Hardware configuration is extremely flexible, the Brisbane installation being one of many possible alternatives. Included in this establishment are twenty-one tri-density tape drives, five 300 mega-byte disc units, four FPS array processors, two Benson electrostatic plotters, and twelve remote input/output terminals allowing multi-user, multi-functional interactive capability.

The 32-Bit central processing unit and a 4 billion byte virtual memory capacity enhance the scientific application of the Vax 11/780.

Plotting in a variety of modes is available through the on-line Benson plotters. Off-line a Xerox 2080 copier gives a choice of high quality reproductions on film or paper at a range of enlarged or reduced sizes.

The DISCO system (DIGICON's INTERACTIVE SEISMIC COMPUTER) is an extension of the DIGICON modular seismic data processing system developed over many years. Being modular, the system is completely flexible allowing complete user control of the number and sequence of operations performed in any job. The DISCO Seismic Monitor assembles the selected modules in the specified order and controls the processing run.

Respectfully submitted
DIGITAL EXPLORATION LIMITED.

for J.R. Morris

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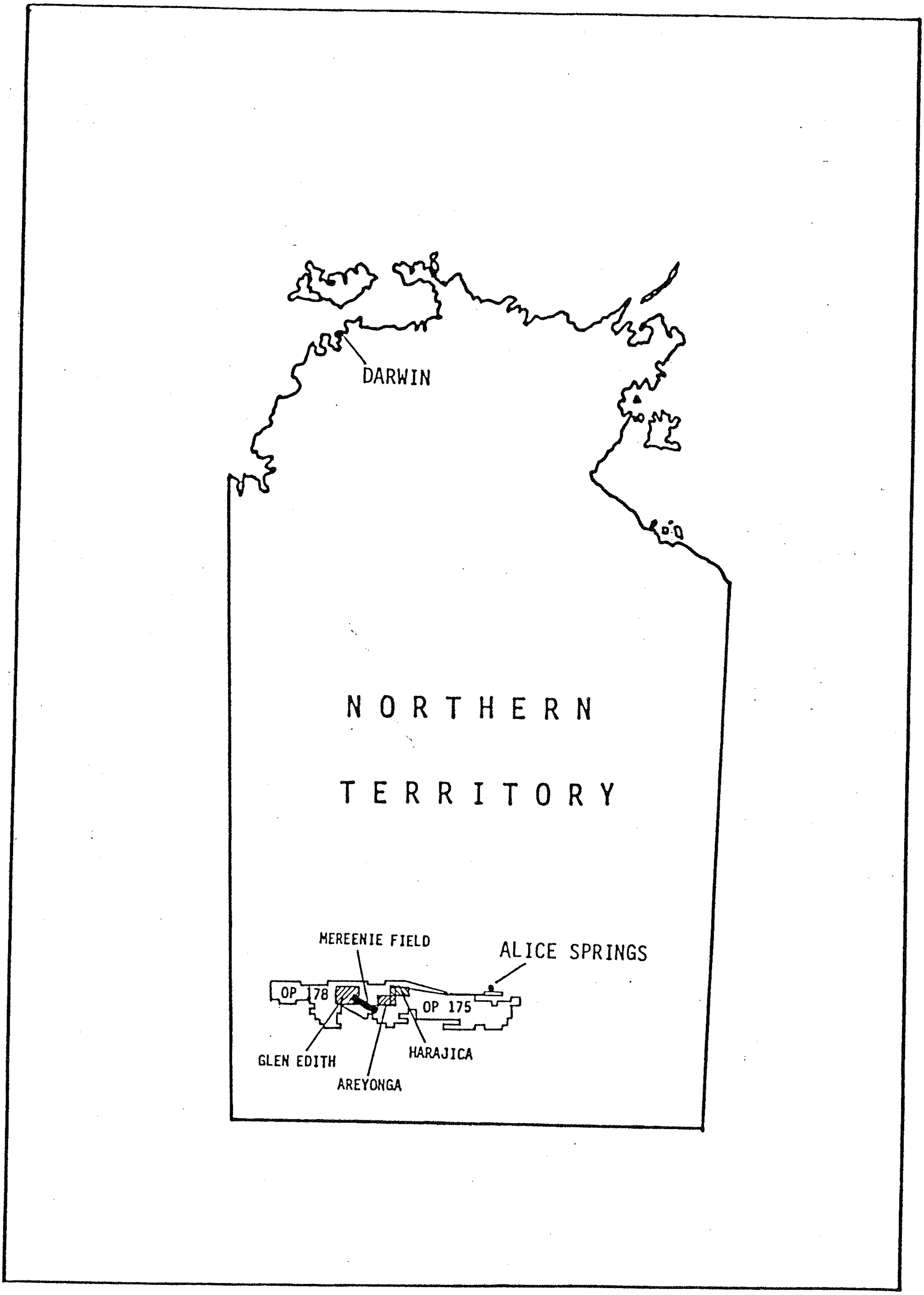
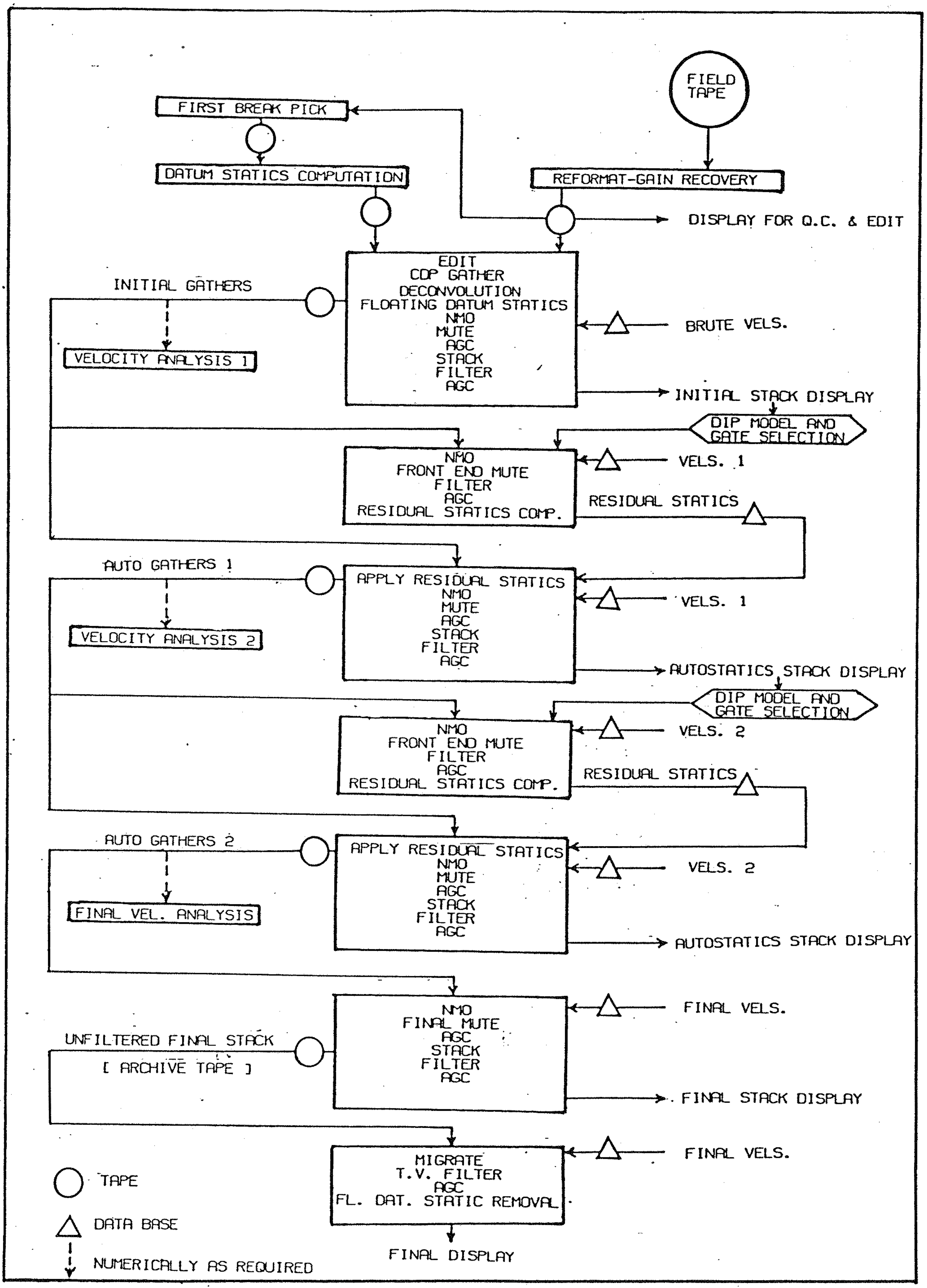


AREA LOCATION DIAGRAM

PLATE 1



PROCESSING FLOW DIAGRAM

PLATE 2