1991/60
c.4

BUREAU OF MINERAL RESOURCES
LIBRARY
22 JUL 1991
CANBERRA, A.C.T.

Bureau of Mineral Resources, Geology & Geophysics

BMR PUBLICATIONS COMPACTUS
(LENDING SECTION)

R E C O R D

Record 1991/60

AUSTPLAY

A MENU DRIVEN COMPUTER PROGRAM FOR THE ASSESSMENT OF UNDISCOVERED PETROLEUM RESOURCES

USER'S MANUAL

BY

ALAN L HINDE, DAVID J FORMAN, and

ANDRZEJ P RADLINSKI

1991/60
c.4

The information contained in this report has been obtained by the Bureau of Mineral Resources, Geology and Geophysics as part of the policy of the Australian Government to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus or statement without the permission in writing of the Director.

Bureau of Mineral Resources,
Geology & Geophysics

Record 1991/60

AUSTPLAY

A MENU DRIVEN COMPUTER PROGRAM FOR THE ASSESSMENT OF UNDISCOVERED PETROLEUM RESOURCES

USER'S MANUAL

BY

ALAN L HINDE, DAVID J FORMAN, and

ANDRZEJ P RADLINSKI

Program AUSTPLAY may be purchased for $5000 from: **BMR** *Geology and Geophysics*, Australia (Sales Centre)
GPO Box 378
Canberra ACT 2601
Telephone: (06) 249 9642 Fax: (06) 257 6466

© Commonwealth of Australia, 1991
This work is copyright. Apart from any fair dealing for the purposes of study, research, criticism or review, as permitted under the Copyright Act, no part may be reproduced by any process without written permission. Inquiries should be directed to the Principal Information Officer, Bureau of Mineral Resources, Geology and Geophysics, GPO Box 378, Canberra, ACT 2601.

CONTENTS

1. INTRODUCTION 4

2. INSTALLATION OF AUSTPLAY 5
2.1 INSTALLATION ONTO HARD DISK 5
Directory: C:\AUSTPLAY 5
Directory: C:\BAT (batch file directory) 6
Directory: C:\DOS (DOS system files) 6
Directory: C:\WS (Wordstar directory) 6
Directory: C:\WS\INSET (Inset directory) 6
Alterations to C:\AUTOEXEC.BAT and C:\CONFIG.SYS 7
2.2 THE RAM DISK 8

3. WELL DATA BASE 8
3.1 Entering well data 8
3.2 Saving, sorting, and selecting subsets of the data base 10
3.3 Locating specific wells within a file. 10
3.4 'Load file of forms' 11
3.5 'Save file of forms' 12
3.6 'Sort well forms:' 13
3.7 '- specify sort' 13
3.8 '- remove orders' 14
3.9 'Subset of forms:' 14
3.10 '- specify masks' 14
3.11 '- load masks' 16
3.12 '- save masks' 16
3.13 '- cancel masks' 16
3.14 '- use boundary' 16
3.15 'Add file of forms' 17
3.16 'Add well from a file' 17
3.17 'Delete well file' 17
3.18 'Edit well form' 18
3.19 'List' 18
3.20 'Print' 19

4. PLOTTING AND ANALYSING THE WELL DATA 20
4.1 'log Ac vs Ndrill' 20
4.2 'log Ad vs Ndrill' 20
4.3 'log V/Ac vs Ndisc' 21
4.4 'log V/Ad vs Ndisc' 21
4.5 'log Ad/Ac vs Ndrill' 22
4.6 'success rate' 22

5. INTERACTING WITH THE PLOTTING AND ANALYSIS OF DATA 23
5.1 Tagging the data 23
left TAG 23
right RE-PLOT 23

5.2 Wobbling the fitted line 23
both WOBBLE 24
left INTERCEPT 24
right SLOPE 24
both ABORT 24
5.3 Icons 24
ACCPT 24
ABORT 24
SCALE 24
TITLE 25

6. THE STATISTICAL ANALYSIS 25
6.1 Slope, intercept, and standard deviation of residuals 25
6.2 z-statistic 26
6.3 Lambda 26
6.4 The standard deviation of lambda 26
6.5 Log normal? 27

7. PLAY DATA FORM FILING SYSTEM 28
7.1 Play data form 28
7.2 'Load file of forms' 29
7.3 'Select play form' 30
7.4 'Sort play forms' 30
7.5 'Specify subset ' 31
7.6 'Delete play form' 32
7.7 'Delete file of forms' 32
7.8 'Save play form' 33
7.9 'Save in new file' 33
7.10 'Save subset of forms' 34
7.11 'Calc drill seq traps' 34
7.12 'Edit play form' 35

8. RUNNING AN ASSESSMENT 35
8.1 'Run oil assessment' 35
8.2 'Run gas assessment' 35
8.3 'Run & sum all oil' 36
8.4 'Run & sum all gas' 36
8.5 'Set no. iterations' 38
8.6 'Set histogram range' 39

9. PRINTING OR STORING THE ASSESSMENT 39
9.1 'Print assessment' 40
9.2 The printout 40
General information 40
Statistical moments of unrisked recoverable resources 41
Mean 41
Standard deviation 41
Skewness 41
Kurtosis 42
Statistical moments of risked recoverable resources 42
The risks 42
Economic risk 43

Generation risk....43
Trap risk....43
Total risk....43
Percentiles of recoverable resources....43
Cumulative probability distribution of recoverable resouces....44
Mean cutoff for resources per unit area....44
Maximum field size....44
Seriation of generated accumulation sizes....45
Cutoff statistics....45
Area cutoff....46
V/A cutoff....46
Maximum accumulation size cutoff....46
Minimum accumulation size cutoff....46
Average number of economic discoveries....46
Input data....47
9.3 'Save assessment'....47
9.4 'View with Wordstar'....47

10. TRANSFERRING WELL DATA FROM AUSTRES WITHIN BMR'S PEDIN DATA BASE....48
10.1 Entering CEO and logging onto BMR's DG computer....48
10.2 Extracting well data from PEDIN....49
10.3 Transferring the extracted well data to the personal computer....50

11. REFERENCES....50

FIGURES

Figure 1.1 - The organisation of AUSTPLAY....4
Figure 3.1 - The well data form....9
Figure 3.2 - An example of locating specific wells in a well file....11
Figure 3.3 - The form for specifying masks....15
Figure 3.4 - Listing of the well data base....18
Figure 7.1 - The play data form....28

1. INTRODUCTION

AUSTPLAY is a menu-driven program with on-screen help for the assessment of undiscovered petroleum resources. It can assess prospects, plays, or entire basins, world-wide.

Figure 1.1 is a flowchart showing how AUSTPLAY is organised.

In order to assess a play, the user must compile information about the area and geometry of its traps, and the sizes of its accumulations in the well data base, accessed by an '<Alt>-W' keystroke (abbreviated ^W - simultaneously holding down the <Alt> key and the W key). Some of these data are sorted, plotted, and analysed using a part of the program accessed by an ^G keystroke. The user must then interpret the historic trends, select analogues, make quantitative models, and use subjective judgement in order to determine the information to be entered onto the play data form.

The use of AUSTPLAY centres around the well data form (Figure 3.1), which appears on the computer screen when the program is first entered, and the play data form (Figure 7.1) which is stored on disk in a filing system accessed by ^L.

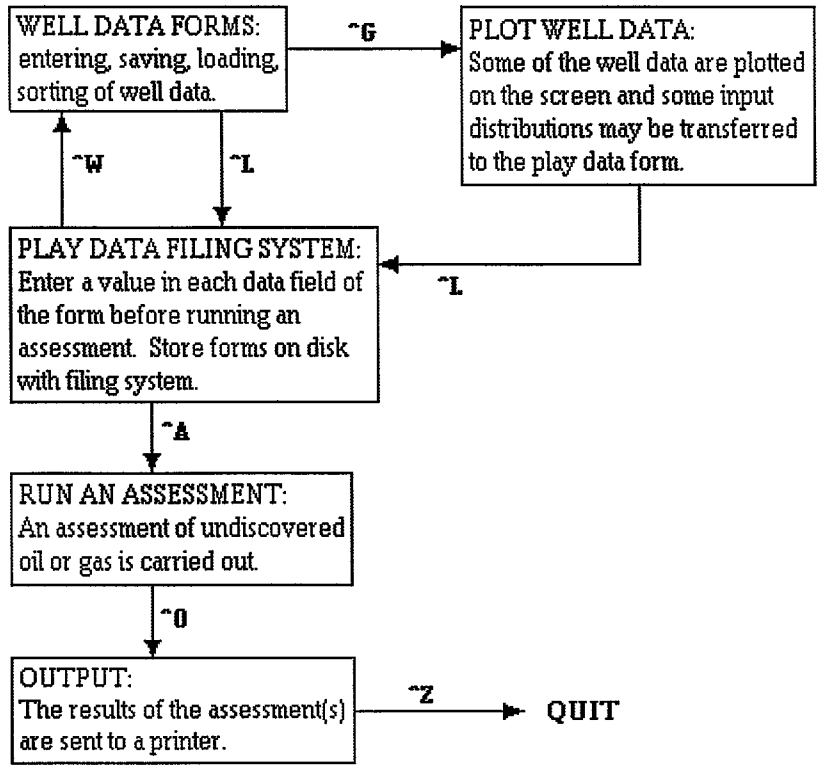


Figure 1.1 - The organisation of AUSTPLAY.

An assessment is carried out using the ^A keystroke. AUSTPLAY simulates drilling each untested trap in each play. It estimates the size of each simulated discovery using estimates of the area of closure and of the resources per unit area of closure of each trap which are entered onto the play data form in order of drilling or discovery, as loglinear models. The program also uses other types of information from the play data form such as existence risk, success rate, the proportion of oil to oil and gas, and the smallest size of accumulation to be included as a resource. Output of the assessment is printed using ^O. Undiscovered resources are given as cumulative probability distributions. The averages and standard deviations of the accumulation sizes are also output.

The program is exited with ^Z.

The methodology is described in detail in: Forman, Cadman, Hinde and Radlinski (1989); Forman, Hinde and Cadman (1989); Forman, Hinde and Radlinski (in press); and Forman, Hinde, Cadman, Radlinski, and Morton (in press). The methodology is also described on screen in HELP which is available using ^H when the well and play data forms are displayed.

2. INSTALLATION OF AUSTPLAY

This chapter describes how to install AUSTPLAY on a personal computer. The computer should be an IBM compatible 486 or a 386 supplied with a maths coprocessor chip, at least 2 MEG of RAM, a hard disk, installed as drive C:, a RAM disk, installed as drive D:, and MetaWINDOW-DOS-resident graphics-driver and font files.

2.1. INSTALLATION ONTO HARD DISK

The following directories must be created on the hard disk and the following files copied to them.

Directory: C:\AUSTPLAY

AUSTMAIN.EXE	-	executable file for starting AUSTPLAY. First invoked by the batch command AUSTPLAY; it contains the codes for the well data base and the play data form filing system.
OP_MAINV.EXE	-	executable file invoked for plotting well data (the interactive plots).
OP_MAINS.EXE	-	executable file invoked for plotting well data (the success rate plot).
AUSTRUN.EXE	-	executable file invoked for running assessments.
HELP.DOC	-	text for displaying on-screen help.
MARKERS.FNT	-	MetaWINDOWS font file for graphics.
ROMANSIM.FNT	-	" " " " " "
SYSTEM16.FNT	-	" " " " " "
SYSTEM24.FNT	-	" " " " " "
METAWNDO.EXE	-	MetaWINDOWS graphics driver.

The MetaWINDOWS files must be purchased separately (note that MetaWINDOWS will not run on some Toshiba personal computers).

Directory: C:\BAT (batch file directory)

AUSTPLAY.BAT - DOS macro file for invoking AUSTMAIN.EXE and controlling the execution of the other executables.

Some lines should be removed from this file (see 'Directory: C:\WS\INSET (Inset Directory)' below) if INSET is not installed.

Directory: C:\DOS (DOS system files)

ANSI.SYS
COMMAND.COM
COUNTRY.SYS
RAMDRIVE.SYS

Directory: C:\WS (Wordstar directory)

Wordstar is installed in this optional directory (see Wordstar manual) in order to use the menu item 'View with Wordstar' under ^O. Once installed, Wordstar must be configured to accept files on drive D:. This is done by typing 'C:\WS\WINSTALL' after the DOS prompt, selecting the menu item 'Customize WordStar (WSCHANGE)' with the down-arrow key and pressing <Enter>, and typing the following commands.

C	(Computer ..... Disk Drives Wordstar files)
A	(Disk drives ..... Valid disk drives)
A	(Valid disk drives)
Y	(to change the current valid disk drives)

Next, specify each disk drive already valid by following the instructions displayed on the screen, then type

D	(to specify drive D as valid)
N	(to indicate that the drive is not a floppy disk drive)
<Enter>	(to exit)
X	('')
X	('')
X	('')
Y	('')

Finally, select the menu item 'Save and Return to DOS', and press <Enter>.

Directory: C:\WS\INSET (Inset directory)

Inset is installed in this optional directory (see Inset manual) in order to capture and plot screens. If absent, the lines

'cd c:\ws\inset'
'inset/s'

and

'cd c:\ws\inset'
'ri'

should be removed from the file C:\BAT\AUSTPLAY.BAT.

Once installed, run program SETUP, in this directory, once, and reset the override pop-up keys and override macro by typing the following commands: 'CD C:\WS\INSET' after the DOS prompt; 'SETUP'; then:

CD C:\WS\INSET	(to enter the INSET directory)
SETUP	(to run the Inset SETUP program)
M	(to select the override pop-up keys option)
N	(to indicate that the current setting is wrong)
2	(to indicate that two simultaneous keys are to be used)
<Alt><PrintScrn>	(to set the override pop-up keys to <Alt><PrintScrn> - this is equivalent to<Alt><SysRq>. See Note below, however.)
Y	(to accept the entry)
O	(to select the override macro option)
ME3ID00112233445566778899AABBCCDDEEFF^BS^^PG^N	(to set the macro so that the screen will be plotted with an expansion factor of x3 if <Alt><PrintScrn> is pressed and INSET is loaded with the /s option (INSET is automatically loaded with the /s option when AUSTPLAY is invoked).)
<Enter>	(to accept the entry)
F10	(to exit SETUP and save the settings)

Note: If AUSTPLAY is to be run in the WINDOWS environment, <Alt><PrintScrn> would put the display into the Clipboard. To avoid this replace <Alt><PrintScrn> with shift-F10 in the above instuctions.

When the above procedure has been carried out, it will be possible to plot the screen anywhere in AUSTPLAY by pressing <Alt><PrintScrn> simultaneously or shift-F10. Alternatively, INSET may be invoked by pressing left-<Ctrl> and left-<Shift> simultaneously; the screen may then be printed by selecting the appropriate menu and sub-menu items.

Alterations to C:\AUTOEXEC.BAT and C:\CONFIG.SYS

In addition to the above files the following line:

PATH C:\BAT

must be present in the file C:\AUTOEXEC.BAT to ensure that DOS searches the C:\BAT directory when invoking AUSTPLAY, and the line:

DEVICE=C:\RAMDRIVE.SYS 512/e

must be added to the file C:\CONFIG.SYS so that a RAM disk (drive D:) will be set up when the computer is booted up. The value of 512 may be changed to give a larger or smaller RAM disk. The size of the RAM disk limits the number of well data forms that can be loaded into the computer.

Note: If drive D: is already present as a hard disk, this line is not necessary. The program will use the hard disk, but may run a little slower when accessing it.

2.2. THE RAM DISK

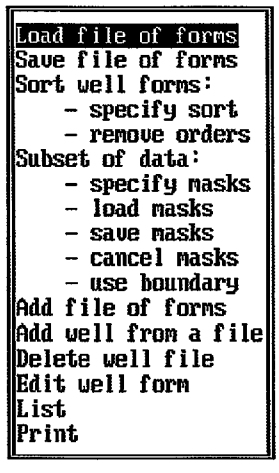
A RAM disk will be set up as drive D: when the computer is booted up, with the above files installed. Various files will be written to the RAM disk for temporary storage during execution of AUSTPLAY. The largest of these is a copy of the file of forms which is loaded with the menu item 'Load file of forms' after pressing ^W.

The files that are created on the RAM disk are as follows.

WELL_DAT	-	stores the well data forms.
WDATA	-	stores information needed to file, list, sort, and display the well data forms.
PDATA	-	stores information needed to file, list, sort, save, and display the play data forms.
SEL	-	records the ^G menu item that was selected.
COMMAND	-	records ^L, ^A, ^O, and ^W menu items.
_LS1	-	stores the assessment.

3. WELL DATA BASE

The well data base is a collection of well data forms stored within the computer. It may be accessed by ^W followed by selection of any of the ^W menu items shown below.



3.1. Entering well data

A blank well data form (Figure 3.1) appears automatically when the program is first entered. In order to type into a data field, the cursor is positioned within the field. The cursor is moved cyclically forwards through the data fields using the down-arrow key, or backwards using the up-arrow key. Within each data field, the cursor is moved to the next character position using the right-arrow key, or to the previous position using the left arrow key.

The data fields appear as red underscores. Help about the data field in which the cursor is positioned may be obtained by pressing ^H or F7 (the ^H command is shown at the bottom of the screen). In response to ^H or F7, the data form disappears and help text appears. If there is more text than can fit on one screen, the text will pause. Press any key to continue to the next page or <Esc> to return to the play data form. Press any key to return to the play data form when all the help text has been displayed.

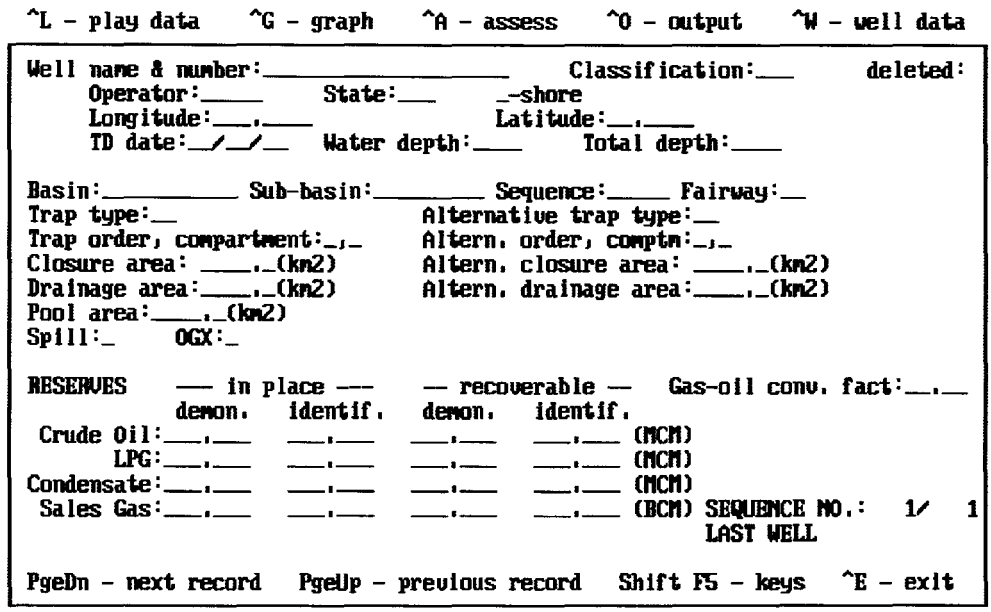


Figure 3.1 - The well data form

The following keys are used to enter the data. These keys and their actions are listed on the computer screen when shift-F5 is pressed as noted at the bottom of the screen.

down-arrow	-	move cursor to the next data field;
Enter	-	" " " " " " "
Tab	-	" " " " " " "
up-arrow	-	move cursor to the previous data field;
Home	-	" " " " " " "
right-arrow	-	move cursor one character to the right;
left-arrow	-	move cursor one character to the left;
Delete or F8	-	delete one character;
Insert	-	insert one space;
Esc	-	escape from the current data field and cancel any changes to it;
^H or F7	-	show help about the current data field;
^Z	-	quit the program (leave AUSTPLAY);
^E	-	exit to the play data form (leave the data base);
F1	-	Execute query (retrieve wells that match the data entered using F2);
F2	-	Enter query (enter data in any of the data fields for retrieving matching wells);
F3		'Save file of forms';
F4	-	insert an empty well data form after the current one;

F7	-	show help about the current data field;
F8	-	delete one character;
F9	-	clear the well data form;
F10	-	clear the remainder of the well data form from the current data field to the end;
shift-F1	-	count the number of query hits;
shift-F3	-	duplicate data from the previous well into the current data field;
shift-F4	-	duplicate all the data for the previous well into the current well. (This only works if the current well data form is empty, ie if it has been created using F4);
shift-F5	-	show the meanings of the various keys displayed in this table;
shift-F6	-	set the delete status;
shift-F7	-	reset the delete status;
shift-F9	-	delete (remove) the currently displayed well;
shift-F10	-	plot the screen on the laser printer.

Another blank well data form may be obtained by pressing F4. A copy of the previous well data form may be obtained using shift-F4 or an individual data field may be copied using shift-F3, after positioning the cursor on the required field.

Alternatively, well data may be transferred from BMR's AUSTRES data base, which is part of the PEDIN data base. This is done by terminating AUSTPLAY and using the CEO software. The process is described in chapter 10.

At the bottom of the well data form on the right is shown '**SEQUENCE NO.: 1/ 1**'. This gives the sequence number of the well within the data base (first number), and the total number of wells in the data base (second number). The message '**LAST WELL**' is shown beneath these numbers whenever the currently displayed well is the last in the data base.

3.2. Saving, sorting, and selecting subsets of the data base

Data are saved to disk using the menu item 'Save file of forms', and later reloaded using 'Load file of forms'. The <Page up> and <Page Down> keys may be used to cycle through the wells. The wells may be sorted in a number of ways using menu items under 'Sort well forms:'. A subset of the wells may be selected using items under 'Subset of forms:'.

Wells may be permanently deleted from the loaded or entered well data forms using shift-F9. Alternatively, a well may be deleted from plots produced using ^G by setting the delete status with shift-F6. This causes an asterisk (*) to appear after the word 'deleted:' at the top right of the well data form. The delete status is removed by pressing shift-F7.

3.3. Locating specific wells within a file.

The wells that match specific data in any or all of the data fields may be located in the loaded or entered well data forms by pressing F2 ('enter query') whereupon an empty well data form will appear. At the bottom of the form appears the line, in yellow:

ENTER QUERY (specify fields as required) (% may be used as a mask)

The required data fields are filled out. The % sign may be used before or after any characters in a data field, but not amongst them. It is used to unconditionally match characters before (and/or after) the

entered characters. For example, to retrieve all wells beginning with the characters 'Gidgea', the characters 'Gidgea%' would be entered into the well name & number data field. If the query is to be further restricted to operators ending in the characters 'hi', the characters '%hi', would be entered into the operator data field. The well data form would then appear as in figure 3.2.

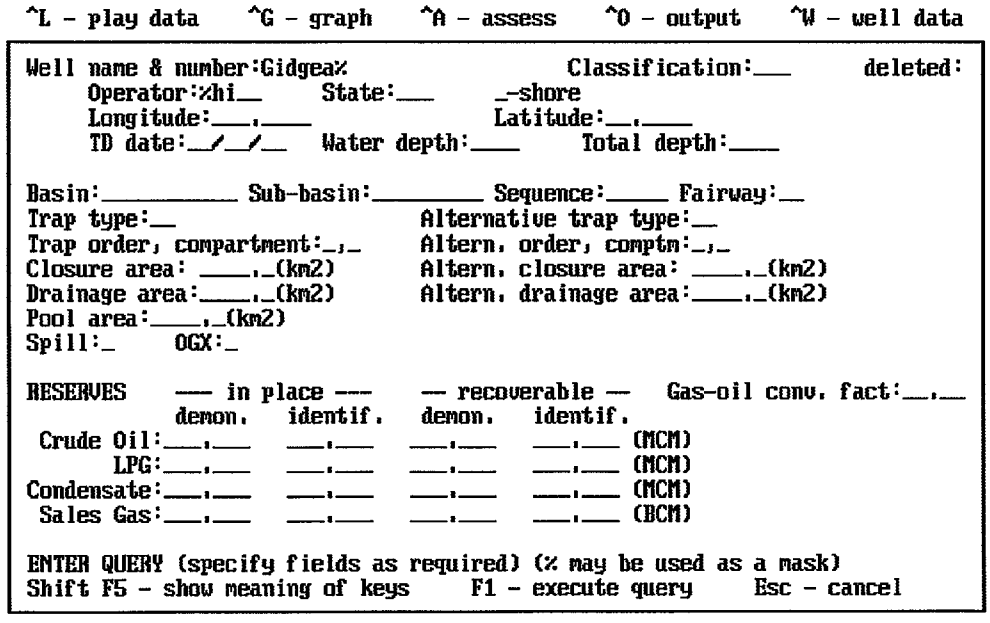


Figure 3.2 - An example of locating specific wells in a well file.

While entering a query some of the keys used for editing the well data form will not work: in particular, <Page Up>; <Page Down>; ^Z; F4; shift-F3; shift-F4; shift-F6; shift-F7; and shift-F9. As usual, shift-F5 will display the list of available keys, and their actions.

After the query form has been completed, the matching wells are retrieved by pressing F1. This displays them one at a time and the bottom line indicates, in yellow, how many more remain. 'Last match to query' appears on the line when the last one is displayed.

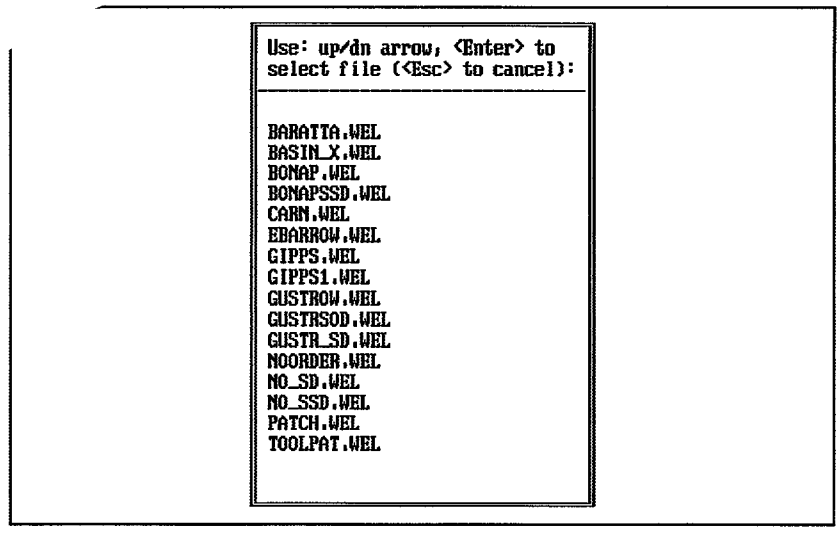
Pressing F1 gives the message '**No matches to query**' either when there are no matches, or when '**Last match to query**' appears.

Each ^W menu item is described now in detail.

3.4. 'Load file of forms'

Selection of this menu item loads a file of well data forms from disk into the computer.

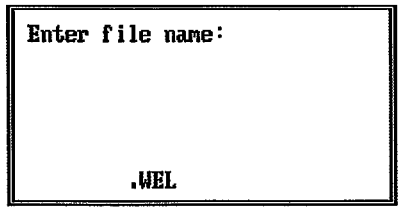
When this menu item is selected a window like the following will appear on the screen.



The window lists the available files. A file is selected by using the up-arrow and down-arrow keys to highlight it. The two lines at the top of the window remind the user to use the up-arrow, down-arrow keys to highlight the file, and the <Enter> key to load the file and display the first form. The <Esc> key is used to cancel the selection procedure.

3.5. 'Save file of forms'

The well data forms in the computer may be saved to disk by selecting this menu item. The following window will appear when the menu item is selected.



An eight letter file name should be entered in the space before '.WEL' and the well data forms saved to disk by pressing <Enter>. If the forms were originally loaded from disk using 'Load file of forms', the file name will appear before the extension '.WEL' (the '.WEL' extension identifies a well data base file). Press <Enter> to replace the data in this file.

If the data are to be saved in a different file, or if the data have not yet been saved on disk, the user may type in a file name of up to eight letters. The file name is entered using the keys listed below.

left-arrow	-	moves cursor one character to the left;
right-arrow	-	moves cursor one character to the right;
Backspace	-	deletes previous character;
Delete	-	deletes current character and closes up;
Insert	-	inserts a space;
Esc	-	cancels the saving procedure and re-displays the well data form.

Press <Enter> after the file name has been typed in and the well data forms will be saved to disk.

A message will appear if there are no new data or if there are no well data to be saved.

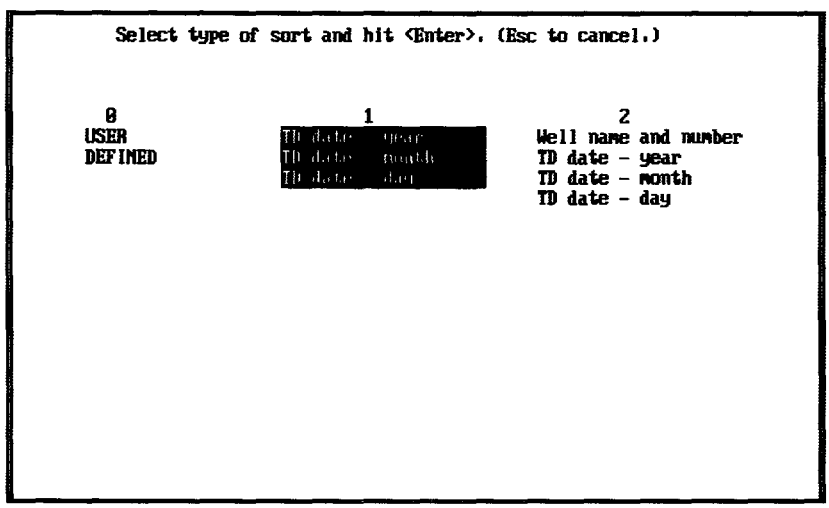
3.6. 'Sort well forms:'

Two menu items appear beneath this heading. They are used for sorting a loaded file and for condensing the file by removing information about the orders of the traps.

3.7. '- specify sort'

This menu item allows the user to sort a loaded well file according to a list of sort fields. The list may be selected from a number of preset lists or it may be constructed by the user.

The following window will appear.



The window contains three columns. The left-most column, headed '0', is used to construct a list of sort fields, while the other columns are used to select preset sort lists. There are a total of nine preset lists (headed '1' to '9'), listed below:

1 - TD date;
2 - Well name and number, TD date;
3 - Well name and number, sequence, fairway, trap type, order of trap;
4 - Basin, sub-basin, TD date;
5 - Basin, sub-basin, sequence, fairway, trap type, order of trap, TD date;
6 - Basin, sub-basin, sequence, fairway, order of trap;
7 - Basin, sub-basin, sequence, fairway, trap type;
8 - Basin, sub-basin, sequence, fairway, TD date;
9 - State, well name and number.

A column is chosen by using the left- and right-arrow keys then pressing <Enter>. Pressing the right-arrow key a number of times will bring other preset sort lists into view.

Note that sorting by TD date requires that the year has to appear first, followed by the month, then the day.

Upon pressing <Enter>, the message '**Sorting the wells ....**' appears. It may take several seconds or a few minutes to sort the wells, after which the first well form is displayed. The <Page Down> and <Page Up> keys may then be used to cycle through the wells in their new order.

The following screen appears when the column headed '0' ('**USER DEFINED**') is selected.

```
 1. Well name and number   2. Delete status (*)     3. Well classification
 4. Operator               5. State                 6. On/offshore (N/F)
 7. Longitude              8. Latitude              9. TD date - day
10. TD date - month       11. TD date - year       12. Water depth (m)
13. Total depth (m)       14. Basin                15. Sub-basin
16. Sequence              17. Fairway              18. Trap type
19. Alternate trap type   20. Order of trap        21. Compartment
22. Alternate order       23. Altern. compartment  24. Closure area (km2)
25. Altern. clos. area    26. Drainage area (km2)  27. Altern. drain. area
28. Pool area (km2)       29. Filled to spill?     30. O-oil, G-gas, X-both
31. Gas-oil conv. fact    32. Oil demon. in place  33. Oil ident. in place
34. Oil demon. recov.     35. Oil ident. recov.    36. LPG demon. in place
37. LPG ident. in place   38. LPG demon. recov.    39. LPG ident. recov.
40. Cond demon. in place  41. Cond ident. in place 42. Cond demon. recov.
43. Cond ident. recov.    44. Gas demon. in place  45. Gas ident. in place
46. Gas demon. recov.     47. Gas ident. recov.

Enter numbers corresponding to the fields to be sorted,
separated by commas (no spaces). <Enter> to cancel.

>
```

The list shows the data fields, numbered 1 to 47. Instructions for specifying a sort list appear below it. For example, to sort by state, operator, and TD date, enter:

>5,4,11,10,9

followed by <Enter> (the '>' is already on the screen). The list of chosen data fields will appear and must be confirmed in order to commence sorting. A message will appear if a mistake has been made, and another sort may be attempted.

3.8. '- remove orders'

This menu item is used to select from the loaded file the subset of data that might have been available if the orders of traps were unknown. It selects the data from the form for the lowest order for each well, unless a discovery has been made in which case the data are selected from the form for the order in which the accumulation occurs.

The new subset should be saved in a separate file (using 'Save file of forms') and this file reloaded (using 'Load file of forms') before any further work is carried out. If not, and the new subset is later sorted, it will revert to the original file.

3.9. 'Subset of forms:'

Four menu items appear beneath this heading. They are used to create the masks that are required to select a subset of wells from the currently loaded well file, for loading and storing the masks on disk, and for cancelling the masks.

3.10. '- specify masks'

The mask form in figure 3.3 appears when this menu item is selected.

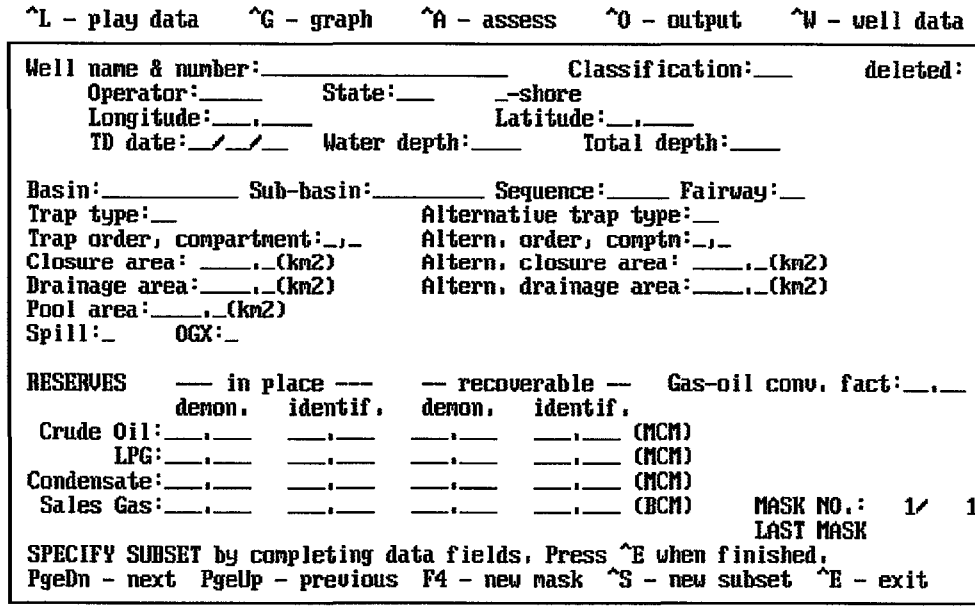


Figure 3.3 - The form for specifying masks.

The form contains the same data fields as the well data form. When some or all of these data fields are completed and ^E is pressed, the program will select the matching subset of wells.

'**MASK NO.: 1/ 1**' appears at the bottom right of the form. The first number is the current mask number and the second number shows the total number of masks. '**LAST MASK**' will appear beneath the mask number display when the last mask in the set is displayed. Use the <Page Up> and <Page Down> keys to cycle through all the masks. Press F4 to create another mask. Press ^S to cancel the current set of masks and start a new set.

The second last line of the form is coloured yellow. It briefly describes how to select a subset. The last line summarises the most important commands to be used when creating masks. A complete list of keys and their actions appear when shift-F5 is pressed. These are reproduced below.

down-arrow	-	move cursor to the next data field;
Enter	-	" " " " " " "
Tab	-	" " " " " " "
up-arrow	-	move cursor to the previous data field;
Home	-	" " " " " " "
right-arrow	-	move cursor one character to the right;
left-arrow	-	move cursor one character to the left;
Page down	-	display the next mask;
^N	-	" " " "
Page up	-	display the previous mask;
^V	-	" " " "
Delete or F8	-	delete one character;
Insert	-	insert one space;
Esc	-	escape from the current data field and cancel any changes to it;
^H or F7	-	show help about the current data field;
^S	-	delete all masks and start again (create a new subset);

^E	-	select the subset of wells using the entered masks;
F3		'- save masks';
F4	-	create (append) a new mask;
F7	-	show help about the current data field;
F8	-	delete one character;
F9	-	clear the data in the current mask;
F10	-	clear the remainder of the mask from the current data field to the end;
shift-F3	-	duplicate the data from the current field of the previous mask into the current field;
shift-F4	-	duplicate all the data from the previous mask into the current mask. (Note: this is only allowed for a newly-created mask with no data);
shift-F5	-	show the meanings of the various keys displayed in this table;
shift-F9	-	delete (remove) the current mask;
shift-F10	-	plot the screen on the laser printer.

The command ^E will select the subset using the masks that have been created. Each mask selects a subset and the final subset consists of all the subsets combined. For example, if a subset consisting of several fairways is required, a mask must be created for each of the fairways. The entire set of wells will be selected if no masks have been created (that is only one mask which is left blank). If, in contrast, there are no wells in the subset, the user is informed and the original well data base is restored.

If required, the masks may be saved using the menu option '- save masks'.

3.11. '- load masks'

A set of masks is loaded from disk using this option. Upon selecting the '- load masks' menu item a window will appear showing a list of files each containing a set of available masks. The files all have an extension of '.MSK'.

A file is selected using the up- and down-arrow keys to highlight the file. Pressing <Enter> will load the masks and select a subset of the current data file.

3.12. '- save masks'

A window appears when this menu item is selected. An eight letter file name should be entered in the space before '.MSK' and the file is saved to disk by pressing <Enter>.

A list of keys that may be used to enter the file name is listed under 'Save file of forms' above.

3.13. '- cancel masks'

When this menu item is selected, the subset of wells will be removed and the original file will be restored.

3.14. '- use boundary'

This menu item allows selection of all wells drilled inside or outside a specified boundary. When selected, the following instructions will appear on the screen.

To select wells INSIDE a boundary, enter the longitude and latitude
of the points that define the boundary, in clockwise order.

Enter numbers as decimal degrees separated by commas, eg 142.0425,27.0000.

Enter a parir of zeros (0.0,0.0) to signify the end of the boundary.

To select wells OUTSIDE the boundary, terminate the boundary with a pair of -1's (-1.,-1.).

The user then types in each longitude/latitude pair followed by <Enter>.

The longitude/latitude pairs are listed on the screen both in decimal degrees and in degrees, minutes, and seconds. The program checks to make sure that the boundary does not cross itself anywhere. If it does, the user is informed, otherwise a subset is selected by pressing <Enter>. Wells that are not located by longitude or latitude are excluded from the subset, and the original set of wells is retained if no wells are found.

3.15. 'Add file of forms'

This menu item allows a file of well data forms stored on disk to be added to the loaded file. A window will appear that shows a list of well files on disk (as with 'Load file of forms'). The up-arrow and down-arrow keys are used to highlight the required file and <Enter> is pressed to add all the forms in the file to the forms in the loaded file.

A message is displayed if the computer runs out of storage (on drive D:) and no more forms will be added.

3.16. 'Add well from a file'

This menu item allows a single well data form to be selected from a file of well data forms stored on disk and added to the loaded file. A window will appear that shows a list of well files on disk (as with 'Load file of forms'). The up- and down-arrow keys are used to highlight the required file and <Enter> is pressed to select it. Next, a list of the wells within the file will appear. The up- and down-arrow keys are used to highlight the required well and <Enter> is pressed to add the well to the working file. To add several wells from the same file, press the <Ctrl>-<Enter> keys simultaneously after highlighting the first well. The well will be added and the list of wells will reappear so that the process may be repeated, provided that storage remains on drive D.

3.17. 'Delete well file'

This menu item allows a file of well data forms to be deleted from disk. Upon selection of the menu item, a window will appear showing a list of well files (as with 'Load file of forms'). A well file is selected for deletion using the up- and down-arrow keys to highlight the required file, then pressing <Enter>, upon which the following window will appear.

```
Delete file:
TEST.WEL
(Y/N)?



N
```

Type the letter 'y', and press <Enter>, to delete the file. Press <Enter> to cancel the process (the <Esc> key will cancel the process at any time).

3.18. 'Edit well form'

A well data form will be displayed when this menu item is selected. The first well form will appear if a file of well forms has already been entered or loaded from disk, otherwise an empty well form will appear.

3.19. 'List'

When this menu item is selected the data for each well are listed on the screen in separate lines. Each line consists of 272 characters, but only part of the line is displayed as shown in Figure 3.4.

```
Well name and number*Cla Oper. Sta S Longitde Latitde TDdate WDep TDep Basin--
Well  1                  Delhi SA  N 140.0504 27.9456 100264      2749 Apea Ba
Well  2                  Delhi SA  N 139.9739 28.0225 020964      2659 Apea Ba
Well  3                  Pexa  SA  N 139.9089 28.2511 151069      2212 Apea Ba
Well  4                  Pexa  SA  N 139.9858 28.2611 111269      2228 Apea Ba
Well  5                  Delhi SA  N 140.0214 28.2633 010978      2327 Apea Ba
Well  6                  Delhi SA  N 140.0472 27.9028 250484      2841 Apea Ba
Well  7                  Delhi SA  N 139.8944 28.1347 210485      2011 Apea Ba
Well  8                  Delhi SA  N 140.0196 27.8774 300386      3246 Apea Ba
Well  9                  Delhi SA  N 139.9244 28.0689 150187      2662 Apea Ba
Well 10                  Delhi SA  N 139.9386 28.0511 220587      2627 Apea Ba
Well 11                  Delhi SA  N 139.8561 28.2794 140687      2149 Apea Ba
Well 12                  Delhi SA  N 139.8958 28.1986 200687      2012 Apea Ba
Well 13                  Santo SA  N 139.7801 28.2429 101187      1906 Apea Ba
Well 14                  Santo SA  N 140.0974 28.1356 021188      3175 Apea Ba
Well 15                  Santo SA  N 139.9989 28.1887 061188      2476 Apea Ba
Well 16                  Santo SA  N 139.9784 28.1794 220189      2478 Apea Ba
Well 17                  Santo SA  N 139.9721 28.2396 241089      2289 Apea Ba
-------------------------end----------of----------file-------------------------

SEQ:   1     COL:   1   Well name and number (A20)    Shift F5 - keys ^E - exit
```

Figure 3.4 - Listing of the well data base.

Abbreviated headings for each of the data fields appear above the box that contains the list. For example, the first twenty columns are headed 'Well name and number', the 21st is labelled '*', and the 22nd to 24th are labelled 'Cla'. These correspond to well name and number, delete status, and well classification respectively.

Additional information appears below the box. For example: the sequence number of the well on which the cursor is currently positioned (shown 'SEQ:' followed by the sequence number); the column number, within the 272-character line, on which the cursor is positioned (shown 'COL:' followed by the column number); the full name of the data field within which the cursor is positioned; the Fortran format for the data field (in brackets); a reminder that shift-F5 will display the commands that may be used to edit the list, and that ^E will exit from the listing.

The information shown on the bottom line will change as the cursor is moved throughout the file. Shifting the cursor to the far right (or far left) will shift the display to the next portion of the 272-line character listing, but the well name and number will always be shown at the left. Moving the cursor to the top (or bottom) of the box will display the adjacent lines of the file.

The file may be edited by placing the cursor within a data field and replacing the data. Characters may not be entered beyond the end of the data fields. The cursor can be moved to the next field by the keys as described below. The user must take care to type in valid data as very little checking is done.

The keys that may be used to both position the cursor and edit the file are listed below and can be viewed on the computer screen by pressing shift-F5.

down-arrow	-	move cursor to the next line of data;
up-arrow	-	move cursor to the previous line of data;
right-arrow	-	move cursor one character to the right;
left-arrow	-	move cursor one character to the left;
Tab	-	move cursor to the beginning of the next data field;
Enter	-	display the frame of data adjacent to the right of the display;
End	-	display the right-most frame of the lines;
Home	-	display the left-most frame of the lines;
Page Down	-	move cursor forward 20 lines;
Page Up	-	move cursor backward 20 lines;
Delete or F8	-	delete one character;
^H or F7	-	show help about the current data field;
^E	-	exit from the listing;
F4	-	insert a blank line;
F7	-	show help about the current data field;
F8	-	delete one character;
F9	-	clear the line;
F10	-	clear the remainder of the line from the current data field to the end;
shift-F3	-	duplicate the previous data field into the current data field;
shift-F4	-	duplicate the previous line into the current line. (This only works if the current line is empty, ie if it has been created using F4);
shift-F5	-	show the meanings of the various keys displayed in this table;
shift-F9	-	delete (remove) the current line;
shift-F10	-	plot the screen on the laser printer.

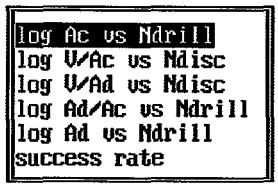
3.20. 'Print'

When this menu item is selected a set of data from each well in the well file is printed. The item is not available in version 1.0 of AUSTPLAY.

4. PLOTTING AND ANALYSING THE WELL DATA

This chapter describes the plots and the statistical analysis carried out in AUSTPLAY, how to interact with them, and how they may be used to help determine the input data for the play data form. Before plotting data, a file of well forms should be loaded and, if necessary, a subset selected. The wells should be sorted by TD date.

The ^G keystroke produces the following menu.



Selection of any of the first five menu items will produce loglinear plots: either log A versus drilling sequence number; or log V/A versus discovery sequence number; or log Ad/Ac versus drilling sequence number. Selection of the sixth item, 'success rate', will produce a plot of drilling sequence number versus discovery sequence number.

The user may interact with the plotting and analysis carried out by the first five menu items. Data points may be removed from plots and the position of the least-squares fitted line may be altered during viewing. These are done using the cursor which is controlled by a mouse. Some actions are invoked by positioning the cursor tip over an icon on the screen and pressing the left mouse button. Other actions are invoked simply by pressing the left, the right, or both mouse buttons. All these possible actions are displayed either as abbreviations within the icons or as a line of text at the top of the screen.

Wells may also be removed from the plot by setting the delete status on the well form prior to plotting. The delete status may be set or reset with a shift-F6 or shift-F7 keystroke while the data form for the well is being displayed (see section 3.2). The well file is left unaltered when data points are temporarily removed.

A title will appear on the plots if any of the basin, sub-basin, sequence, fairway, trap type, or trap order fields on the play data form have been filled out.

4.1. 'log Ac vs Ndrill'

4.2. 'log Ad vs Ndrill'

Selection of these menu items produces a plot of area of closure or area of drainage on a logarithmic scale versus drilling sequence number and a statistical analysis of the data. Small squares in the plot show the data for each well and the squares are connected by straight-line segments. The plot and statistical analysis may be used to suggest values for the linear model of log area of closure and, if required, the values displayed may be transferred to the play data form. The program calculates and displays the values of slope, intercept, standard deviation of the residuals, lambda, standard deviation of lambda, and the number of data points of the straight line fitted to the data by the method of least squares and the z-statistic and w-statistic which provide tests of the correlation of the data and whether the areas of closure or drainage are lognormally distributed.

The statistical analysis is shown in two lines beneath the plot. The second line may take a little time to appear, depending on the number of data points, as some of the statistical calculations are lengthy. The

cursor appears as a hand during this time and changes to the usual arrow when the calculations are complete.

The x- and y-axes are labelled and scaled automatically by the program. The scales may subsequently be altered by the user (**SCALE** icon).

A number of icons appear to the right of the plot. These may be used to exit the plot and transfer the statistical model directly to the play data form, abort the plot and analysis, alter the scale, and provide a new title.

4.3. 'log V/Ac vs Ndisc'

4.4. 'log V/Ad vs Ndisc'

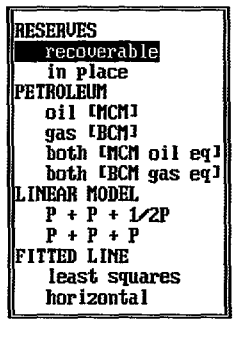
Selection of these menu items produces a plot of V/Ac (accumulation size divided by area of closure) or V/Ad (accumulation size divided by area of drainage) on a logarithmic scale versus discovery sequence number. Up to two values, shown as squares joined by a straight line, are plotted for each well. The top value is the value of V/A using V = proved plus probable plus possible reserves and the bottom value is the value using V = proved plus probable reserves. If the lower value is less than the minimum value of the y-axis, the vertical line will end at the y-axis. Filled in squares show accumulations that are known to be filled to their spill point. The program calculates and displays the values of slope, intercept, standard deviation of the residuals, lambda, standard deviation of lambda, and the number of data points for the straight line fitted to the data and the z-statistic and w-statistic which provide tests of the correlation of the data, and whether V/Ad and V/Ac have lognormal distributions. The plot and the analysis can be used to suggest a linear model of log resources per unit area for the undiscovered accumulations. If required, the historic values may be transferred automatically to the play data form.

The statistical analysis is shown in two lines beneath the plot. The second line may take a little time to appear, depending on the number of data points, as some of the statistical calculations are lengthy. The cursor appears as a hand during this time and changes to the usual arrow when the calculations are complete.

The x- and y-axes are labelled and scaled automatically by the program. The scales may subsequently be altered by the user (**SCALE** icon).

A number of icons appear to the right of the plot. These may be used to exit the plot and transfer the statistical model directly to the play data form, abort the plot and analysis, alter the scale, and provide a new title.

There are several ways the plots can be produced and a menu appears offering the following choices:



Select 'recoverable' or 'in place' 'RESERVES' by using the up- and down-arrow keys to highlight the required option and pressing <Enter>.

Four menu items appear under the heading 'PETROLEUM': selecting 'oil [MCM]' will plot the values of V/Ac or V/Ad for each oil accumulation in metres of oil; selecting 'gas [BCM]' will plot the values of V/Ac or V/Ad for each gas accumulation in metres of gas; selecting 'both [MCM oil eq]' will plot the values of V/Ac or V/Ad for each oil and gas accumulation in metres of oil equivalent; selecting 'both [BCM gas eq]' will plot the values for each oil and gas accumulation in metres of gas equivalent. The menu item required is selected by using the up- and down-arrow keys and then pressing <Enter>.

Two menu items appear under the heading 'LINEAR MODEL': selecting 'P + P + 1/2P' fits a least-squares straight line to the values of proved plus probable plus one half possible reserves; selecting 'P + P + P' fits the least-squares line to the values of proved plus probable plus possible reserves.

Two menu items appear under the heading 'FITTED LINE': selecting 'least squares' will ensure that the line is fitted by that method; selecting 'horizontal' will ensure that a horizontal straight line is fitted to the data and that the statistics displayed refer to the data as though they fit that line.

4.5. 'log Ad/Ac vs Ndrill'

Selection of this menu item produces a plot of the drainage ratio (area of drainage divided by area of closure) plotted on a logarithmic scale versus drilling sequence number. The program also calculates and displays the values of slope, intercept, standard deviation of the residuals, lambda, standard deviation of lambda, the number of data points for the straight line fitted to the data, and the z-statistic and w-statistic which provide tests of the correlation of the data and whether the values for the drainage ratio have a lognormal distribution.

The statistical analysis is shown in two lines beneath the plot. The second line may take a little time to appear, depending on the number of data points, as some of the statistical calculations are lengthy. The cursor appears as a hand during this time and changes to the usual arrow when the calculations are complete.

The x- and y-axes are labelled and scaled automatically by the program. The scales may subsequently be altered by the user (**SCALE** icon).

A number of icons appear to the right of the plot. These may be used to exit the plot and transfer the statistical model directly to the play data form, abort the plot and analysis, alter the scale, and provide a new title.

4.6. 'success rate'

The last menu item, appearing after ^G, produces a plot for estimating the success rate. It shows discovery sequence number versus drilling sequence number. A box first appears that allows maximum values for the discovery sequence number and the drilling sequence number to be entered (this may be skipped by pressing the <Esc> key - the values will then be chosen automatically by the program). If <Enter> is pressed the number of wells and number of discoveries in the well file appear within the box for reference. The user first enters the maximum value for the discovery sequence number (x-axis) followed by <Enter>, then the maximum value for the drilling sequence number (y-axis) followed by <Enter>. <Enter> may be pressed without entering a value if the displayed value is acceptable. Press <Esc> if a mistake is made while entering a value, and re-enter the value.

The plot consists of a number of steps. A vertical line shows a new discovery. The colour of the line (green, red, yellow) indicates the type of discovery (oil, gas, oil and gas). Horizontal lines show the number of wells drilled.

The slope of this plot is the success rate which may be measured over the entire plot, to give the average success rate for the historical data, or over small sections to show how success rate has varied. The historic range of success rates so determined may help the user to determine a triangular distribution of success rates for future drilling for entry onto the play data form.

Press <Enter> to exit from the success rate plot.

5. INTERACTING WITH THE PLOTTING AND ANALYSIS OF DATA

The user may interact with the plotting and analysis of data carried out under the first five menu items under ^G. The same procedure is followed in all five menu items.

5.1. Tagging the data

When the plot first appears, one data point at a time may be tagged and removed, at the user's discretion to eliminate outliers and unwanted points, using the left and right mouse buttons. The data points removed from the plot are retained in the well data base and will reappear in subsequent plots.

The line of text at the top of the screen ('**MOUSE BUTTONS: left TAG, right RE-PLOT, both WOBBLE**') reminds the user of the mouse buttons to use to remove the data and to wobble the line.

left TAG

Positioning the cursor over a data point causes the name of the well corresponding to the data point to appear at the bottom right of the rectangle. When the left mouse button is clicked, a cross will appear over the data point. This means that the well has been tagged and that it will be temporarily removed from the plot if the right mouse button is clicked.

right RE-PLOT

When the right mouse button is clicked, the data are replotted without the tagged data point and the statistical information is recalculated. The tagged point will disappear and new statistical values will appear at the bottom. Additional wells may now be tagged and removed, one at a time, and the data replotted, provided that at least three remain.

5.2. Wobbling the fitted line

This option allows the user to see how the plot would look fitted with another straight line. The new line will appear in red and the original least-squares line remains on the plot in green.

New statistical information will appear at the top of the plot each time the position of the line is changed. The new information is calculated for the new position of the line and includes: the new intercept; slope; standard deviation of the residuals (calculated assuming a non-zero slope); the new value of lambda and its standard deviation; and the number of data points.

The line of text that appears at the top of the screen ('**MOUSE BUTTONS: left INTERCEPT, right SLOPE, both ABORT**') reminds the user of the mouse buttons to use to wobble the line. The **ABORT** or **ACCPT** icons may be activated to exit the plot if the user does not wish to wobble the line.

The position of the line is changed using the left and right mouse buttons as described below.

both WOBBLE

Pressing both mouse buttons simultaneously will stop tagging and replotting so that the mouse may be used to wobble the fitted straight line. It may be necessary to hold both mouse buttons down firmly for a second or so to ensure the required response.

left INTERCEPT

The intercept of the new (red) line may be selected by positioning the cursor at the left hand end of the (green) least-squares line, holding down the left mouse button, and moving the cursor. The button should be released when the red line has been dragged to the desired intercept. The new line will appear in red, parallel to the original line in green.

right SLOPE

The slope of the new (red) line may be selected by positioning the cursor at the right hand end of the (red) line, holding down the right mouse button, and moving the cursor. The button should be released when the red line has been dragged to the desired slope.

both ABORT

Pressing both mouse buttons simultaneously will return the user to the main program without transferring data to the play data form. When pressing both buttons, it may be necessary to hold them down firmly for a second or so, to ensure the required response. The same result is obtained by activating the **ABORT** icon.

5.3. Icons

The icons at the right of the screen are activated by positioning the cursor over the icon box and pressing the left mouse button. The actions that follow are described below.

ACCPT

This icon may be activated at any time to transfer the current statistical values of the linear model (slope, intercept, standard deviation of residuals, lambda, standard deviation of lambda, and the number of data points) from the log area of closure or log resources per unit area of closure plots to the play data form and to return to the play data form.

ABORT

This icon may be activated at any time to return to the play data form without transferring any values.

SCALE

This icon may be activated to alter the scales on the x- and y-axes. Once altered, the new scales will be used for all subsequent plots until AUSTPLAY is exited or the scales re-defined. This icon is not available while wobbling the line.

When first activated, a box will appear that allows the user to enter a maximum value for the y-axis. The value must be a power of ten. The range of y-values in the data are displayed in the box for reference. Press <Enter> to keep the current scale. If a new scale is required, type in the selected value and press <Enter> to accept the value or <Esc> to re-enter it.

A box will appear next in which the user should enter the number of logarithmic cycles on the y-axis.

Finally, a box will appear that allows the user to enter a maximum value for the x-axis. Press <Enter> to keep the current scale or else type in a new value, which must be a multiple of ten.

Press <Enter> to re-plot the data at the new scales.

TITLE

This icon may be activated to provide a new title for the plot. A box will appear that allows the user to type in up to 58 characters spread over two lines. As soon as <Enter> is pressed the plot will reappear with the new title (on one line). The <Esc> key may be used to re-enter the title if a mistake has been made.

6. THE STATISTICAL ANALYSIS

The following statistics are calculated and displayed for the interactive plots.

6.1. Slope, intercept, and standard deviation of residuals

The method of least squares is used to estimate these quantities which are displayed at the bottom of the screen. The slope is given by,

$$b = (\Sigma xy - \Sigma x \Sigma y/n) / (n\sigma_x^2)$$

The intercept is given by,

$$a = (\Sigma y - b \Sigma x) / n$$

The standard deviation of the residuals is given by,

$$\sigma_{res}^2 = \Sigma [y - (a + bx)]^2 / (n-2)$$

where,

Σxy = sum of x values times y values
Σx = sum of x values
Σy = sum of y values
n = the number of values
σ_x^2 = variance of x values

and x is either ln A, ln V/A, or ln drainage ratio, and y is either the drilling sequence number or the discovery sequence number. The (n-2) denominator is replaced by (n-1) if the slope is forced to be zero.

When the position of the fitted line has been changed interactively, the slope and intercept are taken from the user-created values while the standard deviation of the residuals is calculated and the new values are displayed in red at the top of the rectangle.

6.2. z-statistic

The value of the z-statistic for the plotted data appears on the first line of statistical information beneath the plot ("Z=..."). The z-statistic is derived from the correlation coefficient and is an indicator of whether or not the slope of the fitted line is non-zero. It is given by the equation

$$z = 0.5 \log [(1 - r)/(1 + r)] / (n - 3)$$

where r is the correlation coefficient given by,

$$r = (\Sigma xy - \Sigma x \Sigma y/n) / (n\sigma_x\sigma_y)$$

where

σ_x = the standard deviation of the x values
σ_y = the standard deviation of the y values

If the value of z lies between the five percent critical values (plus or minus 1.96) then, at the five percent level of significance, there is no indication that the plot forms a declining or inclining trend. The hypothesis of a non-zero slope can be accepted if z lies outside this range.

The one percent critical values (plus or minus 2.58) may be used if a more stringent test is required to indicate that the slope is non-zero.

6.3. Lambda

The value of lambda is estimated from the slope of the least squares fitted line given above and the empirical equation,

$$b = b_{max} (1 - e^{-\sigma_y \lambda})$$

which gives for lambda,

$$\lambda = -\ln [1 - (b/b_{max})] / \sigma_y$$

where b_{max} is the slope of a straight line fitted to the data points when they are ordered strictly according to decreasing x value.

6.4. The standard deviation of lambda

The standard deviation of lambda is estimated using the theory of maximum likelihood. First, the maximum likelihood estimate of lambda is obtained by iteratively solving the following equation (Hinde, 1984)

$$\sum_{m=1}^{n} \frac{\sum_{i=m}^{n} z_i^{\lambda} \ln z_i}{\sum_{i=m}^{n} z_i^{\lambda}} = \sum_{m=1}^{n} \ln z_m$$

where z_i = A, V/A, or drainage ratio.

The estimate of lambda is then used in the following equation to obtain the variance of lambda (the standard deviation of lambda = $\sqrt{var(\lambda)}$).

$$var(\lambda) = \frac{(\sum_{i=m}^{n} z_i^{\lambda})^2}{\sum_{i<j} \sum_{j=m}^{n} z_i^{\lambda} z_j^{\lambda} (\ln z_i - \ln z_j)^2}$$

6.5. Log normal?

The program tests whether the distribution of the values of A and of V/A is log normal and the results are displayed in the second line of statistical information beneath the plot ("**LOG NORMAL AT 1pc?: . 5pc?: .**").

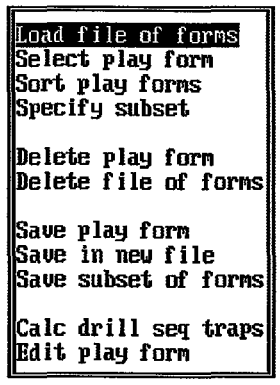
If a "Y" appears for the one percent level of significance ("**1pc?: Y**") then the values are log normally distributed at the one percent level of significance. If a "Y" also appears for the five percent level of significance ("**5pc?: Y**") then the values are also log normally distributed at the five percent level of significance. The one percent level is a more stringent test than the five percent level; it is more likely to favour the null hypothesis that the distribution is log normal. An "N" will appear if the test fails for either level .

The Shapiro-Wilk w-statistic (Shapiro and Wilk, 1965), for the logarithms of the data values, is used to test the hypothesis that the data values (A, V/A, etc) are log normally distributed if the number of data points is less than or equal to 50. The value of w is compared to critical values of w at both the one and five percent levels of significance and the hypothesis of log normality is rejected at that level of significance if the value of w is less than the critical value.

The D'Agostino y-statistic (D'Agostino, 1971), for the logarithms of the y values, is used to test the hypothesis that the data values (A, V/A, etc) are log normally distributed if the number of data points is greater than 50. The value of y is compared to critical ranges of y both at the one and five percent levels of significance. If the value of y lies outside one or both of the critical ranges then the hypothesis of log normality is rejected at the corresponding level(s) of significance.

7. PLAY DATA FORM FILING SYSTEM

Pressing ^L (this command appears at the top of the screen) produces the following menu for the play data form filing system.



The menu items are selected using the up-arrow and down- arrow keys until the required item is highlighted and then pressing <Enter>.

7.1. Play data form

The play data form (Figure 7.1) contains a number of blank data fields which appear as red underscores on the screen. <Alt> keystroke commands are shown along the top row of the form and some additional commands are shown along the bottom.

```
^L - play data   ^G - graph   ^A - assess   ^O - output   ^W - well data

        PLAY DATA FOR ASSESSMENT OF UNDISCOVERED RESOURCES
Basin: _____ Sub-basin: _____ Sequence: _____ Fairway: _____
      Trap type: _____ Order: _ On/off: _                    Date: __/__/__
Number of traps to be tested: _____
Triangular disn for success rate: Min: _.__ ML: _.__ Max: _.__
___ to ___ conversion factor(      ): Min: __.__ ML: __.__ Max: __.__
Minimum size of accumulation(            ): _____.___ Max size: _____.___
Proportion of oil accumulations: _.__ gas: _.__ oil & gas: _.__
Proportion of oil to oil plus gas (MOE): Min: _.__ ML: _.__ Max: _.__
Ratio of condensate to sales gas(MCM/BCM): Min: _.__ ML: _.__ Max: _.__
Prob. hydrocarbons generated: _.__    Prob. hydrocarbons trapped: _.__
Linear model of Log Ac vs drilling sequence number
     Intercept(km2):_____.___    Slope(ln):___.___    S.D.Res(ln):___.___
     Lambda:__.__    S.D.Lambda:__.__    No. data points:_____
     Start simulation at Ndrill=_____          Max A(km2):_____.___
Linear model of Log V/Ac vs discovery sequence number
     Intercept(m):____.___    Slope(ln):___.___    S.D.Res(ln):___.___
     Lambda:__.__    S.D.Lambda:__.__    No. data points:_____
     Start at =_____   MAX V/Ac(m): Min:_____.__ ML:_____.__ Max:_____.___
Comments:_____

 ^H - help about data   Shift F5 - shows meaning of keys   ^Z - quit program
```

Figure 7.1 - The play data form.

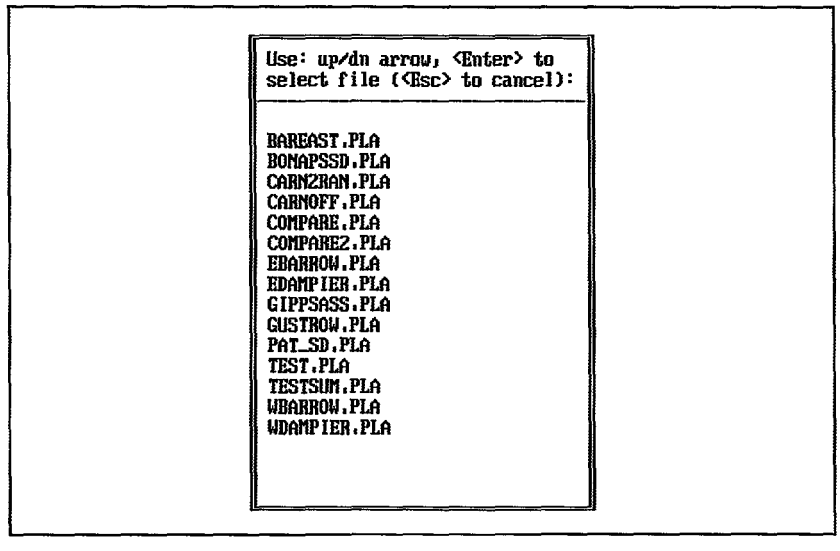
Data may be entered into the data fields using the up- and down-arrow keys to position the cursor within the data fields, then typing the data. Help about each data field may be obtained by pressing ^H or F7.

A number of other keys may be used to help enter the data. These keys and their actions may be listed by pressing shift-F5 (this is noted at the bottom of the screen). The list is reproduced below.

right-arrow	-	move cursor one character to the right;
left-arrow	-	move cursor one character to the left;
Delete or F8	-	delete one character;
Insert	-	insert one space;
Esc	-	escape from the current data field and cancel any changes to it;
^H or F7	-	show help about the current data field;
^Z	-	quit the program (leave AUSTPLAY);
F3		'Save play form'
F6	-	create a data file from all the play data forms that can be run on BMR's data general computer's version of AUSTPLAY (program VALAL);
F7	-	show help about the current data field;
F8	-	delete one character;
F9	-	clear the entire play data form;
F10	-	clear the remainder of the play data form from the current data field to the end;
shift-F4	-	provide instructions on how to duplicate play data;
shift-F5	-	show the meanings of the various keys displayed in this table;
shift-F10	-	plot the screen on the laser printer.

7.2. 'Load file of forms'

Upon selection of this menu item a window appears on the screen, listing the files of play data forms that are available for loading into the computer from disk.



A file is selected by using the up-arrow and down-arrow keys to highlight the file, and it is loaded by pressing <Enter>.

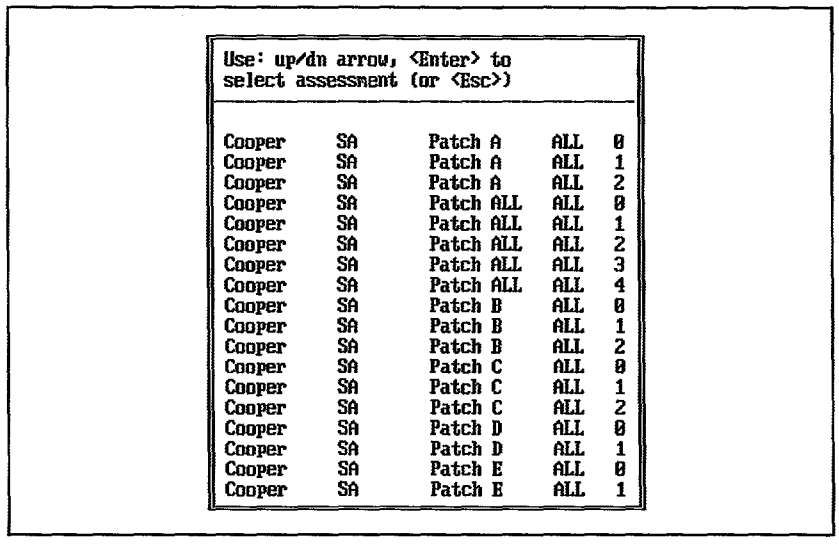
The two lines at the top of the window remind the user to use the up-arrow, down-arrow, <Enter> and <Esc> keys. The <Esc> key may be pressed at any time to escape from the procedure.

Another menu appears when the file of play data forms is loaded. This menu allows a specific play data form to be selected from within the file and to be displayed on the screen. The menu also appears upon selection of the menu item, 'Select play form'.

7.3. 'Select play form'

This menu items allows the user to select a specific play data form from the currently loaded file of play data forms and to display it on the screen. Before a play data form can be selected, a file of play data forms must be loaded (see menu item, 'Load file of forms', for instructions on loading a file of play data forms).

Upon selection of the menu item a window appears on the screen listing the play data forms stored in the current file of play data forms. The list shows the basin, sub-basin, sequence, fairway, trap type, and order of each play, sorted alphanumerically. This identifying information is contained in the first six data fields of each play data form.



A specific play data form is selected using the up- and down-arrow keys to highlight the required play data form, then pressing <Enter>. The data of the play data form then appears on the screen (the <Esc> key may be used to cancel the process).

7.4. 'Sort play forms'

This menu item allows the user to sort the play data forms, within the currently loaded file of play data forms, according to any of the first six data fields. The sorting will alter the order in which the play data forms are displayed when 'Select play form' is selected and the order in which assessments are summed.

Upon selection of this item, the screen is cleared and the following information appears at the top.

1. Basin	**2. Sub-basin**	**3. Sequence**
4. Fairway	**5. Trap type**	**6. Order of trap**

At the bottom of the screen the following instructions appear.

Enter numbers corresponding to the fields to be sorted,
separated by commas (no spaces). <Enter> to cancel.

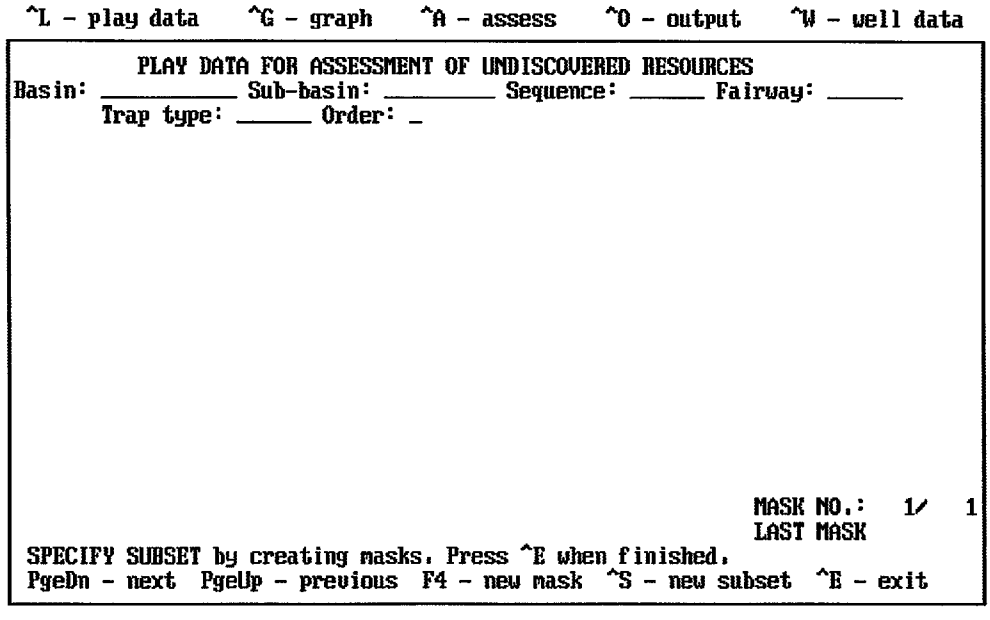
The user should then type in numbers corresponding to the desired data fields. For example, to sort alphanumerically by sequence and trap type, type:

>3,5

followed by <Enter> (the '>' is placed on the screen by the computer). The program will then sort the play data forms and re-display the last play data form.

7.5. 'Specify subset'

This menu item allows the user to select a subset of the play data forms. Upon selection of the menu item the following mask form appears.



The top of the form contains the first six data fields of the play data form. The user must complete some or all of the fields. When ^E is pressed, the program will select those plays that match the fields entered.

The current mask number and the total number of masks is shown on the lower right of the form, ie **'MASK NO: 1/ 1'.** Press F4 to create more masks. The first mask will be stored and the second mask will appear as a blank form. Press ^S to cancel the current masks and start a completely new set of masks.

'LAST MASK' will appear beneath the mask number display when the last mask in a set is displayed. Use the <Page Up> and <Page Down> keys to cycle through all the masks.

The second last line appears in yellow and gives short instructions for specifying a subset. The last line summarises the most important commands that may be used while specifying masks. A complete list of commands, shown below, is obtained by pressing shift-F5.

down-arrow	-	move cursor to the next data field;
Enter	-	" " " " " " "
Tab	-	" " " " " " "
up-arrow	-	move cursor to the previous data field;

Home	-	" " " " " " "
right-arrow	-	move cursor one character to the right;
left-arrow	-	move cursor one character to the left;
Page down	-	display the next mask;
^N	-	" " " "
Page up	-	display the previous mask;
^V	-	" " " "
Delete or F8	-	delete one character;
Insert	-	insert one space;
Esc	-	escape from current data field and cancel any changes to it;
^H or F7	-	show help about the current data field;
^S	-	delete all masks and start again (create a new subset);
^E	-	select a subset of play data forms using the entered masks;
F4	-	create (append) a new mask;
F7	-	show help about the current data field;
F8	-	delete one character;
F9	-	clear the data in the current mask;
F10	-	clear the remainder of the mask from the current data field to the end;
shift-F3	-	duplicate the data from the current field of the previous mask into the current field;
shift-F4	-	duplicate all the data from the previous mask into the current mask. (Note: this is only allowed for a newly-created mask with no data);
shift-F5	-	show the meanings of the various keys displayed in this table;
shift-F9	-	delete (remove) the current mask;
shift-F10	-	plot the screen on the laser printer.

Upon pressing ^E, the subset is selected using the masks that have been created. Each mask selects a subset and the final subset consists of all the subsets combined. For example, if a subset consisting of several trap types is required, a mask must be created for each of the trap types.

Finally, the directory of play data forms appears, allowing the user to select a play data form from the newly-created subset as described above in 'Select play form'.

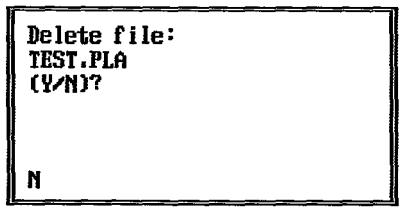
If no masks have been created (that is only one mask which is left blank) the entire set of play data forms will be selected. If no plays are selected by the masks, the message, '**No plays found**' followed by the message '**No data**', will appear on the screen.

7.6. 'Delete play form'

This menu item allows the user to delete a play data form from the currently loaded file of play data forms. Upon selection of the menu item, the directory of play data forms will appear (as with 'Select play form'). Select the play data form for deletion by using the up- and down-arrow keys to highlight it. Then press <Enter> to delete it (the <Esc> key is used to cancel the process).

7.7. 'Delete file of forms'

This menu item allows the user to delete an entire file of play data forms from disk. Upon selection of the menu item, a list of files will appear (as with 'Load file of forms'). Highlight the file that is to be deleted using the up- and down-arrow keys. Then press <Enter>, upon which the following window will appear.



To confirm deletion, type the letter 'y', and press <Enter>. The file is then deleted. If the user does not wish to delete the file press <Enter> or <Esc>. The <Esc> key may be used at any time to cancel the process.

7.8. 'Save play form'

This menu item saves the play data form that is displayed on the screen into the currently loaded file of play data forms directly to disk. If the form is newly-created, with new identifying information, a new form is added to the file. If the form is old, but data other than the identifying information have been changed, the existing play data form is replaced.

Upon selection of the menu item, the screen is cleared and the following appears on the screen (provided that a play data file has been loaded).

Play: basin, sub-basin, sequence, fairway, trap type, and order
saved in file: (name of the currently loaded file of play data forms)

Press <Enter> to continue.

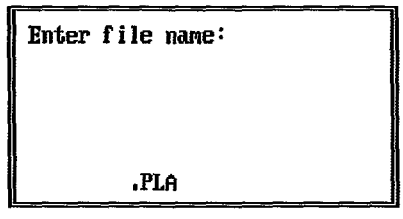
Pressing <Enter> saves and re-displays the play data form.

If a file of play data forms has not been loaded the user is asked to provide an eight-letter name for a file that will be created and used to save the current play data form. This file becomes the currently loaded file of play data forms (note: if this file name already exists, the play data form will be added to the play data forms already in it, regardless of whether the same play is already present or not). The procedure for naming a file is described further in the next section.

7.9. 'Save in new file'

This menu item saves the play data form that is displayed on the screen into a new file, specified by the user, directly to disk. If the file already exists, the play data form will be added to the play data forms already in it, regardless of whether the same play (as identified by the first six data fields) is already present or not.

The following window will appear.



The user should enter a name of up to eight letters in the bottom line in front of '.PLA' (the '.PLA' extension cannot be changed and identifies the file as containing play data forms).

While entering the file name, the user may make use of the following keys.

left-arrow	-	moves cursor one character to the left;
right-arrow	-	moves cursor one character to the right;
Backspace	-	deletes previous character;
Delete	-	deletes current character and closes up;
Insert	-	inserts a space;
Esc	-	cancels the saving procedure and re-displays the play data form.

Press <Enter> when finished. The following will then appear on the screen.

Play: basin, sub-basin, sequence, fairway, trap type, and order
saved in file: (name of the new file of play data forms)

Press <Enter> to continue.

Pressing <Enter> saves and re-displays the play data form. The new file becomes the currently loaded file.

7.10. 'Save subset of forms'

This menu item saves a current subset of play data forms into a new file named by the user. If the file already exists, the user is warned that the file will be over-written, and given the option to cancel.

Upon selection of the menu item a window appears (as in 'Save in new file'). Upon typing the name of the new file and pressing <Enter>, the play data forms within the currently selected subset (or all the play data forms if no subset has been selected) are copied into the new file. The new file, however, does not become the currently loaded file.

7.11. 'Calc drill seq traps'

This menu item determines the parameters of a loglinear model for log area of closure of the traps to be drilled when the probability of drilling a trap next is proportional to its area of closure raised to the power lambda. The parameters of the model are the intercept, slope, standard deviation of residuals, lambda, standard deviation of lambda, and number of data points.

The user must enter a value for lambda. The areas of closure of the traps to be drilled are then entered, one at a time, in any order. Input of areas of closure is terminated by entering a zero.

When <Enter> is pressed, the areas of closure are re-displayed, and the message

Simulating linear model. Come back later!

appears. The program commences the calculation of the linear model. This calculation may take some time, especially if a large number of areas of closure are entered (the maximum number of areas of closure that may be entered is 100).

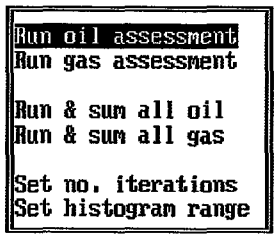
When the calculation is completed, the parameters of the linear model appear on the screen. Press <Enter> and the play data form reappears on the screen with the model parameters already entered.

7.12. 'Edit play form'

The latest play data form will be displayed when this menu item is selected.

8. RUNNING AN ASSESSMENT

The undiscovered petroleum resources of a play or of a group of plays may be assessed and added together using the command ^A. The following menu will appear.

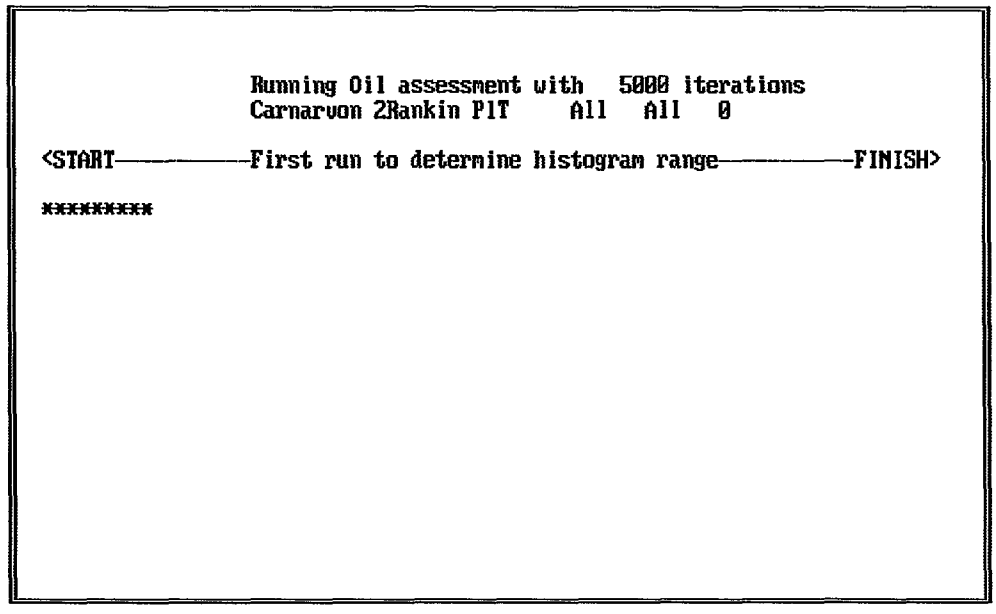


8.1. 'Run oil assessment'

8.2. 'Run gas assessment'

These two menu items are used to assess the oil or gas resources of the play for which the input data are displayed. If essential data fields have not been completed (they appear as red underscores) the user will be informed and the assessment will not run.

The following screen appears while the assessment is running.



The top line shows whether oil or gas is being assessed and the total number of iterations of the computer program used to carry out the assessment. The next line gives the information needed to identify the play being assessed: basin, sub-basin, sequence, fairway, trap type, and order of the traps.

At the beginning of the assessment, an additional one thousand iterations are used to determine the range of values of each class in the histogram of undiscovered resources. While this is happening the third line displays

'**<START----------First run to determine histogram range----------FINISH>**'.

A row of asterisks appears and grows in proportion to the progress of the simulation.

The actual assessment of undiscovered petroleum resources follows automatically. While this happens '**Production run to obtain histograms**' is displayed within the third line and a fresh row of asterisks starts from the left again until it reaches the right.

When the assessment is completed, a summary, similar to that shown below, will appear on the screen.

```
                Running Oil assessment with   5000 iterations
                Test basin A sub-basTriassX     All   0

 <START----------Production run to obtain histograms----------FINISH>

 **************************************************************************

STATISTICAL MOMENTS OF UNRISKED RECOVERABLE RESOURCES:

   MEAN(MCM)=     9.702  S.D.=     8.708  SKEWNESS=   2.04  KURTOSIS=   6.69

RISKS =      ECONOMIC          0.953
             GENERATION        1.000
             TRAP              0.500
             - TOTAL RISK -    0.476


                           <Enter> to continue.
                           (To get a printout of the assessment, use ^O
                           and select menu item 'Print assessment'.)
```

The summary shows the mean, standard deviation, skewness, and kurtosis of the unrisked distribution of undiscovered resources, the calculated 'economic risk', the input risks for the generation and migration of petroleum and the adequacy of the traps, and the calculated total risk. Pressing <Enter> returns the user to the play data form. A complete printout of the assessment is available using ^O as described below in chapter 9, 'PRINTING OR STORING THE ASSESSMENT'.

8.3. 'Run & sum all oil'

8.4. 'Run & sum all gas'

These two menu items are used to assess and sum the oil or gas resources of all the plays contained within the currently loaded file of play data forms. It does not matter whether or not any play data are currently displayed.

If some of the risks for the generation and migration of hydrocarbons (generation risk) are less than one, the following will appear on the screen:

SPECIFY GENERATION RISK DEPENDENCIES

To specify generation risk dependencies, select sets of basin/sub-basin/sequence/fairway combinations that are all dependent.

Terminate each set with <Esc>
Press <Enter> to continue or <Esc> to omit dependencies.

Press <Esc> if there are no dependent relationships among the risks. Press <Enter> and a window will appear containing a list of play combinations (basin/sub-basin/sequence/fairway) that are present within the file of play data forms in which at least one play has a risk less than one. Each combination may consist of several plays (different trap types or orders).

A set of play combinations is selected by repeatedly using the up- and down-arrow keys to highlight the combination and pressing <Enter>. When <Esc> is pressed these combinations will be displayed on the screen as follows:

The following basin/sub-basin/sequence/fairway combinations will be dependently risked:

followed by the list of combinations then:

Press <Enter> to Continue.

The generation risk for all the plays in these combinations will be treated as dependent, that is, if petroleum generation is simulated in one play it will also be simulated in the others. The user must ensure that the generation risk is the same for each play within the set. If not, the following warning will appear:

The risks specified for this set are not all equal.

The risks for this set are:

followed by the list of component plays and their generation risks, followed by:

They should be made equal before running assessment.

Press <Enter> to Continue or <Esc> to omit all dependencies.

If the user presses <Esc>, all dependencies will be cancelled. If the user presses <Enter>, the program will run using the first risk of the set, and the window displaying the remaining combinations that may be selected will appear and if no more sets are required (the rest of the plays are to be risked independently) press <Esc> or <Enter> without selecting any combinations. The following will then appear:

The remaining basin/sub-basin/sequence/fairway combinations will be INdependently risked:

followed by the list of remaining combinations, followed by:

Press <Enter> to Continue.

The user will next be asked to enter the trap dependencies in exactly the same way as the generation dependencies. The play combinations that will be displayed, however, will now consist of basin/sub-basin/sequence/trap type. Each combination may contain a number of fairways and orders of trap.

After the dependent risks have been specified, the play data forms will be checked to see if any essential data are missing. During this, the screen will show:

Checking all input data before running assessments.

A message will appear if any essential data are missing. The relevant play data form(s) must then be corrected and saved before an assessment can be made.

If all the necessary data are present, the program will assess each play within the file of play data forms, displaying the summary results for a few seconds after each assessment. When all the plays have been assessed, the program will sum them during a final simulation. The screen will show:

Summing all assessments with n iterations

where n is the number of iterations used to make the final summation (one thousand iterations will also be used to determine the histogram range).

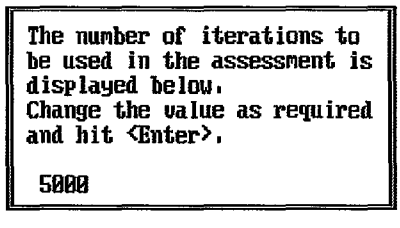
When the assessment is completed, a summary of the total summed assessment, the mean, standard deviation, skewness, and kurtosis of the unrisked and risked distributions, as well as the total risk, will be displayed.

Press <Enter> to return to the play data form. Press ^O to obtain a printout detailing the individual assessments and the summed assessment.

8.5. 'Set no. iterations'

Selection of this menu item will allow the user to alter the number of iterations used by the program. Increasing the number of iterations will increase the precision of the assessment, while decreasing it will decrease the precision but speed up the assessment.

The following window will appear.



The current number of iterations is displayed at the bottom. The default value is 5000. To change the value, use the left- and right-arrow keys to position the cursor, type in the required number, and press <Enter>. The number of iterations entered will remain in force until changed again or until the program is exited and re-entered.

Wrong values, if entered, will not be accepted; values less than 4 or greater than 31999 will not be accepted. A message will be displayed and the user must re-enter the value.

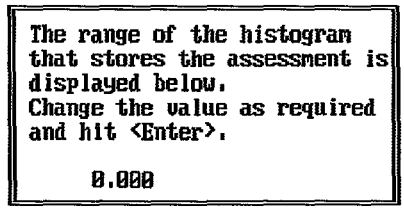
While entering the value, the user may make use of the following keys.

left-arrow	-	move cursor one character to the left;
right-arrow	-	move cursor one character to the right;
Backspace	-	delete the previous character;
Delete	-	delete current character and close up;
Insert	-	insert a space;
Esc	-	cancel the setting procedure.

8.6. 'Set histogram range'

Selection of this menu item allows the user to select the maximum amount of oil (in $10^6 m^3$) or gas (in $10^9 m^3$) that the play is likely to contain so that this forms the upper limit for the range of the histogram of the assessment of undiscovered resources, instead of the upper limit being selected by the computer as described above ('Run oil assessment', 'Run gas assessment').

The following window will appear.

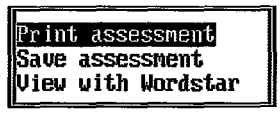


The default value of 0.000 displayed at the bottom indicates that the computer will determine the range. To change the upper limit of the range, use the left- and right-arrow keys to position the cursor, change 0.000 to the required value, and press <Enter>. The computer will determine the range again after the next assessment, so that, if needed, the range must be reset for every assessment. If a summed assessment is chosen, the upper limit of the range will apply only to the summed assessment, not to the component assessments.

Wrong characters, if entered, are not accepted; a message is displayed and the user must try again. The keys described above under 'Set no. iterations' may be used to enter the range.

9. PRINTING OR STORING THE ASSESSMENT

Press ^O and select a menu item in order to print the assessment or save it on disk.



9.1. 'Print assessment'

Selection of this menu item prints (on the attached laser printer) the last assessment that was run. A message will appear if there is no assessment to print.

The types of information contained in the printout are explained in section 9.2 below.

9.2. The printout

A three page printout is obtained for each play data form used in the assessment. This section explains the types of information in the printout and the mathematical basis for the calculations.

General information

The top line of the printout identifies the program, the version number, and its date of creation:

***** PROGRAM AUSTPLAY *** VERSION 1.0/3JUN91**

The next line shows the date and time of the computer run:

Date and time of computer run: dd/mm/yy HH:mm:ss.ss

Then the printout shows whether the assessment was calculated in MCMs of oil equivalents or BCMs of gas equivalents:

The assessment was calculated in OIL equivalents ;

whether the assessment is for undiscovered oil or undiscovered gas resources:

The assessment is for: GAS ;

the units of the assessed resource (MCMs for oil, BCMs for gas):

Units: BCM ;

the number of iterations used in the Monte Carlo simulation:

Number of iterations: 5000 ;

and the default value used for the standard deviation of lambda if this value is omitted from the linear model in the play data form:

Default s.dev of lambda: 1/SQRT(N) .

where N is the number of data points used in the regression, or 10, whichever is larger.

The assessed play is identified by printing out the first six data fields in the play data form and the type of hydrocarbon assessed:

PLAY ASSESSED: **Basin=.....** **Sub-basin=.....** **Sequence=.....**
Fairway=..... **Trap=.....** **Order=.** **H/C type=...**

This is followed by a repeat of the number of iterations and the number of traps tested in each simulation:

NUMBER OF ITERATIONS= ..... **NUMBER OF TRAPS TESTED=.....**

Statistical moments of unrisked recoverable resources

The first four statistical moments (mean, standard deviation, skewness, and kurtosis) for the unrisked resources are printed out in both metric and imperial units:

STATISTICAL MOMENTS OF UNRISKED RECOVERABLE RESOURCES:

MEAN(BCM)= .....S.D.= ..... SKEWNESS= ..... KURTOSIS= .....

MEAN(TCF)= ..... S.D.= ..... SKEWNESS= ..... KURTOSIS= .....

Mean

The mean or average value is calculated by the equation,

$$\text{Mean} = \Sigma v/n'$$

where Σv is the sum of the resources for all n' iterations in which discoveries where simulated.

Standard deviation

The standard deviation is a measure of the spread of the distribution. For undiscovered resources the standard deviation is likely to be large (of a comparable magnitude to the mean) because the distributions tend to be spread out with a long tail.

The standard deviation is calculated by the following equation.

$$\text{Standard deviation} = \sigma_v = [\ \Sigma v^2/n' - (\Sigma v/n')^2\ ]^{1/2}$$

where Σv^2 is the sum of the squares of the resources for all n' iterations in which discoveries were simulated.

Skewness

Skewness is a measure of the asymmetry of the distribution. A value of zero for the skewness indicates a perfectly symmetrical distribution. A positive value indicates a distribution that is skewed to the right of the mean, while a negative value indicates a distribution that is skewed to the left. Skewness is usually positive for undiscovered resources.

Skewness is given by the following equation.

$$\text{Skewness} = \mu_3/\sigma_v^{3/2}$$

where μ_3 is the third statistical moment given by,

$$\mu_3 = \Sigma v^3/n' - 3(\Sigma v^2/n')(\Sigma v/n') + 2(\Sigma v/n')^3$$

where Σv^3 is the sum of the cubes of the resources for all n´ iterations in which discoveries were simulated.

Kurtosis

Kurtosis is a measure of the flatness or peakedness of the distribution. Large values of kurtosis indicate a distribution that is peaked with long tails. Small values indicate a distribution that is flat with short tails. A value of zero is considered neutral as this is the value for a normal distribution. Kurtosis is usually large for undiscovered resources because of the long tail.

Kurtosis is given by the following equation,

$$\text{Kurtosis} = \mu_4/\sigma_v^2 - 3$$

where μ_4 is the fourth statistical moment given by,

$$\mu_4 = \Sigma v^4/n' - 4(\Sigma v^2/n')(\Sigma v/n') + 6(\Sigma v^2/n')(\Sigma v/n')^2 - 3(\Sigma v/n')^4$$

where Σv^4 is the sum of the fourth powers of the resources for all n´ iterations in which discoveries were simulated.

Statistical moments of risked recoverable resources

The first four statistical moments (mean, standard deviation, skewness, and kurtosis) of the *risked* resources are printed out in both metric and imperial units:

STATISTICAL MOMENTS OF RISKED RECOVERABLE RESOURCES:

MEAN(BCM) = ... S.D. = ... SKEWNESS = ... KURTOSIS = ...

MEAN(TCF) = ... S.D. = ... SKEWNESS = ... KURTOSIS = ...

The equations given above for the unrisked recoverable resources are also used for the mean, standard deviation, skewness, and kurtosis of the risked resources. The value of n´, however, is replaced by a different value, n", given by:

n" = total number of iterations

The risks

The three risks and the total risk are printed out:

RISKS = ECONOMIC .....
GENERATION .....
TRAP .....
- TOTAL RISK - .....

Economic risk

The, so called, economic risk is defined as the number of iterations in which generation and trap risks were both one, and a potentially economic discovery was simulated, divided by the number of iterations in which generation and trap risks were both one. The economic risk arises from the triangular distribution for the success rate and the minimum size of accumulation. The smaller the success rate, the more likely that no discoveries will be made in a given iteration, and the larger the minimum size of accumulation, the more likely that the discoveries will not be counted as a resource. Furthermore, the smaller the number of traps that the program simulates testing, the less likely a discovery will be made (assuming a success rate less than one and a finite minimum size of accumulation).

Generation risk

The generation risk is the probability that hydrocarbons have been generated and migrated within the play being assessed. The value printed is the value entered in the play data form.

Trap risk

The trap risk is the probability that there is at least one effective trap for petroleum within the play. The value printed is the value entered in the play data form.

Total risk

The total risk is defined as the number of iterations in which a potentially economic discovery was simulated divided by the total number of iterations

total risk = economic risk x generation risk x trap risk

It is the overall probability that there are petroleum resources within the play.

Percentiles of recoverable resources

A table is printed showing the cumulative percentage probability of discovering more than the stated amount of risked or unrisked recoverable resources. The percentiles of resources are given in both metric and imperial units.

PERCENTILES OF UNRISKED AND RISKED RECOVERABLE RESOURCES

PERCENT PROB	---UNRISKED VOLUME---		----RISKED VOLUME----	
GREATER THAN	BCM	TCF	BCM	TCF
5.0	1.997	0.071	1.992	0.070
10.0	1.604	0.057	1.597	0.056
20.0	1.177	0.042	1.171	0.041
30.0	0.922	0.033	0.916	0.032
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
90.0	0.152	0.005	0.144	0.004
95.0	0.093	0.003	0.079	0.003

The above table shows that there is a 20% chance that there is at least 1.177 BCM of undiscovered gas in the play (conditional on gas being present in the play because this is an unrisked value).

The unrisked percentiles are obtained from the unrisked cumulative probability distribution. This is the distribution of resources, conditional on the play containing some oil or gas.

The risked percentiles are obtained from the risked cumulative probability distribution which is obtained by multiplying the percentages of the unrisked distribution by the total risk. Thus the risked twentieth percentile is equal to the percentile on the unrisked distribution at (20/total risk)%. If the value of (20/total risk) is greater than 100, the risked percentile is zero.

Cumulative probability distribution of recoverable resouces

The unrisked cumulative probability distribution of the assessed recoverable resources are tabulated on a new page.

UNRISKED CUMULATIVE PROBABILITY DISTRIBUTION OF RECOVERABLE RESOURCES:

VOLUME BCM	CUM.PROB.	
0.000	1.0000	!----------*
0.120	0.9303	! *
0.240	0.8206	! *
0.360	0.7087	! *
0.480	0.6007	! *
0.600	0.4985	! *
0.720	0.4187	! *
0.840	0.3409	! *
0.960	0.2803	! *
1.080	0.2325	! *
.	. .	
.	. .	

The first column of the tabulation lists volumes of the recoverable resources in equal increments. The second column gives the corresponding cumulative probability that the actual volume of recoverable resources is greater than or equal to the volume in the first column. The cumulative probability distribution is plotted on the right of the tabulation.

Mean cutoff for resources per unit area

The mean value for the maximum cutoff of resources per unit area, used in each iteration, is printed on a new page:

MEAN V/A CUTOFF = ...

Whenever an accumulation size is to be calculated by the program, a value of maximum V/A is determined by random sampling of the triangular distribution. The mean obtained over all iterations is the value printed. This value is theoretically equal to the mean of the triangular distribution for the maximum value of V/A (the sum of the minimum, most likely, and maximum values divided by three) entered on the play data form. The actual mean will be slightly different from the theoretical mean because of statistical fluctuations.

Maximum field size

The size of the largest accumulation simulated during the running of the program is printed out in both metric and imperial units. The next line shows the average and standard deviation of the largest size of

accumulation simulated in each iteration. Iterations in which there were no discoveries are ignored when calculating the average and standard deviation.

MAX ACCUMULATION SIZE (ALL ITERATIONS) = ...

AVERAGE MAXIMUM ACCUMULATION SIZE = ...
S. DEV. = ...

Seriation of generated accumulation sizes.

The seriation of generated accumulation sizes is a list showing the average size of the future discoveries, the standard deviation of the sizes of future discoveries, and the average drilling sequence number at which the discoveries occur.

SERIATION, AVERAGE OF GENERATED SIZES OF ACCUMULATIONS CONTAINING GAS(BCM):

WELL	ACCUMULATION SIZES	
	AVERAGE	STANDARD. DEV.
	BCM	BCM
22.4	0.234	0.279
25.2	0.193	0.238
27.5	0.152	0.191
29.2	0.136	0.174
.	.	.
.	.	.

The seriation is obtained by recording the size of each simulated discovery, its discovery sequence number, and the drilling sequence number at which it occurred, with drilling sequence number starting at the first well in the linear model. The drilling sequence numbers for each discovery sequence number are averaged over all the iterations to give the average drilling sequence numbers shown in the first column of the seriation.

The second column is obtained by averaging the sizes of the accumulations for each discovery sequence number over all the iterations. The third column shows the standard deviation of the sizes of the accumulations for each discovery sequence number over all the iterations.

There will generally be more iterations with at least one discovery than with at least two; more with at least two than at least three; and so on. Hence, the seriation will become less accurate with increasing discovery sequence number, because the values will be based on a decreasing number of iterations. The seriation stops when the number of iterations is less than two. Only the first 50 discoveries are listed in the seriation.

Cutoff statistics

The percent of times that the four cutoffs were used is shown as follows.

PERCENT OF TIMES THAT THE CUTOFFS HAD TO BE USED:

AREA CUTOFF: ..%
V/A CUTOFF: ..%
MAX ACCUMULATION SIZE: ..%
MIN ACCUMULATION SIZE: ..%

The values are calculated as follows:

$$\text{percent used} = \frac{\text{number of times the cutoff had to be used}}{\text{number of cutoff tests (all iterations)}} \times 100$$

Area cutoff

The cutoff for the maximum value of log area decreases with increasing future drilling sequence number in parallel with the projected straight line of log area. The cutoff is given by the equation.

$$\text{cutoff for log area} = \ln \text{MaxA} + B_{A,i} \cdot (j - 1)$$

where MaxA is the maximum value for area entered into the play data form; $B_{A,i}$ is the value for the slope of the projected line for iteration i; and j is the future drilling sequence number and equals one for the first future well drilled.

If the value of log area selected lies above the cutoff another value is selected until one is found below the cutoff.

V/A cutoff

The cutoff for the maximum value of log resources per unit area decreases with increasing future discovery sequence number in parallel with the projected straight line of log resources per unit area. The cutoff is given by the equation.

$$\text{cutoff for log V/A} = \ln V_{A,max} + B_{V,i} \cdot (j_d - 1)$$

where $V_{A,max}$ is a value sampled from the triangular distribution for the maximum value of V/A corresponding to the first discovery; $B_{V,i}$ is the value for the slope of the projected line for iteration i; and j_d is the future discovery sequence number and equals one for the first future discovery.

If the value of log V/A selected lies above the cutoff, the cutoff value is used.

Maximum accumulation size cutoff

This cutoff is rarely used. It may be supplied, however, on the play data form (**Max size:**). If the accumulation size calculated is greater than this cutoff it is discarded and new values of log A and log V/A are selected until an accumulation size is calculated below the cutoff.

Minimum accumulation size cutoff

The minimum accumulation size is taken from the play data form (**Minimum size of accumulation( ):**). The accumulation sizes calculated by the program must be larger than this cutoff to be counted as a resource.

Average number of economic discoveries

The average number of discoveries that were above the minimum accumulation size (smallest size of accumulation to be counted as a resource) and the standard deviation of the number of discoveries are printed next.

AVERAGE NUMBER OF POTENTIALLY ECONOMIC DISCOVERIES CONTAINING GAS = ...
STANDARD DEVIATION = ...

Input data

Finally, the input data present on the play data form are listed. These are: the basin, sub-basin, sequence, fairway, trap type and order printed in one identification line; the number of future traps tested; the triangular distribution for success rate; the oil to gas (or gas to oil) conversion factor; the minimum and maximum accumulation sizes; the proportion of oil accumulations, gas accumulations, and oil and gas accumulations; the triangular distribution for the proportion of oil to oil plus gas in the oil and gas accumulations; the triangular distribution for the ratio of condensate to sales gas; the probability that hydrocarbons are generated (generation risk); the probability that the hydrocarbons are trapped (trap risk); the loglinear models for area of closure and resources per area of closure; and the comments.

The linear model for log area of closure consists of: the intercept, slope, and standard deviation of residuals of the linear regression; the average and standard deviation of the distribution of lambda; the number of data points used in the regression; the drilling sequence number at which the assessment starts; and the starting value for the maximum area.

The linear model for log resources per unit area of closure consists of: the intercept, slope, and standard deviation of residuals of the linear regression; the average and standard deviation of the distribution of lambda; the number of data points used in the regression; the discovery sequence number at which the assessment starts; and the triangular distribution for the starting value for the maximum resources per unit area.

9.3. 'Save assessment'

This menu item is used to save the last assessment that was run to disk.

A window will appear. The user should enter up to eight letters at the bottom of the window for the name of a file. These letters will appear in front of the '.ASS' extension, which cannot be changed (the '.ASS' extension identifies the file as containing an assessment).

The keys described under the menu item 'Save play form' are also used to enter the file name.

Press <Enter> to save the assessment in the file (the file is stored in the directory 'C:\AUSTPLAY'). The file may now be accessed using, for example, Wordstar or Xtpro.

A message appears if there is no assessment to save .

9.4. 'View with Wordstar'

Selection of this menu item allows the full assessment to be viewed (or edited) using Wordstar. Wordstar is exited by holding down <Ctrl> and pressing K then X.

10. TRANSFERRING WELL DATA FROM AUSTRES WITHIN BMR'S PEDIN DATA BASE

This chapter provides instructions for BMR users who wish to extract well data from the PEDIN data base and import it into the AUSTPLAY system. The computer on which AUSTPLAY is installed must be connected to BMR's DG Mainframe computer and must have CEO software installed.

The steps involved in transferring well data are:

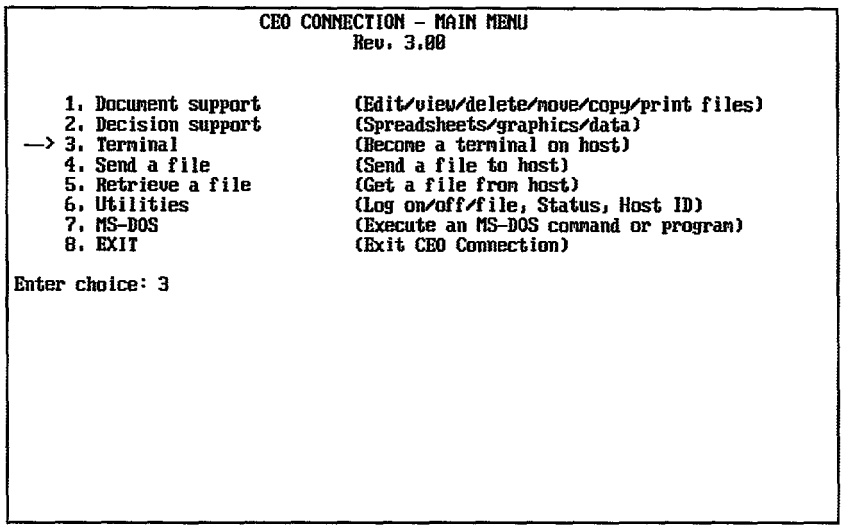
(1) enter the CEO program and logon to BMR's DG computer;
(2) extract the required well data from PEDIN;
(3) transfer the extracted well data from the DG to the personal computer.

10.1. Entering CEO and logging onto BMR's DG computer

The CEO program is entered from Microsoft WINDOWS by clicking on the CEO icon, from the DOS shell by selecting the CEO menu item, or from the DOS prompt by typing 'CEO'. A new screen will appear and the user is required to first enter the Host ID. This is done by typing , 'DG', and pressing <Enter>. Next, the user's Username is entered followed by the user's password. The resulting screen is displayed below.

```
                    CEO Connection

      (C) Copyright Data General Corporation 1984, 1985, 1986
                    All Rights Reserved




Host ID: DG

Username: ALAN.RESAS
Password:
Logging on ...
```

If logon is successful, another screen will appear. It will display a number of menu items. The third menu item, which gains access to the DG computer, is selected by repeatedly pressing the down arrow key until the displayed arrow points to it. The screen should appear as follows.



When <Enter> is pressed the screen will clear and the DG's prompt will appear.

10.2. Extracting well data from PEDIN

Well data are extracted from PEDIN by typing in the command:

SQR AUSTRES <Enter>

Next the PEDIN Username and Password must be entered:

_Enter Username: ALAN <Enter>
_Enter Password: <Enter>

The Username and Password for PEDIN are not the same as those for logging onto the DG. Note that the Password will not be echoed on the screen.

The computer will respond with the following message:

SQR: Structured Query Report Writer V1.50
Copyright(C) 1986, 1987, SQ Software All Rights Reserved

Enter Basin:

The required basin is then typed in followed by <Enter>. The computer will then ask for the sub-basin and sequence:

Enter Sub basin:
Enter sequence:

Any of these fields may be left blank by pressing <Enter> without typing any characters. The search will then not be limited to a basin, sub-basin or sequence.

After these have been entered the computer will commence the extraction of wells. When complete, the following message will appear.

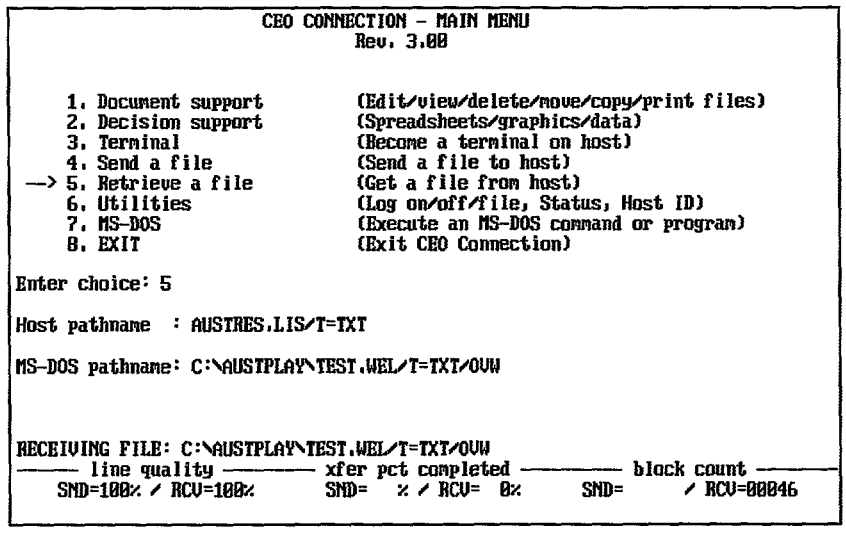
SQR: End of Run.

A file will now exist, called AUSTRES.LIS, and will contain the extracted well data in the same format as the well data files used in AUSTPLAY.

10.3. Transferring the extracted well data to the personal computer

The file of extracted well data, AUSTRES.LIS, is transferred to the personal computer with CEO, which is re-accessed by pressing <Ctrl>-<Break> simultaneously. The fifth menu item, 'Retrieve a file', is selected by using the down-arrow key until the displayed arrow points to it and pressing <Enter>. The host pathname must be entered next. This is the name of the extracted well data file, that is, AUSTRES.LIS. The option, '/T=TXT', should be appended to the file name to indicate that it is a text file.

After pressing <Enter>, the MS-DOS pathname will be requested. This is the name of the file, on the personal computer, to which AUSTRES.LIS will be copied. It should be in the C:\AUSTPLAY directory and have an extension of '.WEL'. The option, '/T=TXT', should be appended. If the file is to be overwritten, the option, '/OVW', should also be appended. When <Enter> is again pressed, the following screen will appear while the file is being transferred.



The bottom lines of the screen shows the status during transfer. When transfer is complete, the CEO menu will reappear. Select the eighth menu item, using the down-arrow key, and press <Enter>, to exit CEO.

11. REFERENCES

D'Agostino, R.B. (1971). An omnibus test of normality for moderate and large size samples. *Biometrika*, **58**, p.341.

Forman, D.J., Cadman S.J., Hinde, A.L. and Radlinski, A.P. (1989). Assessment of petroleum plays containing complex traps: in Abstracts, 28th International Geological Congress, Washington, D.C. USA July 9-19, **1**, p.501.

Forman, D.J., Hinde, A.L., and Cadman, S.J. (1989). Use of closure area and resources per unit area for assessing the undiscovered gas resources of the Cooper Basin, South Australia. In Sinding-Larsen, R., et al. Eds Proceedings of IUGS Research Conference on Petroleum Resource Modeling and Forecasting, Loen, Norway 1988. IUGS Special Publication Series, in press.

Forman, D.J., Hinde, A.L., Cadman, S.J., Radlinski, A.P., and Morton, J. (in press). Towards assessment of plays containing migrated petroleum. Pergamon Press.

Forman, D.J., Hinde, A.L., and Radlinski, A.P. (in press). Assessment of undiscovered petroleum resources at the Bureau of Mineral resources, Australia. Submitted to Energy Sources, 1991.

Hinde, A.L. (1984). LAMDA: A computer program for estimating hypothetical petroleum resources using the 'creaming method'. Bureau of Mineral Resources, Geology and Geophysics, Australia. Record 1984/4.

Shapiro, S.S. and Wilk, M.B. (1965). An analysis of variance test for normality (complete samples). *Biometrika*, **52**, p.591.