British Geological Survey
Marine Geophysics and Offshore
Services Research Programme
Marine Report No 87/44

THE MERLIN SKS SEISMIC REFLECTION PROCESSING PACKAGE ON THE EDINBURGH VAX 8530 COMPUTER

BY

D K SMYTHE

Murchison House
West Mains Road
EDINBURGH
EH9 3LA

Tel: 031-667-1000
Telefax: 031-668-2683
Telex: 727343

March 1988

1. INTRODUCTION

The Merlin SKS package (Seismic Kernel System) was installed in February 1987, under an academic licence agreement. It is fundamental to this agreement that use of the package only be made for academic and research work, not for repayment, commissioned, or other profit-making activities. The package was updated in February 1988, and the new version is described here.

2. DESCRIPTION

The package comprises over 3000 Fortran 77 subroutines, grouped into a number of directories. The source code of everything except the Merlin translator MGLTRAN and the ISAN package is available for study or modification. The user makes up a command file using a simple high level language MGL (Merlin Geophysical Language). This file (which has the .DAT extension) is then translated into a job. If the translation is successful (it is also an error-checking process) an executable image is produced, which can be run in interactive, batch or spawn mode. Normally batch mode is chosen. Requests for tape changes, etc. are made direct to the operators during the run. Input/output can be to or from tape or discfile.

3. TERMINALS

The ideal terminal would be a VT1000 type, with full 132-column width display, combined with a Tektronix 4014 compatible graphics terminal. The Autograph XK1 suffices, but only has 80-column width, so viewing log files (which use the full 132 columns) is messy.

4. THE DIRECTORIES

Note that both data files and Fortran source files have the extension *.FOR, which is confusing. A minority of files are of *.OBJ, *.EXE, *.OLB, *.COM types, with the usual meanings. The version of SKS described here is dated June 1987.

4.1 [MERLIN]

This top-level directory contains odds and ends like the LOGIN.COM file. The record of a job run, JOB.LOG, is sent here. Progress of a large job can be monitored by looking at the log file with $ TYPE JOB.LOG, and judicious use of the scroll/no scroll key (or <CTRL> S, <CTRL> Q). If the terminal only displays 80 columns, the extra columns 81-132 are wrapped around, making reading of the file difficult but not impossible. It is little use looking at the closed log file with EDT or EDIT if only 80 columns can be displayed because a lot of the most useful information is off to the right of column 80. It is quicker to list the file to a line printer.

4.2 [MERLIN.APEX]

This directory contains calls for the FPS array processor, which is not present at Edinburgh. This directory could be archived.

4.3 [MERLIN.APSIM]

Code in this directory simulates an array processor.

4.4 [MERLIN.ERR]

This large directory (788 files) contains error message text files. Files beginning P1--- refer to preprocessing stage, and S1--- to seismic processing stage.

4.5 [MERLIN.ESSR]

This directory holds the various files that are created and deleted during a job run (Execution Stage of Seismic Run). Progress can be monitored - particularly if plots are being made - by initiating $ DIR/SIZE of this directory. It should be wiped regularly with $ DEL *.*;*, so that everything except its subdirectories deleted. If a qualifier is specificed (i.e. a directory) for the file name of input or output - say DATA- then the seismic data are actually stored in a subdirectory [MERLIN.ESSR.DATA].

4.6 [MERLIN.ESSRP]

This directory contains (Execution Stage of Seismic Run Permanent) files and subdirectories, and is not to be wiped without forethought. It contains subdirectories with names like GO---ZZZ.DIR, which are directories containing data bases for geometry processing.

4.7 [MERLIN.ESSRP.MERLIN]

This subdirectory contains plot device tables.

4.8 [MERLIN.GNP]

This is a large directory holding General Non-portable Subroutines.

4.9 [MERLIN.INC]

This holds all the INCLUDE files (which, however, have the *.FOR extension, not *.INC).

4.10 [MERLIN.IP]

This holds one directory for ISAN.

4.11 [MERLIN.IP.ISAN]

This is the Interactive Seismic Analysis suite, for processing and display of small amounts of data on a 4014-type graphics terminal. they do not have the source code for this, as BGS did not pay the extra for ISAN, but Merlin supplied it as being the only means of displaying data at the time of installation. Upgraded versions of SKS may not, therefore, have this extra option, but there is no reason why it should not be kept alongside the latest version of SKS.

4.12 [MERLIN.ISAN]

This contains the online Help file for ISAN.

4.13 [MERLIN.LIB]

This contains the libraries, along with the EXE files of MGL.

4.14 [MERLIN.MICROCODE]

Self-explanatory

4.15 [MERLIN.MPS]

This is part of the translator.

4.16 [MERLIN.PPS]

This holds the preprocessors, which all have names P1---.FOR.

4.17 [MERLIN.SITE]

This holds command files, include files, etc. specific to the VAX. The command $ GRIPS (filename), explained below, invokes the file GRIPS.COM, which is the simulated array processor version of SKS that we run.

4.18 [MERLIN.SPS]

This contains the seismic processing subroutines, many (but not all) of which have file names of the form S1---.FOR.

4.19 [MERLIN.TEST]

This contains many test job command files (*.DAT type), tried out by the engineers during several installations. The files can be looked at to get ideas of how these files are written. The files can be deleted.

4.20 [MERLIN.UTIL] and [MERLIN.UTILS]

These are utility subroutines.

4.21 [MERLIN.VAX]

These are subroutines specific to VAX machines.

5. BOOTING A NEW SOURCE TAPE

The directory [MERLIN.UTILS] contains a file BOOTORG.EXE, which does this. The directions are:

```
$ ALLOCATE MUA0: FOR013
$ MOUNT/FOREIGN MUA0:
$ RUN BOOTORG
```

Then answer all the prompts with answers inside quotation marks (i.e. like $ REQUEST).

When a new source tape is booted, some installation - specific parameters will probably have to be reset, such as the LOGIN.COM file, the plot device table, etc. Also, subroutines written especially for BGS, such as PLTLN3.FOR, the driver for the LN03 laser printer, may not be present on the new version and may have to be "patched in".

6. SEISMIC DATA TYPES

SKS can handle SEG-Y and SEG-D data types, but the latter has not yet been tried out on this installation. Unfortunately SEG-Y is far from being a proper standard, and each new "SEG-Y" data set will probably have its own peculiar problems. Trace sequential, shot-ordered data is classified as data type 1 (see SKS manual, section Introduction p. 8), but after processing it may be turned into other types. The output log file from a job must be consulted to see what the new data type on output may be, prior to input to another job. This and other essential information is given in a box near the end of the printout (see Fig. 1 for an example).

7. RUNNING SKS

Log in in the usual way. The user is Merlin, the password is available from local support or authorised users. Make a directory to store command files in. Make up a command file for the job, say JOB.DAT, consulting the manuals and existing examples for how to do this. Start the error-checking and translation by the command $ GRIPS JOB, from the directory where JOB.DAT resides. A banner is displayed 'SKS', 'GRIPS', etc, and shortly after this interactive stage prompts to start the job will appear, if translation has been successful. It is possible merley stop

stop there, knowing that there is a viable command file ready to go another time (but you will have to go through GRIP again).

If a batch run is chosen (the normal mode), which queue to use must be considered (default is SYS$LARGE, which gives 1 hour of CPU time).

A failed translation gives a prompt to look at the listing, but this is very tedious to look at. It is quicker to go to the directory [.ESSR] and $ TYPE JOB.GRP, which is what is being offered; alternatively, spool this file to a printer.

Common run-time failures are due to running out of disc space (the top of the system traceback stack is SYSERR line 690 in the log file); exceeding the CPU limit; and apparent failures due, for example, to running out of input files on an input reel (which may, however, be quite normal).

8. PLOTTING ON THE LN03 PLUS LASER PRINTER

The plot driver [MERLIN.VAX]PLTLN3.FOR was written for BGS by a Merlin engineer in July 1987. It requires the LN03 PLUS printer, not the LN03 base model. The enhanced model has 1Mb or so of memory, so that a whole bit map can be stored before plotting.

A laser printer plot file is created by the processor :PLOT if LASER is given as the argument of the verb DEVICE. It is sent to directory [MERLIN.ESSR_] which can be inspected for progress during a job run. Various temporary files are created here, and most are deleted when the job is completed. First a plot metafile of format InnnnnnnFOR will be created, where nnnnnnn is a 7-digit number made up from the day of the month (least significant figure only) and the time. Thus the file

I8153704.FOR

was created on the 8th (or possibly the 18th or 28th day of the month) at 15h 37m 04s. Doing a $ DIR/SIZE will initially show the file as 0 blocks in size, but when it appears as being a finite size (several thousand blocks) this indicates, you know it is closed. Immediately the first of two or more files appear with filename Lnnnnnnn.FOR, where the digits indicate a slightly later time. These are the files to be sent to the LN03. Even with a very small plot two of these files are created. As soon as the first one is closed it can be sent to the printer, while the second and subsequent ones are being made, with the system command.

$ LN03 filename

where the numeric LN03 is defined in the LOGIN.COM file.

The large metafile Innnnnnn.FOR is split up into several L-type files as shown in Figure 2. Thus the time direction on a plot is spread over several files. The x direction is catered for by an individual L-type file printing out one or more pages.

Even with the smallest of plots (e.g. Fig. 3), two L-files are made. However the second of these only contains the rest of the box around the information panels, and need not be spooled to the laser printer. At the end of the job, and once the required plot files have been printed, everything in [MERLIN.ESSR] should be deleted. The system needs at least 115,000 blocks free to create a plot file, even though most of that is left available after a job run.

There are two problems with the LN03 driver. Firstly, the scaling of the bottom line of each page within a plot is enlarged, although no data are lost. Secondly, there is a gap instead of the planned 10% overlap of data in continuing from one plot file to another (See Fig. 2). The driver needs to be debugged in conjunction with the description of the 'sixel' graphics mode given in the DEC manuals (C. Fyfe of Global Seismology holds these).

The numbering and annotation around plots is rather faint, but this has been deliberately set in the device driver by setting the minimum line width to be 7 pixel, even though the DEC manual recommends 2 pixels. This is so that the plots themselves have the maximum resolution. Unfortunately, semblance plots turn out to be rather faint (e.g. Fig. 4) because of this.
Note that even if the scaling of plots is defined in :PLOT by metric units, the actual plot scaling is done in imperial units, so that the intended scaling may be rounded off to the nearest equivalent imperial scale. Also, if very small plots are desired (with a trace spacing of less than 30 tr/cm or so) the type of trace desired (a certain bias on a VAR trace, for example) may not be plotted; what results instead is the default trace settings.

9. USE OF ISAN

ISAN is useful for checking data prior to, and in the early stages of processing. For example, a sequence of field records can be displayed on a Tektronix 4014 (or Autographs XK1) and printed out on the Infoscribe 132-column printer (e.g. Fig. 5). Such preliminary displays can be used to determine mute functions, trace sealing and filtering. Figure 6 shows the amplitude spectrum of a trace extracted from a disk file and put into an ISAN work file, where interactive filtering etc. can be applied.

10. PROCESSING LAND DATA

Land geometry definition can be difficult. At least two records are required, in order to define a direction of progression. However if it is wished to process only one shot record, the above limitation could be avoided in the following way; duplicate the data so that there are two records; define a direction of progression from shot print 1 to shot print 2, but then specify an in-line offset which takes the second shot back to the same position as the first.

Geometry is best defined as an isolated job, before any actual processing. It is important to have the job file well annotated, so that it is clearly described. Figure 7 is an example. Note that the only processors required are :DBAS
:GEOM
:PROC
:BIND
:GMAP
:BINA

i.e. no input or ouptut of data is required.

Always define the line ends before and after the first and last shot prints, respectively. If the beginning or end is defined to be at one of these shot prints, the sense of progression of the line is undefined for that shot, and the :GEOM processor will fail.

The processor :MSTATIC limits the user to 25 pairs of (file, shift) coordinates. If it is required to process a dataset with more than 25 files, each with an individual static shift, then the way round
this is to specify :MSTATIC twice; however since each application of the processor has to cover the entire range of field files, the way to do it is by dummy, or zero, shifts, e.g.

	file no.	static shift
:MSTATIC	1	t_1
	n	t_n
	n+1	0 (dummy)
:MSTATIC1	1	0
	n+1	t_{n+1}
	end	end

11. DATA EXAMPLE

Figure 8 shows a final stack display of a 2-km length of land seismic reflection data from Staffin Bay, north Skye. The data were shot as 12-channel analog records with a dynamite source in 1971. Although the section looks extremely poor, reflectors can be identified down to 2s and interpreted with the aid of the velocity structure, gravity modelling, line drawing depth migration, etc. The six short pieces of line from northern Skye which have been processed using SKS compare favourably with the recent commercial data shot between 1981 and 1985, on which nothing is interpretable below the base of the basalts at 0.5s or less.

12. SUMMARY

BGS now has a potentially powerful combination of processing/modelling software available for serious users (i.e. those who are familiary with VAX/VMS, who understand the principles of digital processing, and who are prepared to spend time studying the SKS user manuals). The casual or part-time user will simply end up wasting resources.

The current limitation is on input/output; only small amounts of data (a few kilometres of multichannel reflection data) can be processed at a time by disk storage; processing of realistic quantities of marine and/or deep data will rquire extensive operator mounting/demounting of tapes, which is not practicable at present. The main priority to overcome this limitation is, therefore, more disk space, so that reasonably sized jobs can be run at any time. A future priority will be a raster plotter, for larger, quicker paper plots.

FIGURE CAPTIONS

Fig. 1. The box of information in the LOG file from the :GEM processor, required for further processing. This shows a modulus of 72 (NB wrongly spelled throughout SKS documentation as modulas), fold of coverage of 2, and trace sorting code of 5.

Fig. 2. Layout of separate sheets and files from the LN03 plus laser printer. Current errors in the device driver produce slight sealing error at the bottom of each A4 sheet (shaded) and a gap in data between each file L9, L2, etc.

Fig 3. The very first plot produced by SKS on the Edinburgh VAX 8500. The second plot file produced by the same job merely contains the right-hand edges of the two information panels, so need not be printed.

Fig. 4. Semblance plot; very weak lines are not due to faulty laser plotter, but to the decision to use single pixel line widths (not recommended by DEC) to improve the resolution of plots (e.g. Fig. 3).

Fig. 5. Display of field files (shot records) using ISAN on a Tek 4014 type terminal plus screen dump printer. Such displays are useful for printing mute functions, identifying bad data, etc.

Fig. 6. ISAN display (cf. Fig. 5) of the amplitude spectrum of a single trace.

Fig. 7. Extract from a geometry definition job file, to demonstrate the extensive commenting which is advisable for the file to be understood.

Fig. 8a. Final stacked section of 2km length of analog reflection data obtained in Skye in 1971.

Fig. 8b. Line drawing interpretation of the data of Figure 8a.

```
THE DATABASE FILES FOR GEOM WERE CREATED  2/07/87  12:22:06

MGLTRAN > ESSR  TRACE  LENGTH -       1501 ESSR  WORK   LENGTH -
MGLTRAN > AP    TRACE  LENGTH -       1501


**********************************
**                              **
**     INFO FOR GATHER          **
**                              **
**     UMODLS =       72        **
**     UMFOLD =        2        **
**     USORT  =        5        **
**                              **
**********************************

END   OF P1BINA

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>   PROCESSOR OUTPUT
>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
```

Fig. 1. The box of information in the LOG file from the :GEM processor, required for further processing. This shows a modulus of 72 (NB wrongly spelled throughout SKS documentation as modulas), fold of coverage of 2, and trace sorting code of 5.

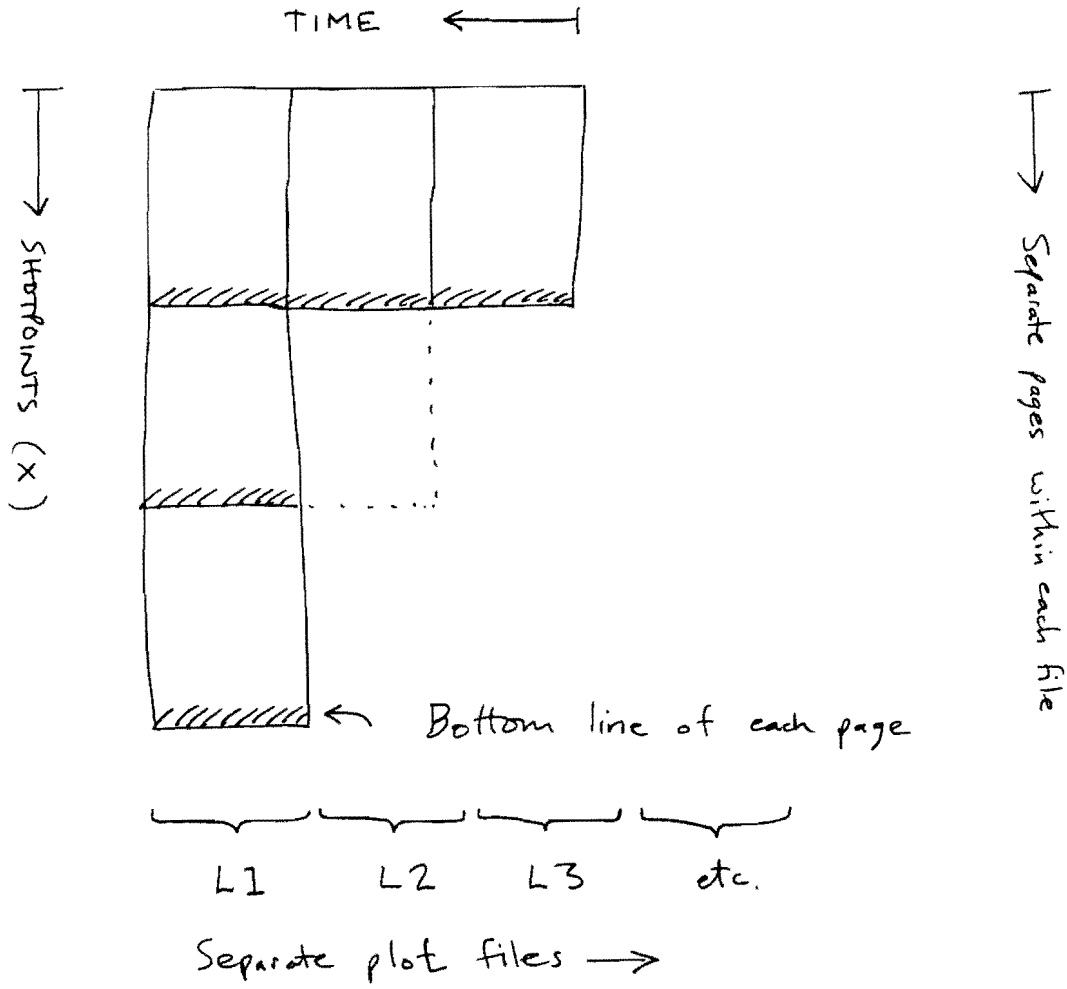


Fig. 2. Layout of separate sheets and files from the LN03 plus laser printer. Current errors in the device driver produce slight sealing error at the bottom of each A4 sheet (shaded) and a gap in data between each file L9, L2, etc.

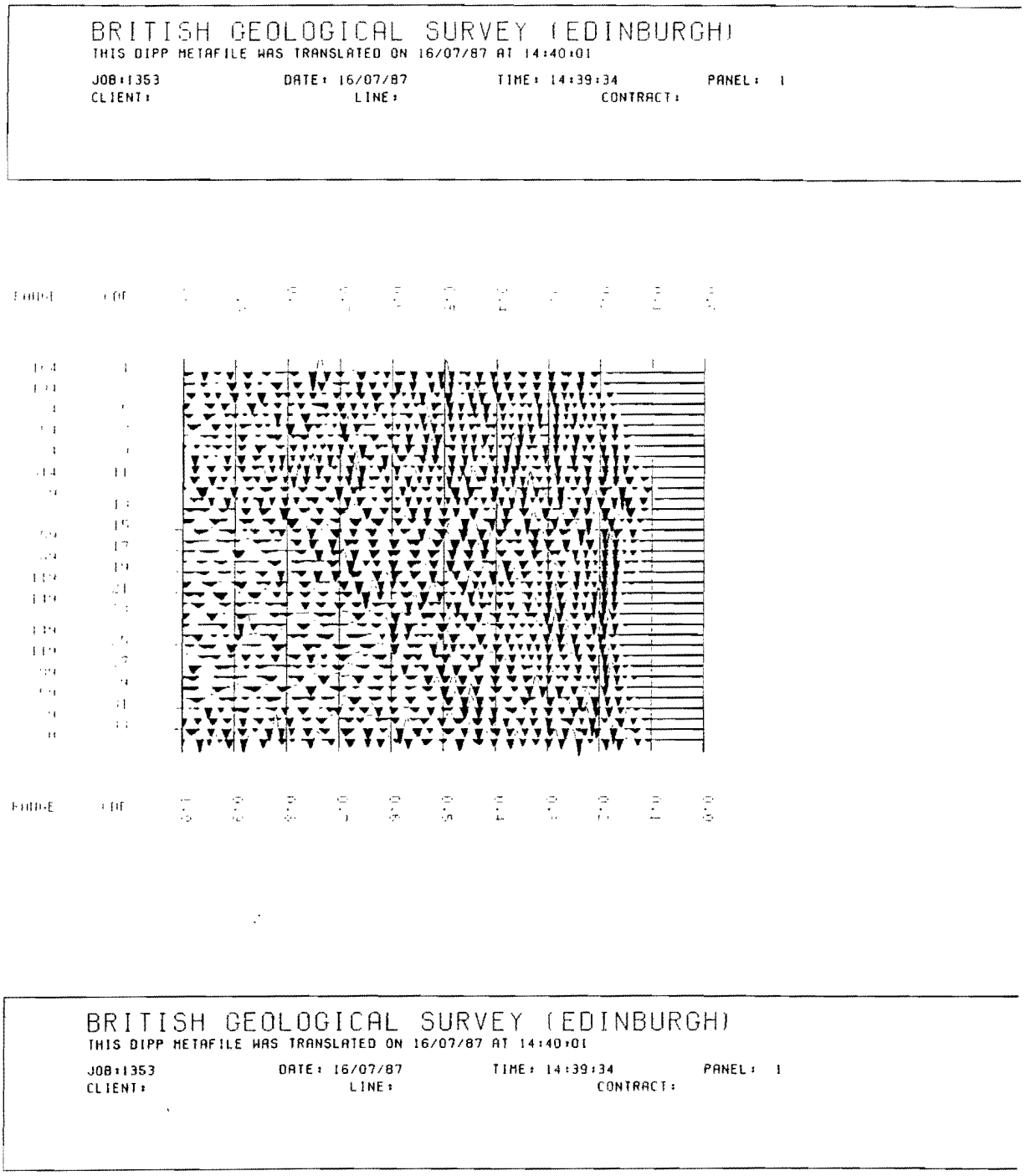


Fig 3. The very first plot produced by SKS on the Edinburgh VAX 8500. The second plot file produced by the same job merely contains the right-hand edges of the two information panels, so need not be printed.

Fig. 4. Semblance plot; very weak lines are not due to faulty laser plotter, but to the decision to use single pixel line widths (not recommended by DEC) to improve the resolution of plots (e.g. Fig. 3).

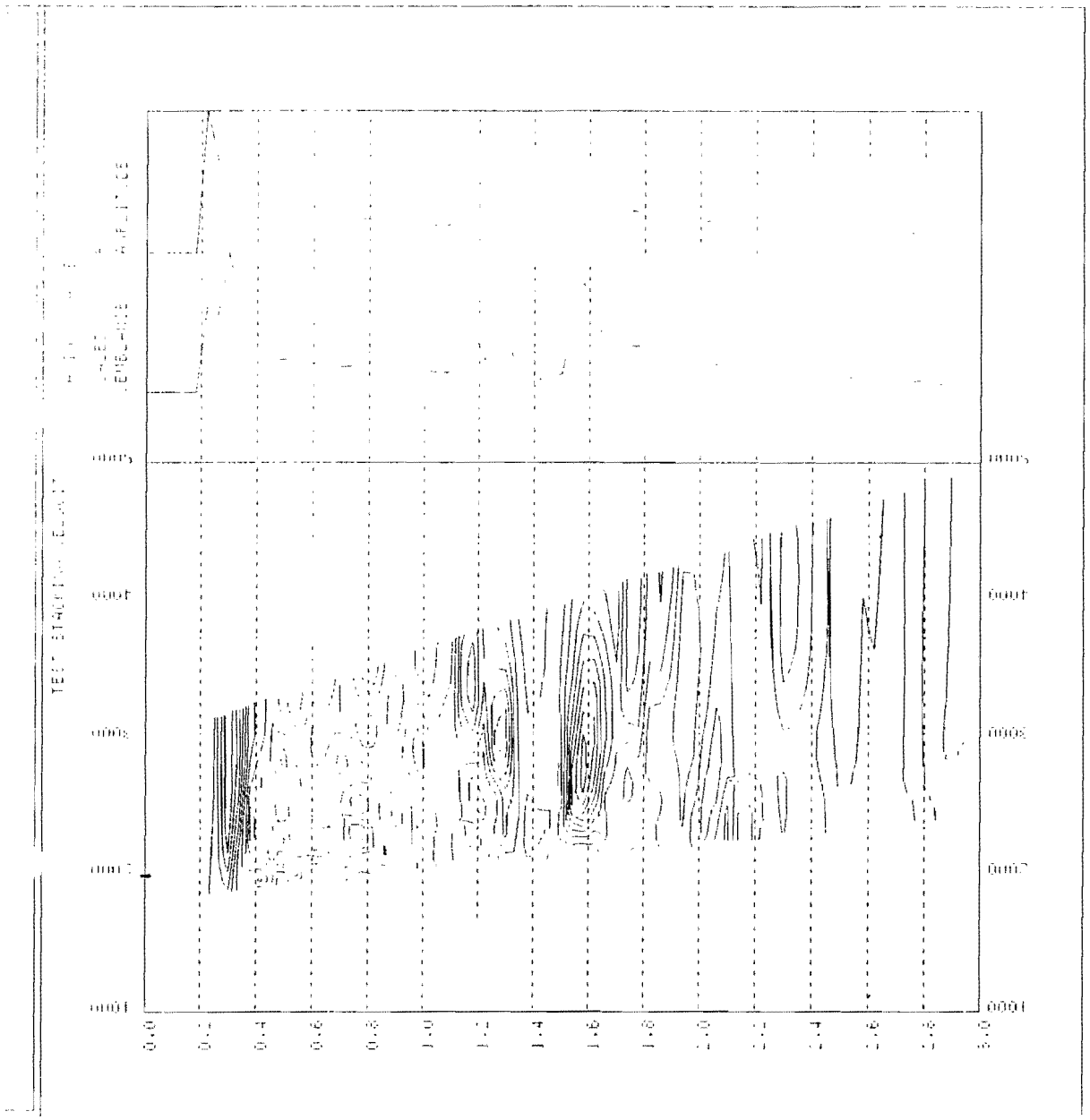
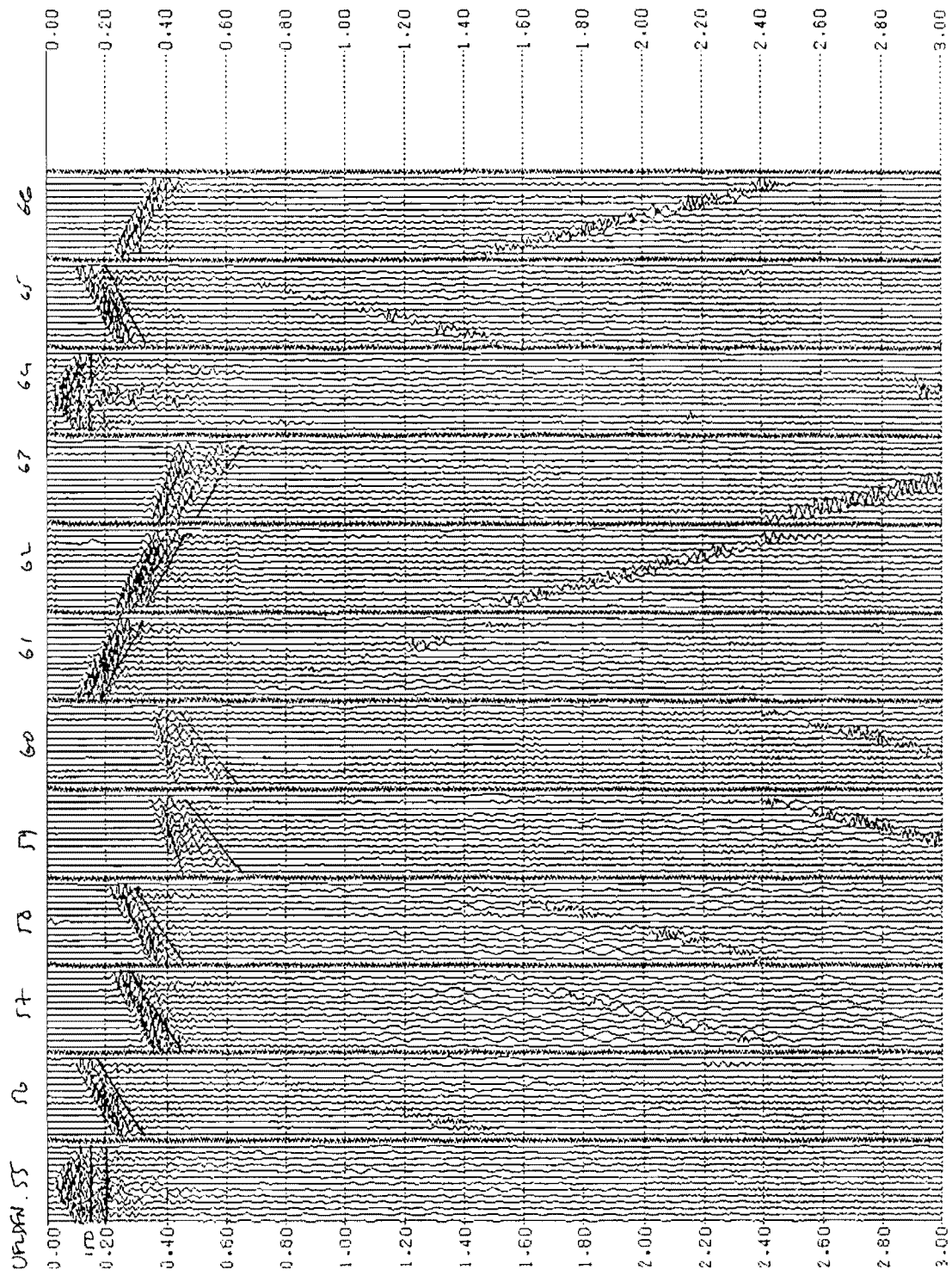


Fig. 5. Display of field files (shot records) using ISAN on a Tek 4014 type terminal plus screen dump printer. Such displays are useful for printing mute functions, identifying bad data, etc.



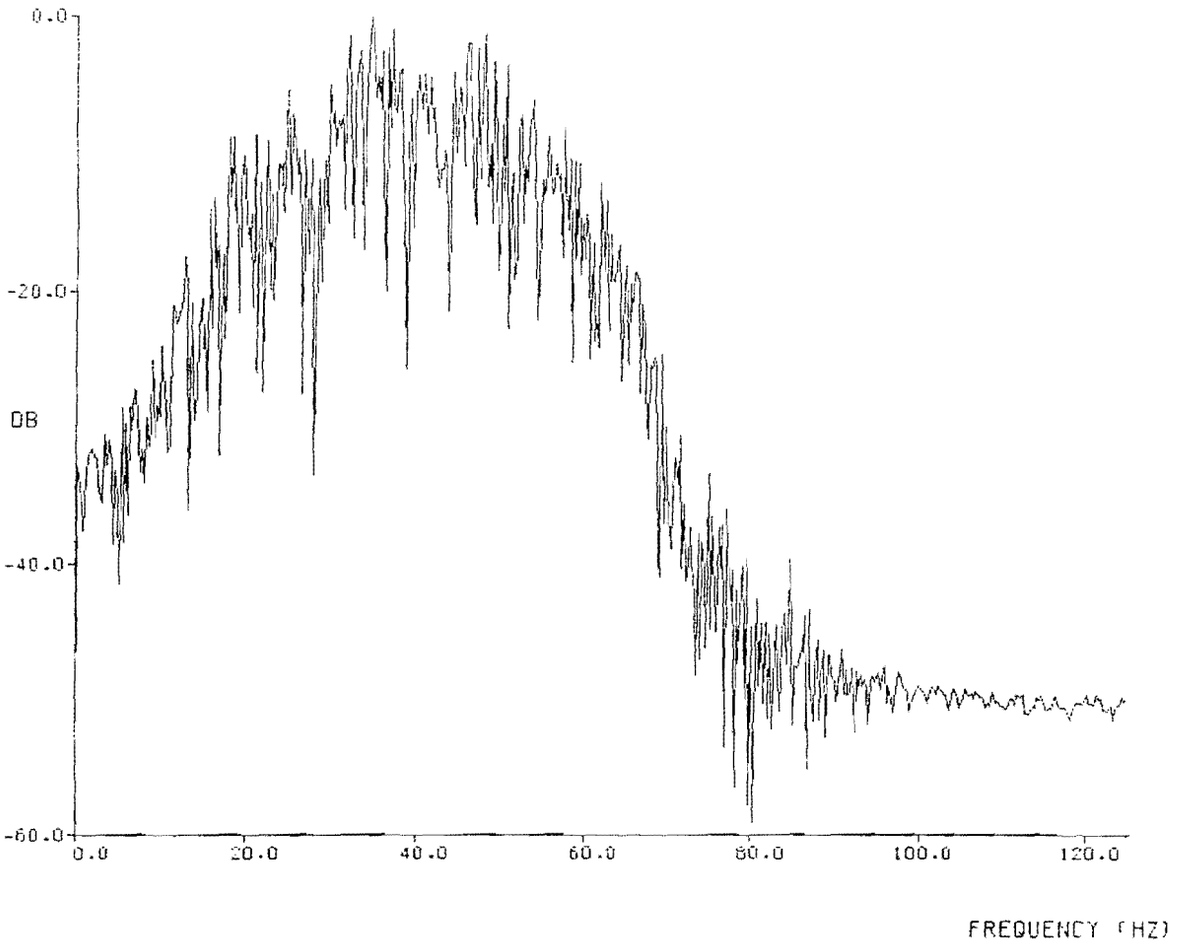


Fig. 6. ISAN display (cf. Fig. 5) of the amplitude spectrum of a single trace.

```
* Make up geometry dbase and put into trace headers
:DBAS
   DATABASE SK4                    SK4GEOM
   LSTRAT 1
   CSTRAT 1
*:INPUT
*   DATA 1 6000 4 12 2
*   AUXLOC 12
* Only pass thru live traces
*   TRACES 1(1)12
*   QUAL SKYE
** Start from the original file for processing
*   DISCFILE SK3SHOT
*   BI 116 EI 130
*   DISCFILE SK3SHOT
*   BI 132 EI 134
*****This group only needed once*********

:GEOM
   UNITS METRES
   RECTYPE FLF
   CHKANG 60
   CHKINT 100
   CHKSOF 600
* Spread definitions
   SPREAD  1  1,-66  12,-88
   SPREAD  2  1,-55  12,-77
   SPREAD  3  1,-44  12,-66
   SPREAD  4  1,-33  12,-55
   SPREAD  5  1,-11  12,-33
   SPREAD  6  1, 55  12, 33
   SPREAD  7  1, 66  12, 44
   SPREAD  8  1, 66  12, 88
   SPREAD  9  1, 44  12, 66
* Station definition
   STNS 1 155
   STNINT 15
   COORDS   1 141640 867275
           34 142120 867395
           56 142450 867380
           89 142940 867390
          100 143110 867425
          155 143820 867840

* The following records
   REC 121 122
* were shot using these spreads
   SPRD 4 R 121
   SPRD 2 R 122
* with these perp and inline offsets
   SOFF PL -25 0 R 121
* at these stations
   STN 122 144
            :
            :
         (etc.)
            :
            :
* The following records
   REC 138 139
* were shot using these spreads
   SPRD 8 R 138
   SPRD 1 R 139
* with these perp and inline offsets
   SOFF PL 80 0 R 138
   SOFF PL 20 0 R 139
* at the following stations
   STN 45 133

* Line processing as defined in LSTRAT 1
:PROC
*   AUTO 100 5 0.5 1.0
* Bin definition as defined in CSTRAT 1
:BIND
   CLINE PROC BIN
   DIAM 1.0 30.0
*****************************
:GMAP
:BINA
* Data at this stage is type 5 (shot + geom info) - but 18
* different shots
```

NB This processor has been commented out from this job file.

Fig. 7. Extract from a geometry definition job file, to demonstrate the extensive commenting which is advisable for the file to be understood.

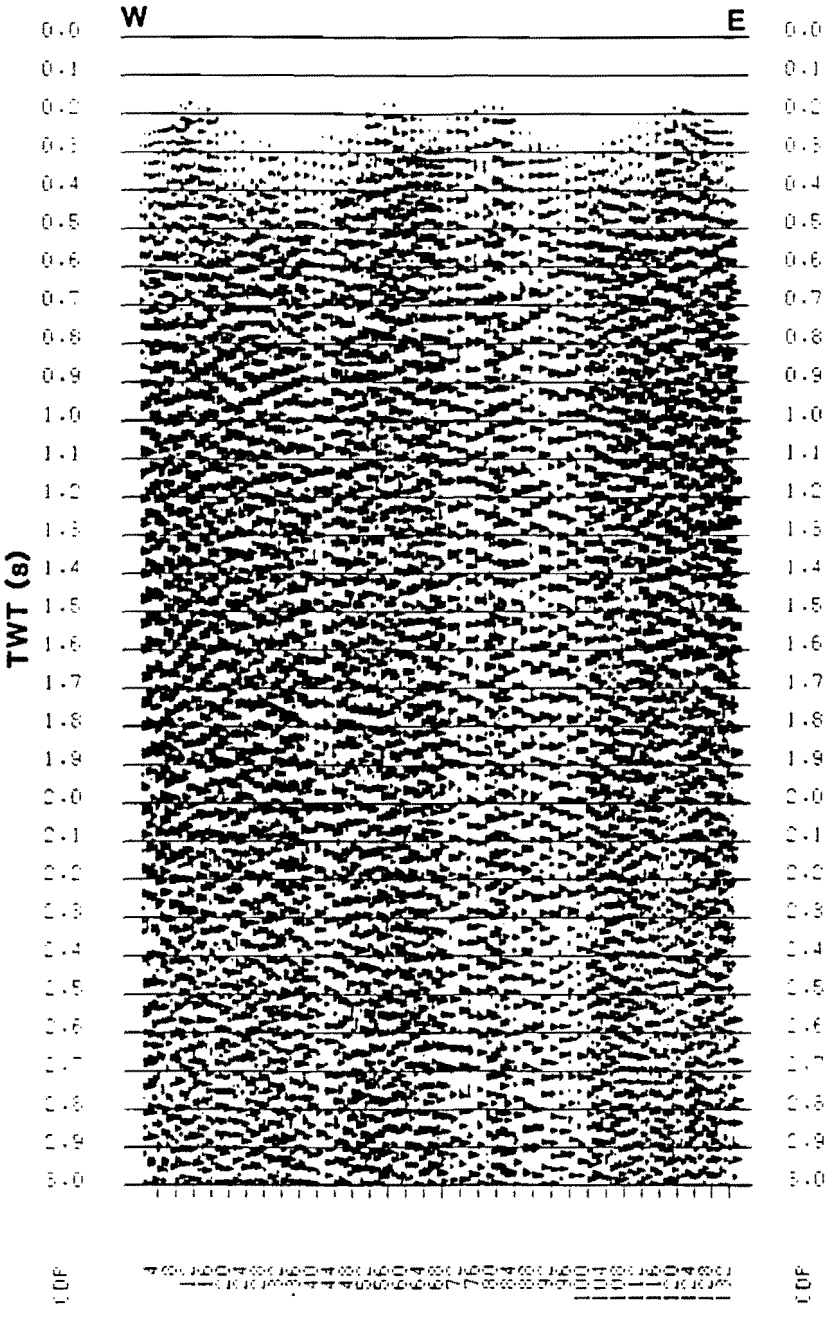


Fig. 8a. Final stacked section of 2km length of analog reflection data obtained in Skye in 1971.

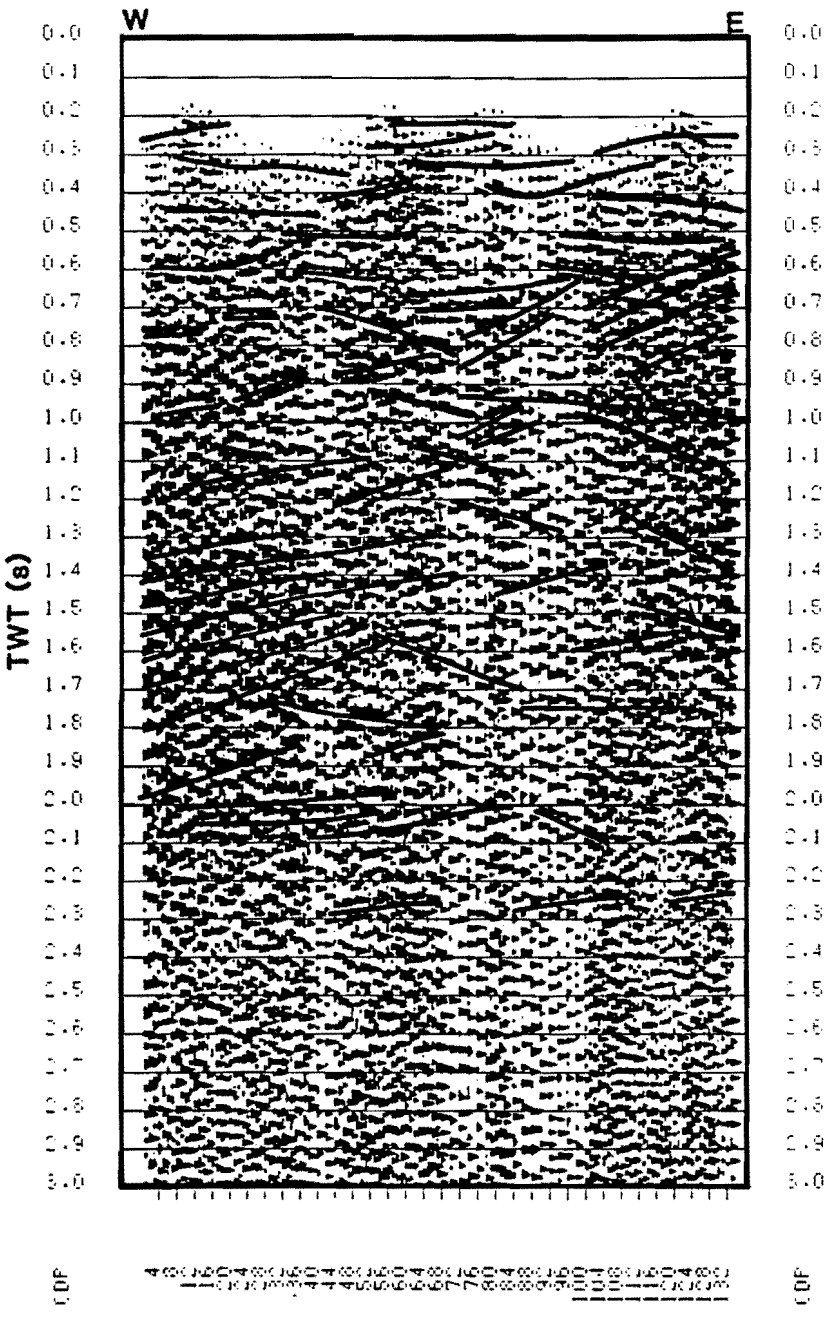


Fig. 8b. Line drawing interpretation of the data of Figure 8a.

FIGURE CAPTIONS

Fig. 1. The box of information in the LOG file from the :GEM processor, required for further processing. This shows a modulus of 72 (NB wrongly spelled throughout SKS documentation as modulas), fold of coverage of 2, and trace sorting code of 5.

Fig. 2. Layout of separate sheets and files from the LN03 plus laser printer. Current errors in the device driver produce slight sealing error at the bottom of each A4 sheet (shaded) and a gap in data between each file L9, L2, etc.

Fig 3. The very first plot produced by SKS on the Edinburgh VAX 8500. The second plot file produced by the same job merely contains the right-hand edges of the two information panels, so need not be printed.

Fig. 4. Semblance plot; very weak lines are not due to faulty laser plotter, but to the decision to use single pixel line widths (not recommended by DEC) to improve the resolution of plots (e.g. Fig. 3).

Fig. 5. Display of field files (shot records) using ISAN on a Tek 4014 type terminal plus screen dump printer. Such displays are useful for printing mute functions, identifying bad data, etc.

Fig. 6. ISAN display (cf. Fig. 5) of the amplitude spectrum of a single trace.

Fig. 7. Extract from a geometry definition job file, to demonstrate the extensive commenting which is advisable for the file to be understood.

Fig. 8a. Final stacked section of 2km length of analog reflection data obtained in Skye in 1971.

Fig. 8b. Line drawing interpretation of the data of Figure 8a.