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DATA PROCESSING REPORT

MEREENIE SEISMIC SURVEY

OP.175/178

Geophysical Service Int.

April 1983.

1. INTRODUCTION

The Mereenie seismic reflection survey in OP175 and OP178 in the Northern Territory, also designated NTL4 and NTL5, was recorded in January 1981 by Seismograph Service Limited using a vibrator energy source and 48 trace recorder. Data were generally recorded for 12 fold CDP coverage. Details of field parameters are included as Plate II.
Initial processing was performed by Geosource.

One line was reprocessed by Geophysical Service International in Sydney in December 1982 and the remainder of the survey in March and April 1983.

Digital processing utilised an IBM 3033 computer and the TIPEX* software system.

The following processing sequence was used:-

Minimum Phase Correlation
Field Record Display

True Amplitude Recovery
Edit
Pre-Deconvolution Ramp
Velocity Filter
Designature
Time Variant Scaling
Velocity Analysis - VELPAC
Brute Stack

Automatic Residual Static Computations
Velocity Analysis - VELSCAN

Application of NMO, Residual and Datum Statics
12-Fold CDP Stack
Time Variant Filter
Time Variant Scaling
Gould Display
Migration of Stack Section
Time Variant Filter
Time Variant Scaling
Dip Filter
Film Display of Dip Filtered Migrated Section

*Trademark of Texas Instruments Inc.

2. EXPERIMENTAL PROCESSING

Prior to production of the initial line in December 1982 a comprehensive series of tests was carried out to determine the optimum sequence to be followed. A report on these tests was submitted to Magellan with that data.

Additional filter tests were made at several locations over the prospect to evaluate the suitability of those filters originally chosen for use over the whole prospect. After these had been studied it was decided to make no change to the original choice.

Line 18 over the well East Mereenie #8 was selected as a trial line to test the effectiveness of "complex trace processing" in the prospect area. Colour plots were made of the Instantaneous Phase, Frequency and Amplitude of the section derived from the complex form of the migrated stack data. The input for the Instantaneous Phase and Frequency sections was also dip filtered. Sections were processed to 1.9sec record time and displayed at twice the production scales.

3. CONCLUSIONS AND RECOMMENDATIONS

The final sections produced were a significant improvement over those from the initial processing. It is likely that changed collection parameters would further improve data for future surveys. Some of the factors to be considered are :-

Static Corrections
It might not be necessary to use a full LVL crew but some uphole data would increase confidence in the absolute values of datum statics. These upholes would need to be so spaced as to give a good regional picture.

Sweep Frequency
The filter analyses all showed that signal containing the maximum sweep frequency used (50Hz) was present well below 1sec. record time. Tests should be made to ascertain maximum frequencies obtainable in the area.

Spread Configuration
Several lines had steeply dipping reflectors. The group interval of 50m. used would have caused some cancellation of signal in these areas. With 96 trace recording becoming standard, shorter group intervals and arrays could be used without losing coverage.

Line Length and Migration
Migration was effective on most of the lines; however, some of the lines with steeply dipping section were very short and showed severe edge effects after migration. The benefits obtained from migration would be enhanced if such lines were extended beyond the areas of steep dip on the flanks of the structure.

Attribute Processing
Interpretative evaluation of the Lithcomp sections should indicate the potential value of the package in this area. It is also felt that the inversion package G-Log might be helpful in defining the extent of target structures and it is recommended that trial processing be performed over a known structure.

Respectfully submitted GEOPHYSICAL SERVICE INTERNATIONAL

D J Tyler

(Processing Party Chief)

APPENDIX A. PRODUCTION PARAMETERS

Typical parameters are listed below and also appended to each final display section.

Processing was at 4msec sample rate to 4 seconds.
Stacking functions used were annotated on each section.

TAR - Alpha 5db/sec, T2 4.0sec.

PDR - Offset/Start time pairs were 150m/0.05sec, 1400m/0.48sec.

Velocity Filter

Positive cut	3125 m/sec	(16msec/trace)
Negative cut	12500 m/sec	(4msec/trace)

Trace equalisation gates were 1000msec long.

Trace edit - from field records.

Designature - one wavelet was estimated for each record.

Stack Ramp
The following post nmo time(msec) and offset(m) pairs were used:- (-150,0) (-50,150) (500,1400)

Time Variant Filter

TIME(msec)	FREQUENCY(hz)
0	16-50
1500	16-50
2500	16-40

Scaling after stack
Regular 1x200msec, 1x300msec, 1x500msec and 3x1000msec gates with no overlap were used.

Velocity analyses - relative statics only were applied for VELPAC analyses and relative plus residuals for VELSCANS.

Residual Statics
Space and time variant gates based on prominent reflectors were picked. Four iterations of computations were performed and a 16-40Hz filter used.

Display Scale

Mode	VA/WT
Vertical scale	10 cm/sec
Horizontal scale	24 TPI

APPENDIX B. DESCRIPTION OF BASIC PROCESSES

Datum statics were supplied by Magellan to a datum of 650m. ASL.

Minimum Phase Correlation

Most deconvolution processes assume that reflection wavelets are minimum phase. Thus it is desirable to have a correlation programme that collapses the Vibroseis sweep to a minimum phase wavelet rather than zero phase.
The minimum phase correlation process can be visualized as a series of operations in the frequency domain, as follows:

a) Fourier Transform both trace and sweep.

b) Multiply the trace by the sweep amplitude spectra, and subtract the sweep phase spectrum from the trace phase spectrum to accomplish conventional zero phase correlation.

c) Divide amplitude spectrum from b) by itself plus white noise - leaving the phase spectrum unchanged. This is the inverse filter.

d) Compute the mimimum phase spectrum for the effective source wavelet from c) and add this to the phase spectrum from c) - leaving the amplitude spectrum unchanged.

e) Inverse transform the amplitude and phase trace spectra from d). This gives the minimum phase correlated trace.

True Amplitude Recovery - TAR

TAR was applied to all field records. This removed the floating point gain applied by the Sercel field system and corrected for signal loss by inelastic attenuation and spherical divergence.

Pre-Deconvolution Ramp - PDR

PDR removes unwanted first arrival noise from the front end of seismic records and is applied prior to deconvolution design.

Velocity Filtering - VEF

Velocity filtering is a multichannel process that has been combined with designature into one executable load module. Multichannel filtering is a two dimensional

frequency wave number operation used to discriminate against specified velocities on pre-stacked data or against specified dips on stacked data.
Velocity filtering processing requires shot organised data that has a group interval representing adequate spatial sampling. Also, the receiver interval should be less than or equal to the shot interval to avoid aliasing.
The process transforms the data from the space-time domain (X-T) to the frequency-wave number domain (F-K) where the filter is applied. After filter application, the data is transformed back to the X-T domain for the application of further conventional processing.
The apparent horizontal velocity of the noise must be adequately separated from the primary signal for the process to be effective. Examples of noise alignment that can be removed are ground roll and air blast. The user supplies a window of primary dip zones to keep; negative dip noise and positive dip noise outside of the keep zone are rejected. Thus it is important that the primary dip on the field records should be known - it should be remembered that moveout is a major factor influencing the selection of keep zones.

Designature

Designature is a generic name for processess which attempt to replace an arbitrary source wavelet convolved with the reflection sequence by a shorter wavelet of improved resolving capability.
DESIG is an alternative to conventional pre-stack deconvolution (TVD). Common features of DESIG and conventional TVD include:

a. Both estimate the input wavelet from seismic traces.
b. Both assume the wavelet to be removed is minimum phase.
c. Both assume the reflection sequence is random.

Significant differences are:-
a. DESIG is a multi channel process that can use the entire record to estimate the wavelet. For land data the process uses the whole record. TVD is a single channel process that uses only a portion of the trace to design an operator.
b. TVD is time and offset variant, whereas DESIG is not time variant but has the capability to be offset dependent.
c. DESIG compensates for the field system low cut phase response and provides a more accurate and stable operator design than conventional single channel deconvolution because of the much greater statistical base for the source wavelet estimation. The assumption of randomness of the reflection sequence is fulfilled

using a record that is not NMO corrected rather than part of a single trace. Thus DESIG is less likely to attempt to remove the periodicity of the signal itself.

Trace Equalisation

A gate of length 1000ms was used. The scalers were determined such that the average absolute values of data words in the design gate was equal to 2exp10.

Velociy Analysis - VELPAC

The VELPAC Velocity Module was applied in the spot analysis mode using 12 adjacent depth points.
Basic steps of the programme for each analysis include:
- Application of normal moveout (NMO) corrections, corresponding to several different constant velocities or velocity functions, to a set of adjacent depth points.
- A stack, for each velocity, of each depth point in the set.
- A time gated, power based search to provide picks as functions of time, amplitude and moveout (which is another expression of velocity).
- Display of selected depth point gather traces, stacks and power picks.

Velocities determined by the VELPAC analyses were used in the residual processing.

Preliminary Stack (Brute)

Brute stack velocities were obtained from prior processing. In addition to the stack Near Trace Gather and 100% coverage sections were also produced.
These sections had two uses:-
1. As a quality control check of the preprocessing.
2. To enable selection of design gates for residual static computation.

Velocity Analysis - VELSCAN

The VELSCAN module was applied in the spot mode using 11 adjacent depth points. The following is a brief description of the process.
The VELSCAN module generates events as functions of time, amplitude, moveout and dip. The event picking proceeds in the following manner:

- NMO, Static and Residual Static corrections corresponding to a series of velocity functions are applied to a set of depth point traces. For each velocity function the NMO corrected traces are stacked. The resulting traces consist of amplitudes as functions of time and moveout.

- Identical operations are applied to adjacent depth points, adding the dimension of space.
- Dip is applied and, for each value of dip, the traces are stacked across depth points. The result is a set of amplitudes as functions of time, moveout and dip.
- An event is located by searching for an amplitude extremum in the time, moveout and dip domains. An extremum may be either a maximum or minimum;that is, both peaks and troughs are picked. The event attributes of time, amplitude, moveout and dip are assigned to the centre depth point.

- Prior to display, the events are subjected to various sorting and classification algorithms. The powerful picking of VELSCAN yields good results even in relatively poor data areas. Where quality or accuracy requirements permit, options are chosen to reduce computer run time and hence cost. The major processing options for event picking for each analysis are as follows:

OPTION A: Specification of time gates.
Several time gates may be selected for independent definition. In each gate the bandpass filters, number of depth points and the dip range may be different.

OPTION B: Number of depth points to process.
There may vary in each time gàte from 3 to 24.

OPTION C: Dip range in each gate selected.

OPTION D: Time variant velocity bounds which determine the boundaries of the moveout scans.

OPTION E: Sorting and grading of events.
Events may be classified in terms of Time, Amplitude, Moveout and Dip.
As aids to interpretation, the VELSCAN module also generates and displays gathers, stacks and velocity functions in a manner similar to VELPAC. The specifications for this capability are independant of the specifications for the event picking. The major options for each analysis are:

OPTION F: Number of velocity functions applied - up to 30 constant or variable in time.

OPTION G: Number of depth points to display - up to 24.

OPTION H: Display of gather traces.
- Display of centre depth point for each function.
- Display of gather traces for each depth point for centre function only.

Also displayed are stacks for all depth points for each velocity function and the centre depth point gather without statics and NMO applied.

Automatic Residual Static Computations

The method is based upon the use of cross-correlation functions to measure the relative time shifts for each of the traces within a common depth point set. Each of the traces of a CDP set is correlated with a reference trace formed by stacking the other traces within the set.

The location of the peak value of the cross-correlation function gives an estimate of the time shift of the static shifted trace. The time shift measured by the cross-correlation is the sum of several effects, namely:

i. Residual shot static
ii. Residual receiver static
iii. Residual normal moveout
iv. Noise

The correlation functions are computed over gates which are chosen such that the signal to noise ratio is high and little or no residual moveout is present.

The time shifts obtained from the correlation functions for each trace are then placed in tables of common shot and surface positions, and a statistical analysis carried out to determine a unique residual source correction for each shot and a unique residual group correction for each receiver. This ensures that at all times statics which are applied to data are surface consistent.

Finally, the statics to be applied are synthesised from the estimates of the individual shot and receiver statics by averaging the values along common source and receivers.

The process is iterative and several rounds are applied to achieve upgraded estimates of the residual statics to apply - the input to successive iterations being the output from the preceding round. To enable a Q.C. of the results apart from the computed statics being listed a plot is made of the selected gates with the computed residual statics applied after each iteration.

Application of Datum Statics

The application of datum statics was performed in the following manner:-
Prior to application of normal moveout corrections a "mean" datum static was computed for each depth point

and a "relative" datum static computed for each trace within that common depth point set. The relative static was simply the difference between the mean datum static and the individual trace datum statics. The relative datum statics thus computed were then applied together with the residual statics to the traces prior to the application of normal moveout corrections. A consequence of this method of datum static application is that velocity functions for normal moveout corrections are expressed relative to the surface and not relative to the datum plane.

Normal Moveout Corrections

Normal moveout corrections are applied to remove increased reflection time on an event caused by spread geometry. The magnitude of the event correction is determined by the following equation:-

$$T = \sqrt{To^2 + \frac{X^2}{V^2}} - To$$

where

T = Normal Moveout
To = Time of the event at zero offset
X = Offset of a trace
V = Root mean square velocity to the event

Common Depth Point Stack

In this process, the traces for each depth point are mixed to give one output trace for each depth point. Prior to the mix, first break energy plus the early portion of the traces where NMO corrections have caused severe stretching resulting in significant frequency changes are suppressed. The result being that the stacking multiplicity varies as a function of record time.

Time Variant Filtering - TVF

Filtering was applied in a time variant manner to take account of the higher frequency content of shallow data and the lower frequency content at depth and to reject unwanted frequencies, or noise.

Migration

Wave equation migration was performed in the KIRCHOFF F-K domain. The principal advantages of the wave equation migration are:-
Migrates properly in the presence of lateral velocity variation
Has a practical dip limit approaching 90deg.

Prevents induced aliasing on flat data where there is a large sample interval.
The routine uses the F-K transform for the migration rather than the moveout and stack of an aperture of traces in the time domain. Aliasing of flat events resulting from too large an aperture in the moveout and stack method does not occur in the F-K method.

Dip Filter

Dip filter in the F-K domain was used as a means of improving the signal to noise ratio by reducing random any organised noise outside dip bounds selected from the stack section.

Lithcomp

LITHCOMP is designed to compute the complex attributes of a seismic trace. Instantaneous amplitude, frequency, and phase may infer geologic information not readily seen on a conventional display. Each attribute is inspected separately and displayed against time. Displays are in colour to assist interpretation. Brief descriptions of each characteristic follows:-
Instantaneous Amplitude
This is also referred to as reflection strength and is a measure of amplitude independent of phase. This is the key to its use since situations occur where the amplitude of a peak or trough vary laterally due to wavelet phase changes not caused by changes in reflection amplitude and hence reflection coefficient.
Instantaneous Phase
This is a measure of phase with respect to time not frequency as in conventional spectral analyses. It emphasises continuity of events, and being independent of amplitude shows weak coherant events just as well as strong ones.
Instantaneous Frequency
This is in a way the measure of the predominant frequency of a reflection or a complex series of reflections. It will change not only with the reflection wavelet change but also for a complex sequence of reflections. This latter change might also be caused by changes in bed thickness or of velocity within a sequence caused by such things as trapped hydrocarbons.

APPENDIX C. TAPE INVENTORY

Stack Data all on VSN 501142
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File Name : SL.MEREENIE.STKTRS.V#.LINENO.LR1
Format : Demultiplexed,Ungapped,1600 BPI(segy)
Data : Raw Stack, 0-3996 at 4 msecs.

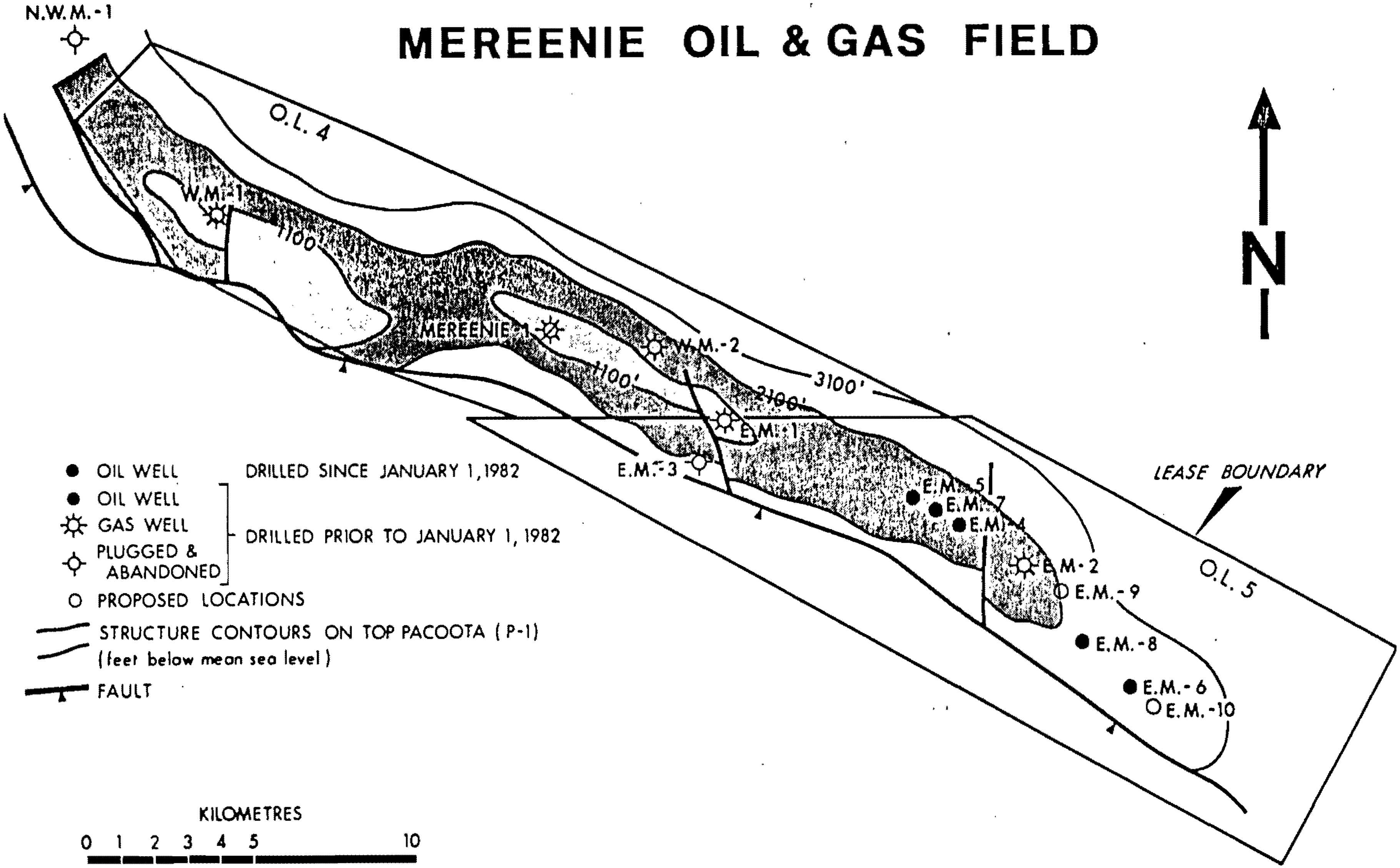
File	V#	LineNO.	CDP range	SPN range
1	V1	MM82-1A	1030-1604	1290-1000
2	V1	MM82-1B	1030-1392	1185-1001
3	V1	MM82-2	1031-1356	1000-1166
4	V1	MM82-3	1030-1184	1082-1002
5	V1	MM82-4	1030-1324	1000-1150
6	V1	MM82-5	1030-1316	1120-974
7	V1	MM82-6	1030-1372	1006-1180
8	V1	MM82-7	1030-1476	1250-1024
9	V1	MM82-8	1034-1366	1000-1170
10	V1	MM82-9	1030-1336	1163-1007
11	V1	MM82-10	1030-1344	1090-930
12	V1	MM82-11	1030-2036	1510-1004
13	V1	MM82-12	1030-1216	1097-1001
14	V1	MM82-13	1030-1416	1000-1200
15	V1	MM82-14	1030-1172	1001-1075
16	V2	MM82-14	1030-1172	1001-1075
17	V1	MM82-15	1030-1572	1016-1290
18	V1	MM82-16	1030-1195	1000-1086
19	V1	MM82-18	1030-1214	1096-1001
20	V1	MM82-20	1030-1360	1169-1001
21	V1	MM82-22	1030-1352	1165-1001
22	V1	MM82-24	1030-1320	1149-1001

Correlated Field Data

Line N#	Tape N#	Rec #	SPN.range
MM82-1A	G43	1-155	1290-1000
-1B	G72	1-93	1185-1001
-2	G21	1-84	1000-1166
-3	G7	1-41	1082-1002
-4	G124	1-79	1000-1150
-5	G18	1-74	1120-974
-6	G45	1-90	1006-1180
-7	G47	1-144	1250-1024
-8	G34	1-104	1000-1170
-9	G35	1-83	1163-1007
-10	G38	1-47	1090-930
-10X	G83	1-44	1013-928
-11	G51	1-161	1510-1202
	G48	1-64	1200-1074
	G138	1-35	1072-1004
-12	G57	1-52	1097-1001
-13	G61	1-125	1000-1200
-14	G70	1-38	1001-1075
-15	G86	1-151	1016-1290
-16	G88	1-54	1000-1086
-18	G109	1-51	1096-1001
-20	G116	1-85	1169-1001
-22	G119	1-89	1165-1001
-24	G121	1-75	1149-1001

PLATE I: MAP OF PROSPECT

MEREENIE OIL & GAS FIELD



GSI-709

PLATE II. FIELD PARAMETERS

SOURCE	
VIBROSEIS	3 Y900 x 30 METRE SPACE
PATTERN	8 SWEEPS IN-LINE
GEOPHONE	
TYPE/FREQUENCY	SM4-PE-3 10 HZ
NO./TRACE	24
INTERVAL	3.9 METRES
RECORDING	
INSTRUMENTS	SERCEL 338HR
TAPE FORMAT	48 TR, 67 CH, 1/2 INCH, 9 TRACK, SEG B, 1600 BPI
RECORD LENGTH	20 SEC
SWEEP LENGTH	16 SEC
UPSWEEP FREQUENCY	50-16 HZ
SAMPLE RATE	4 MSECS
FILTERS	LOW : 12.5 HZ - 12 DB/OCT HIGH : 62.5 HZ - 72 DB/OCT
GEOMETRY	
SPLIT SPREAD	1300 - 150 - 0 - 150 - 1300 METERS
SHOT INTERVAL	100 M
GROUP INTERVAL	50 M
FOLD	12