GRID

Property-Population Software

for input to the

Eclipse **

Reservoir Simulation Software *

vended by

Schlumberger (GeoQuest)

* This tutorial is based on Grid version 1999a_1.
** Eclipse is Schlumberger (GeoQuest) software.

This tutorial uses Grid to create contour maps for each desired property.

The maps are then used to populate the simulation grid with properties such as depth, thickness, porosity, and permeability.

The purpose of this tutorial is to improve the author's personal productivity. The author believes other interested parties will also find this useful.

Major topics

- Starting Grid
- Mesh maps
  - Defining the map mesh
  - Creating contours on the maps mesh
    - Discusses the need for sufficient contour-point density
  - Add wells
  - Exporting contour maps
  - Saving contour maps
  - Importing contour maps

Introduction (2 of 2)

Major topics, continued

- Simulation grids
  - Creating grids
    - Vector
    - N x M
    - Irregular grids
  - Populating the grid
    - Overview
    - Verification
    - Review
    - Required number of grids
  - Exporting grid properties
- Eclipse input (*.GRDECL files)
  - Example and validation
- Quality
  - Sufficient input
  - Control-contour and control-point synergy
- Automated contouring criteria
  - Search radius
  - Empty octants
- Supplemental index for GeoQuest's Grid manual
- Sample hydraulic-fracture grid
- Summary and conclusions

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It is assumed you already have Grid installed on your workstation.

Console

```
Window  Edit  Options

rel1200@sparc309-1:/home/g2/rel1200% @grid
Please enter version (98a, 99a_1[default]) :
Do you want to run a RF in the background (y/n) [default n] ?

No local config file exists.
Master configuration file copied to current directory.

-----------------------------------------------------------------
| Unsupported X emulation package vendor :- StarNet Communications Corp.
| All program functions may not work correctly
| Please contact GeoQuest for advice on supported X Emulators
-----------------------------------------------------------------
 GRID   Version 99A_1.   Week 9920. Build Number  129.
grid  Locked  - Expiry Date 1-jul-2002
  Please choose type of run :
  1 : Interactive, no graphics
  2 : Interactive, with graphics
  3 : Execute run file only
  4 : Show version size and dates
  X : Exit
2
```

Type @grid

Type

Type

Type 2

```
Drivers available from configuration file are:-
 Device  40 : 'NULL DRIVER    ' with hardcopy
 Device  41 : 'TEKTRONIX 41XX' colour TEKTRONIX
 Device  42 : 'TEKTRONIX 41XX' colour TEKTRONIX (H.COPY)
 Device  51 : 'X-Windows      ' for Dec Alpha
 Device  52 : 'X-Windows      ' for Sun (SunOS 4.1.3)
 Device  53 : 'X-Windows      ' for Sun (Solaris 2)
 Device  54 : 'X-Windows      ' for Silicon Graphics
 Device  55 : 'X-Windows      ' for RS/6000
 Device  56 : 'X-Windows      ' for hp700
 Device  57 : 'X-Windows      ' for MacIntosh MacX
 Device  58 : 'X-Windows      ' for PC/XVIEW
 Device  98 : 'X-Windows      ' for Weltest200
 Device  99 : 'X-Windows      ' for RTView

Please input the required device number:
or -1 to repeat the list
58
```

Type 58

Primary Menu Layout

P is the current menu

GRID 99A_1

Model   Map   Str Grid   Size   Property   Dply Edit   8/08/00 10:35:36   P

The menu hierarchy uses a character-period-character format.

Example: P.1 is the edit-model menu.

There are several sub-menus below P.1

1 Edt model
2 Edt map
3 Edt grid
4 Sim results
5 Edt survey
6 Map utils
7 Chg settings
8 Clr wrkspc
9 Exit

P R D A H

P, R, D, A, & H = hot keys

P = return to primary menu
R = enter a file-run option
D = go to display controls
A = abandon edits made during this menu entry
H = show help for selected option

Follow the advice

Please select an option

Type 1 to create a model

Name & Create the Model. Pick Cartesian Coordinates

```
Enter the name of the model
or RETURN for menu options
 : Model1
Model MODEL1 does not exist.
Create new model ? (Y/n)
 : Y_
```

Type MODEL1

Type Y

Capital Y indicates “Yes” is the default.

MODEL1.HIS and MODEL1.FFEATURE have been created

```
      AVAILABLE MAP PROJECTIONS

1. Universal Transverse Mercator
2. Oblique Mercator  (Hotine)
3. Transverse Mercator
4. Mercator
5. Lambert Conformal Conic
6. Albers Equal Area
7. Universal Polar Stereographic
8. Azimuthal Equidistant
9. None ( normal cartesian coordinates )

Choose an option ( H for HELP )
or RETURN for 9
 : 9
Type RETURN to continue _
```

Cartesian coordinates

Type 9

<cr>

Define a 40-ac, 20 x 20 x 2 Map-Mesh (Using Rows & Columns)

This page demonstrates map-MESH sizing by specifying the NUMBER OF LINES

H(elp) provides a selection of units.

```
Enter units for model area ( H for Help )
or RETURN for METRES
 : H
Valid units are METRES   FEET     CM       KM       KFT
Enter units for model area ( H for Help )
or RETURN for METRES
 : feet
Enter minimum X and Y coordinates for model area
 : 0       0
Enter maximum X and Y coordinates for model area
 : 1320    1320

Define default number of mesh rows & columns
as NROW & NCOL or XINC & YINC ? (R/i)
 : R

Enter default number of mesh rows or RETURN for 50
 : 21
Enter default number of mesh columns or RETURN for 50
 : 21

Enter maximum number of model strata ( 1-100 )
or RETURN for 1
 : 2
Type RETURN to continue _
```

Inputs:

- h
- feet
- 0 0
- 1320 1320
- <cr>
- 21 (= 20 +1 rows)
- 21 (= 20 +1 cols)
- 2
- <cr>

See the next page for another way to size a map-MESH

Define a 40-ac, 20 x 20 x 2 Map-Mesh (Using Width & Height Increments)

This page demonstrates map-MESH sizing with INCREMENTAL LENGTHS and WIDTHS

```
Enter units for model area ( H for Help )
or RETURN for METRES
 : feet
Enter minimum X and Y coordinates for model area
 : 0 0
Enter maximum X and Y coordinates for model area
 : 1320 1320

Define default number of mesh rows & columns
as NROW & NCOL or XINC & YINC ? (R/i)
 : i

Enter default mesh cell width
 : 66.0
Enter default mesh cell height
 : 66.0

Resulting number of mesh rows is 21
and resulting number of mesh column is 21.  Ok to continue ? (Y/n)
 : y

Enter maximum number of model strata ( 1-100 )
or RETURN for 1
 : 2
Type RETURN to continue _
```

feet

0 0

1320 1320

i

66.00 (=dx)

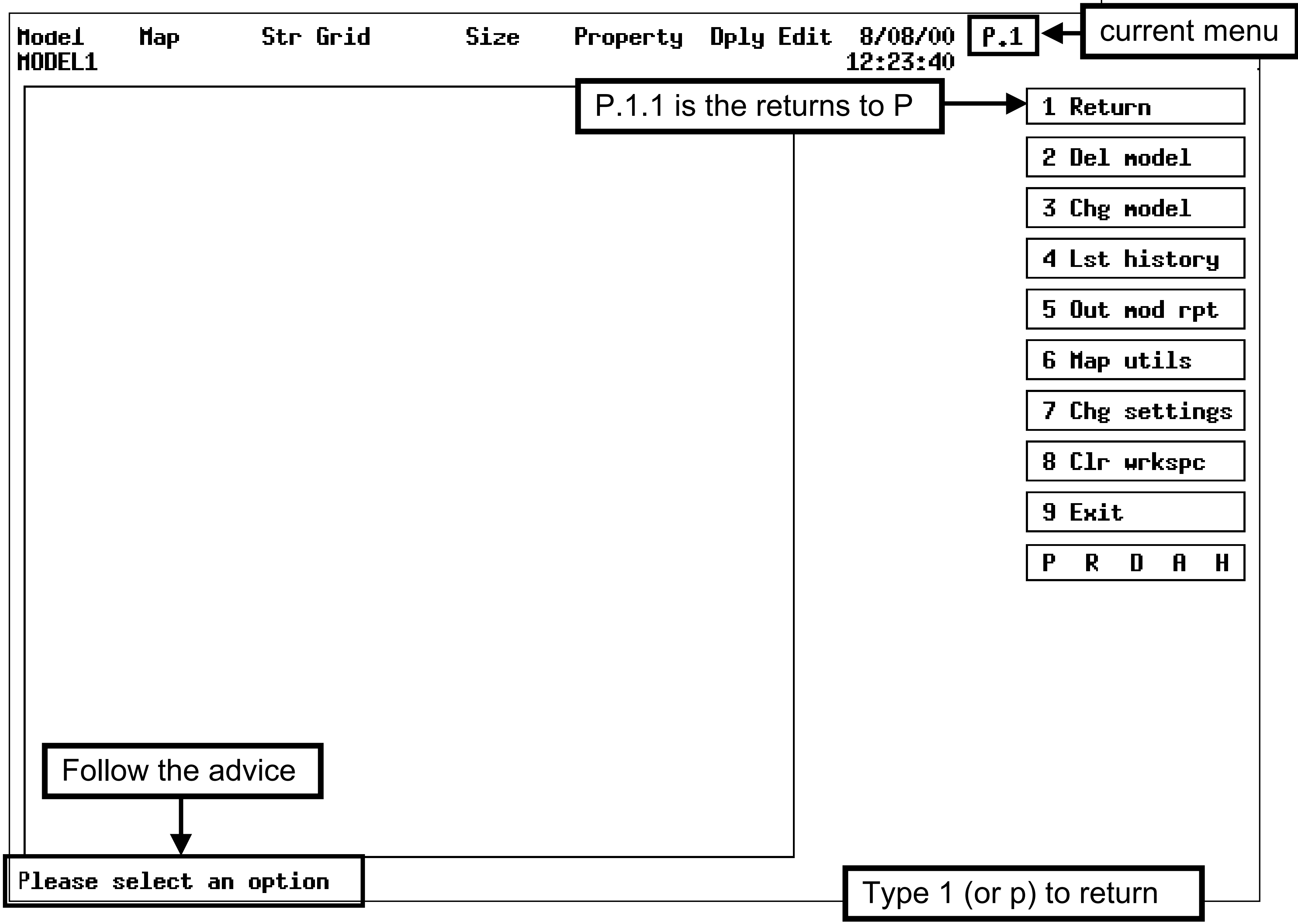
66.00 (=dy)

y

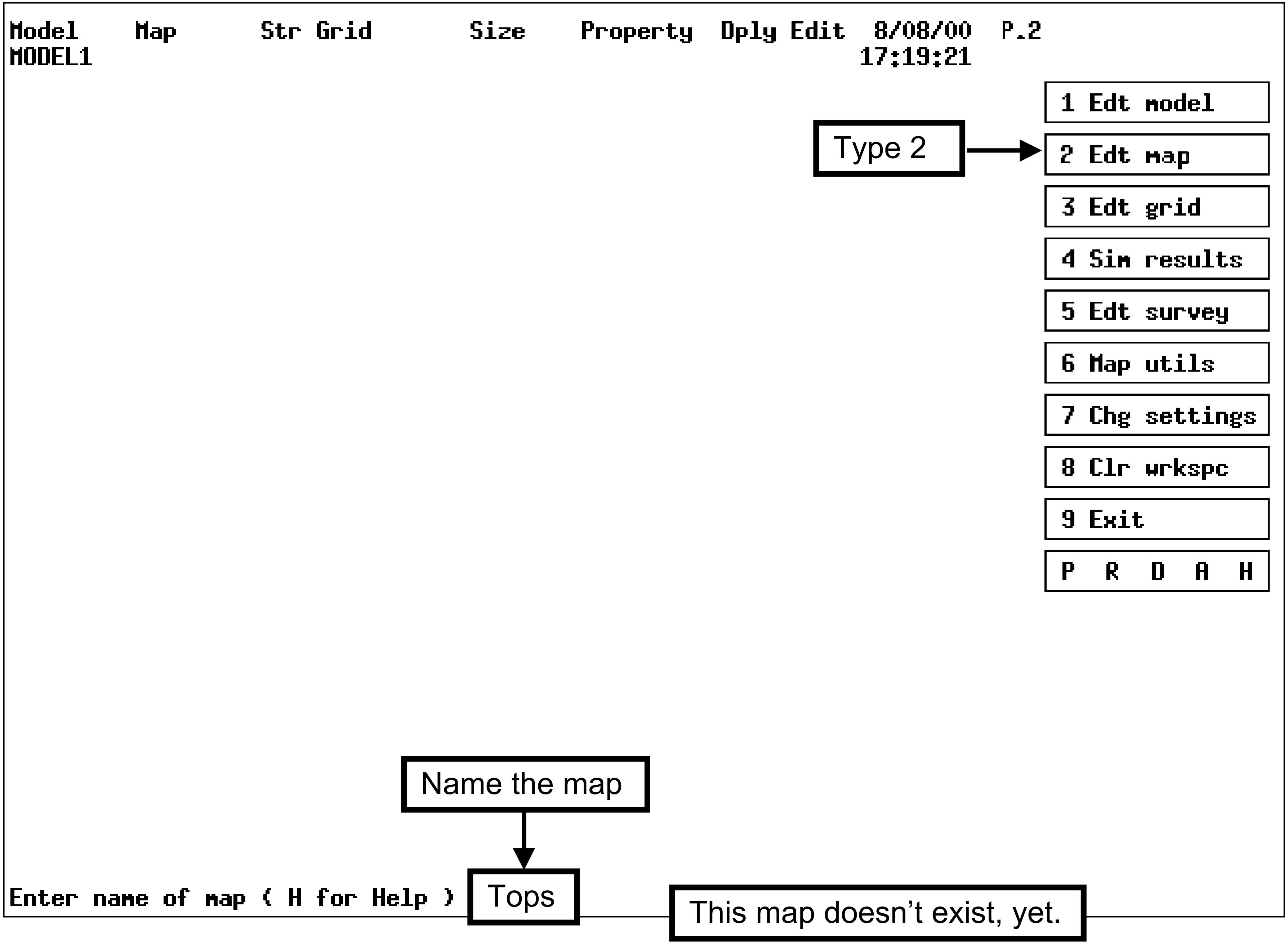
2 (= layers)

<cr>

Prepare to Create Map of Formation Tops



Name the Map to be Created (or Read)



Define the Outline of the New Map

Prompt	Entry	Comment
Map TOPS does not exist. Create new map ? (y/N)	y_	Y confirms new map name
		TOPS is now stored as MODEL1.L0001
Enter Z units for TOPS maps (H for Help)	feet_	feet
Create areal or cross-section map ? (A/x)	A_	Areal map
New map TOPS created...&		<cr>
Enter stratum number (H for Help)	1_	Top for layer 1 Layer 2 set by gross thickness
Stratum 1 does not exist. Create new stratum ? (y/N)	y_	Y confirms
Enter min X and Y coords (0.000,0.000)	0 , 0	0 0
Enter max X and Y coords (1320.000,1320.000)		<cr> gets defaults. 1320 , 1320 works too. Mesh & grid may have same dimensions.
Stratum 1 of map TOPS created...&		<cr>
Draw contours ? (Y/n)	n	None yet

Establish Contour Value and Contour Increment

Please select an option

Type 4 (to Edit Contours) P.2.4

Select option to edit contours...

Type 3 (to Add Contours) P.2.4.3

Enter contour value (,increment) 8000 , 25

Specify the 8000-ft depth contour.
Also specify 25-ft contour increments.

Current contour value is : 8000.00
Current contour interval : 25.00

Confirmation

Please select an option

The wise engineer lets contours extend outside the grid boundary.

This may also mean letting the contours extend outside the map-mesh boundary.

Type 5 (New Contours) P.2.4.3.5

Enter data point or select an option ...

Start the "create one contour" loop

Type 1 (Data Point) P.2.4.3.5.1

Menu 1 starts the contour-creation process.

Use the cursor to locate contour points.
Left click to establish contour points.
Move the cursor to locate the next contour point.

Use menu 3 to delete bad points

Continue until the contour is complete.
Use menu 4 to finish the contour.

Type 4 (End) P.2.4.3.5.4

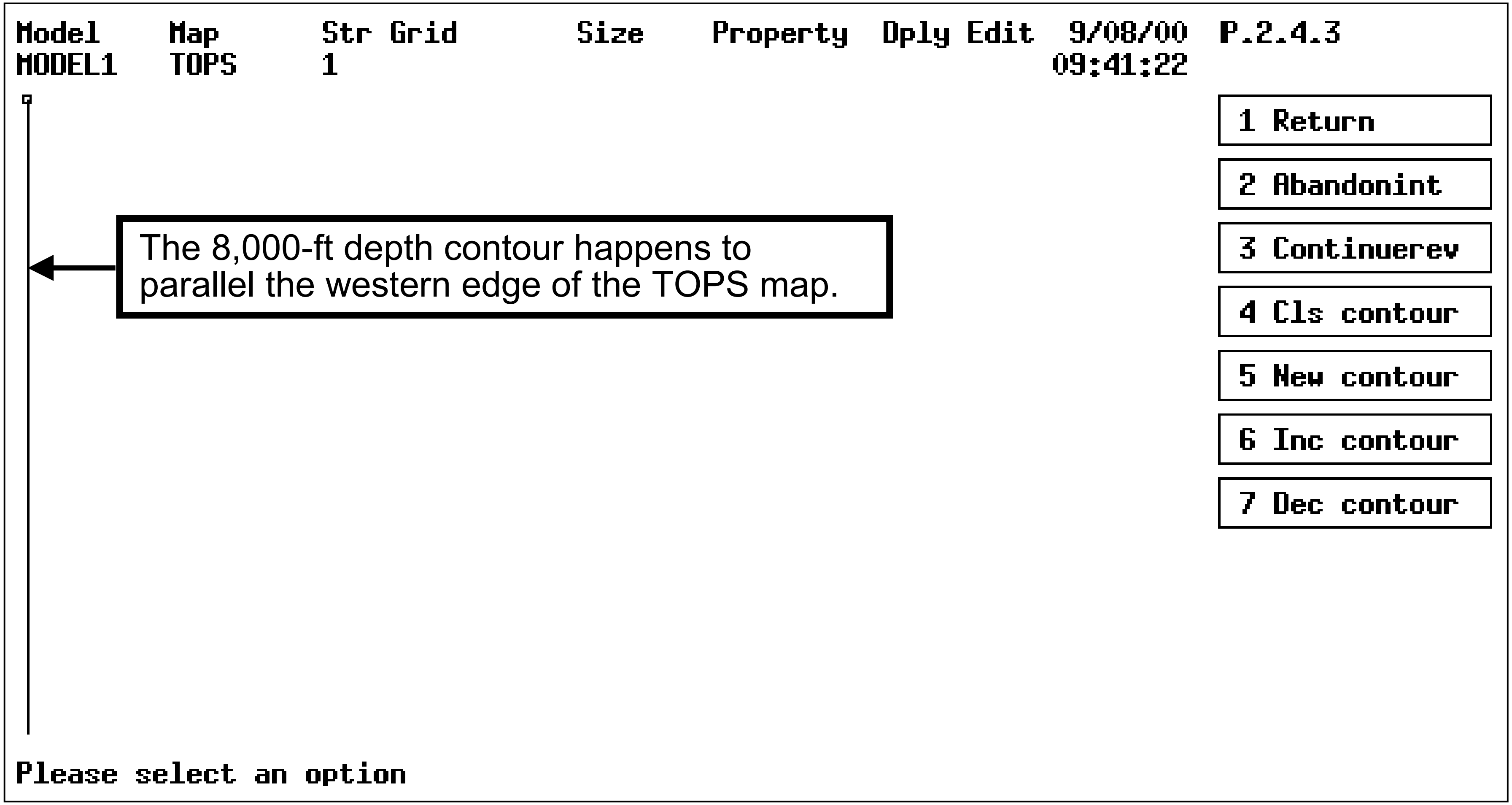
Type 5, 6, or 7 to complete the contour

Finish the "create-one-contour" loop P.2.4.3

Each loop creates one contour on the current map.

Verify the Contour(s)

The first contour is complete.



Now finish TOPS.
Then create THICK, TNET, PORO, KHOR, KVERT.

How many points are actually needed for each contour?
How closely spaced do the points need to be?

BEWARE: there is a huge difference between the definitions for GRID and map MESH.

- MESH shows property data (depth, gross thickness, net thickness, porosity, etc.)
- GRID models reservoir rock as discrete volumes connected by flows.
  - GRID may be block centered or corner point.

The MAP contour points must be close enough to allow the GRID-population software to make reasonable interpolations and extrapolations.

Understanding this is easiest for experienced users. Fortunately, the software provides queues for the rest of us.

Test your contour map by contouring the contours.
OR
Test your contour map by populating the grid.

An excessive number of null points indicates contour points should be closer together.

Too many contour points is a nuisance.
Too many contours is a nuisance.

How close is close enough?

- One point per grid block is too many.
- Try one point for every three (inline) to nine (square) grid blocks.
  - Notice the need to know the grid scale in advance.
  - Allow for future drilling.
  - Allow for future injection.
- Add points until the populated grid looks reasonable.

Add the Other Contours

Please select an option

This example uses 25-ft increments

Type 6 (Increment Contour) P.2.4.3.6
OR
Type 7 (Decrement Contour) P.2.4.3.7

Create additional contours until TOPS is done

Type 5 (New Contours) P.2.4.3.5

Enter data point or select an option ...

Finish the last contour

Verify contours are OK

Type 1 (Return) P.2.4

Type 1 (Return) P.2

Add the Wells

Type 2 (Edit Wells) P.2.2

```
Select option to edit wells...
```

Type 3 (Add Well) P.2.2.3

```
Enter well name  P1
```

```
Enter (X,Y) or digitise ? (x,D)  x
```

<cr>

```
Enter Well Easting,Northing  660  ,  660
```

Type N
Allow contours beyond the map edge.

```
Select option to edit wells...
```

<cr>

Type 1 (Return) P.2

Prepare to write the TOPS contours to a file.

Enter format

<cr>

Type 4 (Edit Contours) P.4

<cr>

Output the Map as an ASCII (or Binary) File


```
Select option to edit contours...
```

Type 8   P.2.4.8

```
Output in SAVE file format ? (y/N)  N
```

← Type **NO** Avoid saving binary file (*.UCT)
Do save a formatted file (*.CNT)

```
Enter output file root  TOPS
```

← Name the contour-output file

```
File TOPS.CNT opened...&
```

← <cr>

```
Clip output data to model area ? (y/N)  N
```

← Type N
Allow contours beyond the map edge.

```
Enter record format e.g. (3E13.5) or RETURN for *
```

← <cr>

OR

```
Enter record format e.g. (3E13.5) or RETURN for *  3G14.6
```

← Enter format

```
Enter contour value on marker card or RETURN for 999999.
```

← <cr>

```
11 contours, 113 points output....&
```

← <cr>

P.2.4   **TOPS.CNT now exists.**

ASCII Contour-File Examples

Formatted output is on the left.

Namelist (default) output is on the right.

999999. is the default separator for formatted output.

1.00000E+30 is the default separator for namelist output.

The three columns are x-coordinate, y-coordinate, and property value (*e.g.*, depth)

(3G14.6)

5.12110	1306.82	8000.00
5.12110	1202.73	8000.00
5.12110	1103.60	8000.00
5.12110	1029.26	8000.00
5.12110	940.039	8000.00
5.12110	860.736	8000.00
5.12110	766.564	8000.00
5.12110	677.347	8000.00
5.12110	588.131	8000.00
5.12110	484.046	8000.00
5.12110	404.743	8000.00
5.12110	310.570	8000.00
5.12110	221.355	8000.00
5.12110	132.139	8000.00
5.12110	28.0532	8000.00
999999.	999999.	999999.
175.227	1307.95	8025.00

*

5.12110	1306.82	8000.00
5.12110	1202.73	8000.00
5.12110	1103.60	8000.00
5.12110	1029.26	8000.00
5.12110	940.039	8000.00
5.12110	860.736	8000.00
5.12110	766.564	8000.00
5.12110	677.347	8000.00
5.12110	588.131	8000.00
5.12110	484.046	8000.00
5.12110	404.743	8000.00
5.12110	310.570	8000.00
5.12110	221.355	8000.00
5.12110	132.139	8000.00
5.12110	28.0532	8000.00
1.00000E+30	1.00000E+30	1.00000E+30
175.227	1307.95	8025.00

The next contour starts immediately after the separator line.

Complete the Map (TOPS)

Type 1 P.2

Type 1 P

```
Save map on disk ? (Y/n) Y
Enter history file comment(s) :
```

Type Y

<cr>

MODEL1.L001 has been updated, and
MODEL1.HIS now exists.

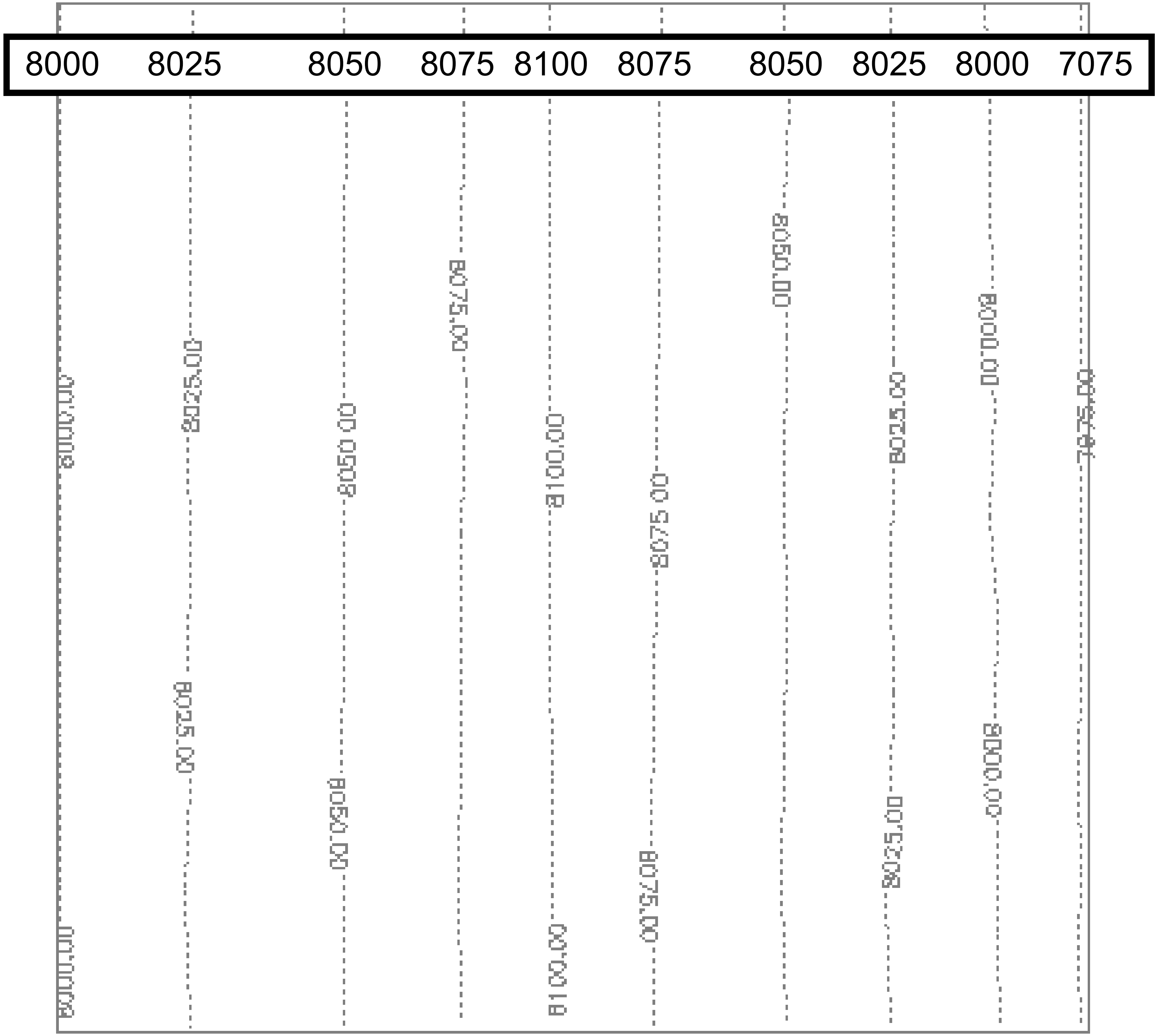
This completes the creation of TOPS.

It is possible to test the map at this point.

I prefer to create the grid,
then test the grid for nulls and acceptable values.

Create the other maps, now that the grid populates reasonably.

Completed Structural-Tops Map (TOPS)



This completes the contour creation (digitizing) portion of the tutorial.
- The formats for contour files are now known.
- The naming convention for contour files is now known.

OK. The “Grid - Internal Model Files” manual may also explain this.

Contours may be created externally (as *.CNT files.)

Contour files may be imported as maps.

The maps will then be tested.
- Get rid of the null points
  - GeoQuest recommends adjusting the contour parameters.
  - It is much more intuitive to add additional contours.
- Make sure the interpolated (cell-block) values are reasonable.
  - It may be necessary to add more contours.

Contours are typically digitized from subsurface maps.
- Geologists, geophysicists, and petrophysicists provide maps.

Simulation engineers then import contours into the simulator.
- Structural tops,
- Gross and net thickness (or net-to-gross ratio,)
- Porosity,
- Horizontal and vertical permeability,
- Well locations, and
- Faults and other boundaries.

Importing Map Contours (1 of 3)

Importing contours to create maps is just a little different than creating maps.

Prerequisites:
Model must exist

Type 2	(Edit Map) P.2
Type TOPS	(Name the Map)
Type Y	(Create New Map)
Type H	(Help with map units)
Type 3	(feet)
Type A	(areal map)
Type <cr>	(TOPS Created)
Type 1	(for layer 1)
Type Y	(Create New Strata)
Type <cr>	(use model origin)
Type <cr>	(use model extreme)
Type <cr>	
Type Y	(Draw contours There aren't any yet.

Now ready to import details.

Import Well Location(s)

Type 2	(Edit Wells) P.2.2
Type <cr>	
Type 6	(Import Wells)
Type WELLS.WEL	(Well File Name)
Type N	(do NOT clip)
Type 2, 3, & 4	(Preview data)
Type 5	(**go to line 1**)
Type 1	(Return) P.2
Type <cr>	(Accept line-1 format)
Type <cr>	(Well file read OK)
Type 1	(Return) P.2

Ready to import structural tops.

Import structural top contours.

Type 4	(Edit Contours) P.2.4
Type 7	(Import Contours)
Type N	(Import formatted "ASCII" *.CNT files
Type TOPS.CNT	(Filename)
Type N	(do NOT clip)
Type N	(do NOT thin) There can be extra data.
Type 2, 3, & 4	(Preview data)
Type 5	(**go to line 1**)
Type 1	(Return) P.2
Type <cr>	(Accept line-1 format)
Type <cr>	(Accept contour marker)
Type <cr>	(Well file read OK)
Type 1	(Return) P.2
Type 1	(Return) P
Type Y	(Save Map on Disk)
Type <cr>	(Or enter comments)

Tops is complete.

Test for Null Nodes

Type 2	(Edit Map) P.2
Type grid	(Name the Grid)
Type <cr>	(Accept TOPS as map)
Type <cr>	(Accept Strata 1)
Type 4	(Edit Contours) P.2.4
Type 9	(Sample Contours) P. 2.4.9
Type 4	(Test Grid) P.2.4.9.4
Type 6	(All Blocks) P.2.4.9.4.6
Type 4	(Avg Center & Corners) P.2.4.9.4.6.4
Type <cr>	(Null Values Exist)
Type <cr>	(Accept Default Value)
Type <cr>	(Interpolation Complete AND FLAWED)

Wise engineers add extra contours to eliminate null values.

Type 7	(Edit Sample Values) P.2.4.9.4.7

Importing Map Contours (3 of 3)t

The following manual method substitutes for adding extra contours.

It works because there are only 25 cells.

Type 2 (Show Block Values) P.2.4.9.4.7.2

Manually find the bad values.

Then calculate good values.

Type 3 (Define Block Values) P.2.4.9.4.7.3

Use cursor to select block

Type “good value”

Repeat until all blocks have good values.

It is tedious AND REQUIRED.

Repeat the “Show Block Values” steps

This is tedious AND REQUIRED too.

Testing TOPS is complete.

Output the Block Values

Type 1	(Return)	P.2.4.9.4.7
Type 6	(Output Block Values)	P.2.4.9.4.7.6
Type BlockVal	(Root for GRDECL file)	
Type Tops_ft	(ID the block property)	
Type <cr>		
Type N	(keep blockval.grdecl open)	
Type 1	(Return)	P.2.4.9.4
Type 1	(Return)	P.2.4.9
Type 1	(Return)	P.2.4
Type 1	(Return)	P.2
Type Y	(Save Map)	
Type 1	(Return)	P

BlockVal.GRDECL now contains the depth of the top of the formation for the top layer of all 25 blocks.

Repeat this process to import contours for the other 5n layer-property combos & save the values in BlockVal.GRDECL.

This is a good time to present the grid-creation process.

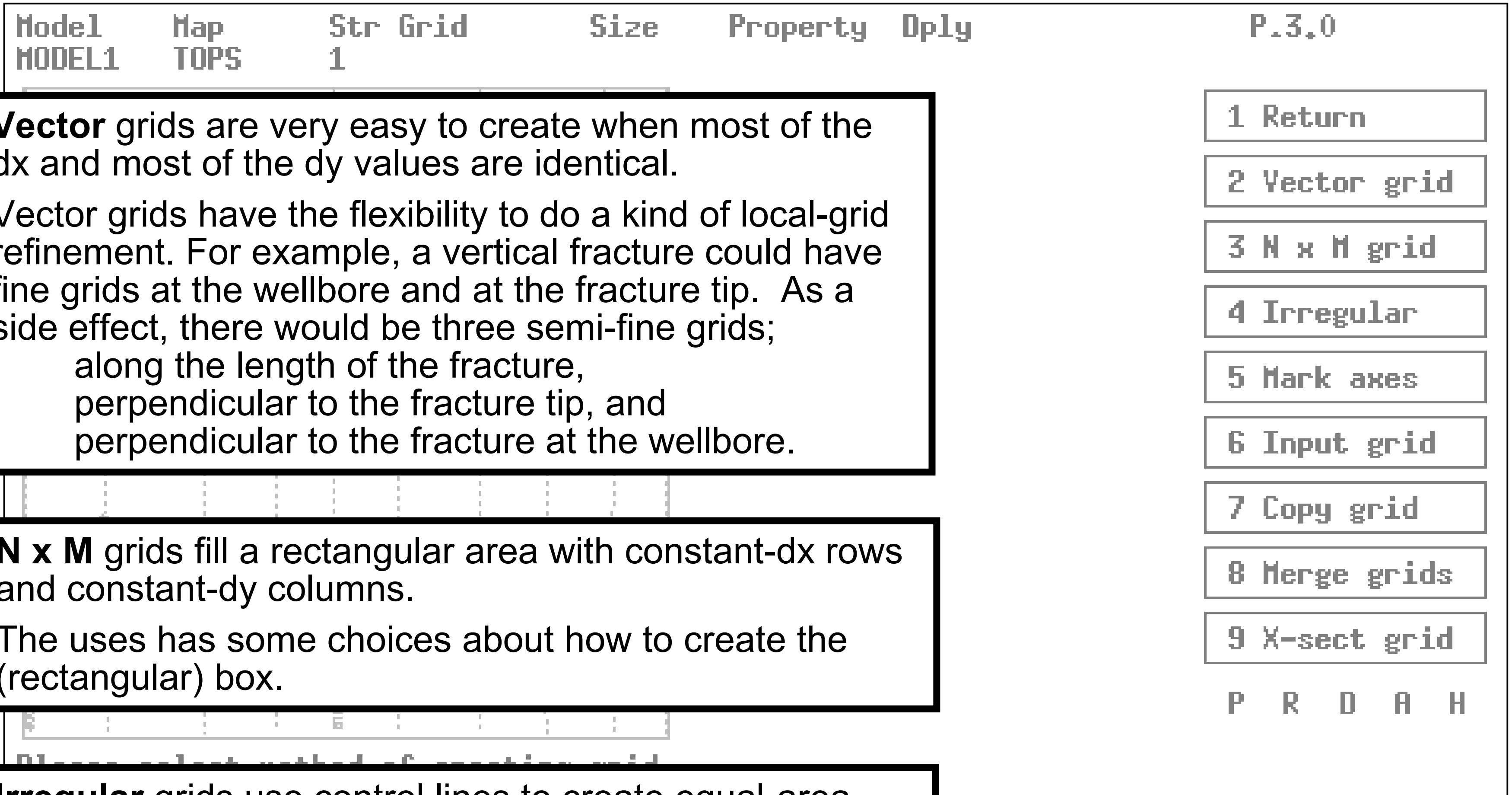
A grid is required before defining structural tops, layer thickness, & other properties.

Prerequisites:
- Model must exist
- Map must exist

Type 3 P.3

Prompt	Entry	Action
Enter the name of the grid	MODEL1	Type model1
Grid MODEL1 does not exist. Create new grid ? (Y/n)	Y	Type Y
Enter name of map (H for Help)	TOPS	Type tops
Enter stratum number (H for Help)	1	Type 1
Draw contours ? (Y/n)		<cr>

Menu P.3.0 appears because there is no grid (yet)



Vector grids are very easy to create when most of the dx and most of the dy values are identical.

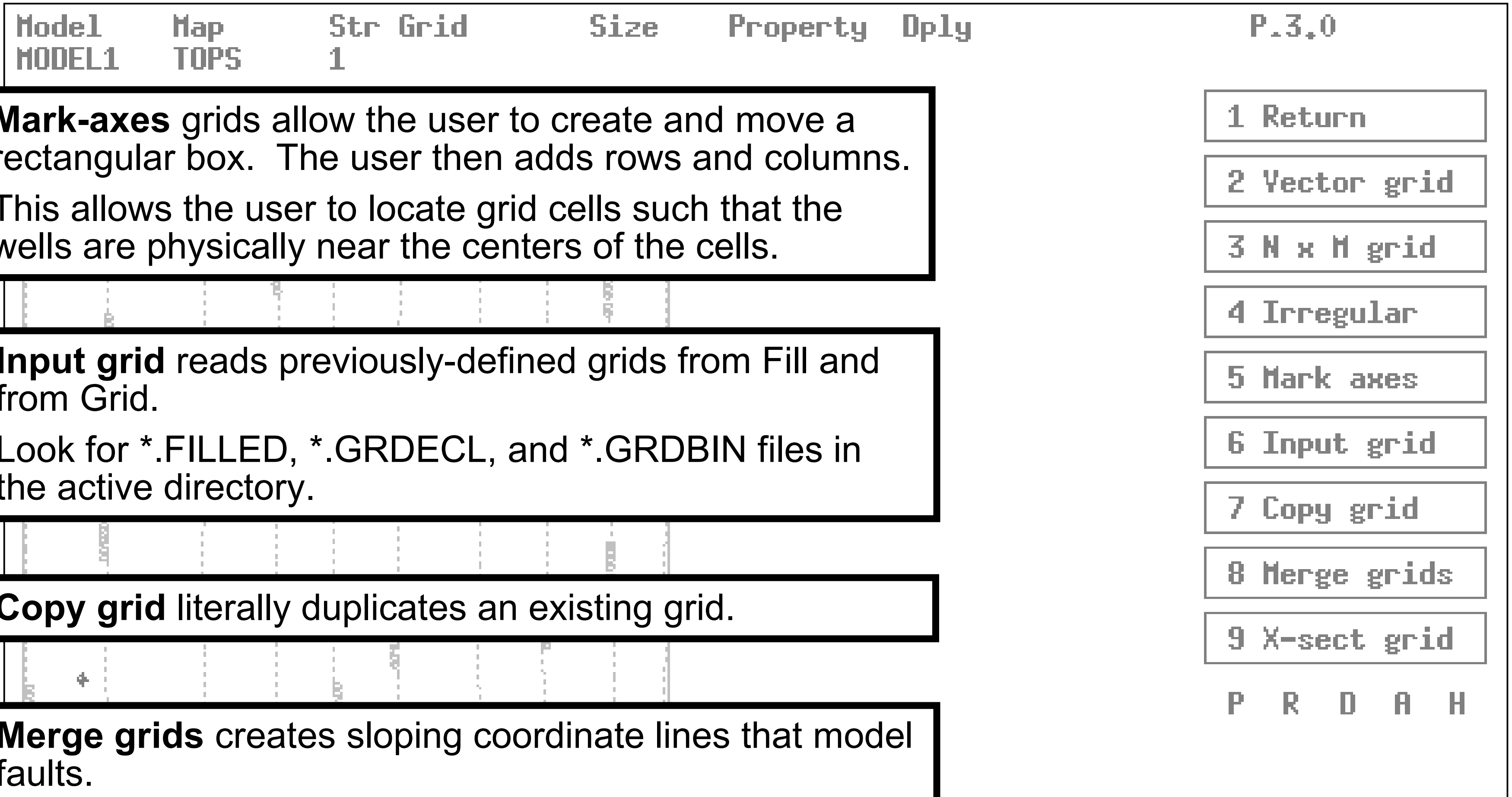
Vector grids have the flexibility to do a kind of local-grid refinement. For example, a vertical fracture could have fine grids at the wellbore and at the fracture tip. As a side effect, there would be three semi-fine grids;
- along the length of the fracture,
- perpendicular to the fracture tip, and
- perpendicular to the fracture at the wellbore.

N x M grids fill a rectangular area with constant-dx rows and constant-dy columns.

The uses has some choices about how to create the (rectangular) box.

Irregular grids use control lines to create equal-area grid cells.

This allows the grid to follow dominant subsurface features such as faults and other reservoir boundaries.



Mark-axes grids allow the user to create and move a rectangular box. The user then adds rows and columns.

This allows the user to locate grid cells such that the wells are physically near the centers of the cells.

Input grid reads previously-defined grids from Fill and from Grid.

Look for *.FILLED, *.GRDECL, and *.GRDBIN files in the active directory.

Copy grid literally duplicates an existing grid.

Merge grids creates sloping coordinate lines that model faults.

X-sect grid creates vertical cross sections.

The next slides show details for creating **vector** grid. Subsequent slides detail **N x M** grid creation.

Type 2 P.3.0.2

```
Enter depth units for grid or RETURN for FEET
```

```
Enter origin as MAP coords, or G for grid default or D to digitize...&
```

"MAP" is **recommended** for new grids.
"GRID" forces grid parallel to map boundaries.
"DIGITIZE" with mouse may lack precision.

```
Enter MAP coords or option (g/D)  0 1320
```

WARNING: Enter map-mesh, x-y coordinates for the grid origin.

```
Enter coordinates of a point in x-direction  1320  1320
```

WARNING: Enter map-mesh, x-y coordinates for any point on the x-axis of the grid.

```
Do Y coordinates increase down the page ? (Y/n)  Y
```

```
Enter the next dX value ( or RETURN to end )  20*66.0
```

Variable spacing would require 20 separate dX entries.

```
Enter the next dX value ( or RETURN to end )
```

```
Enter the next dY value ( or RETURN to end )  20*66.0
```

Variable spacing would require 20 separate dY entries.

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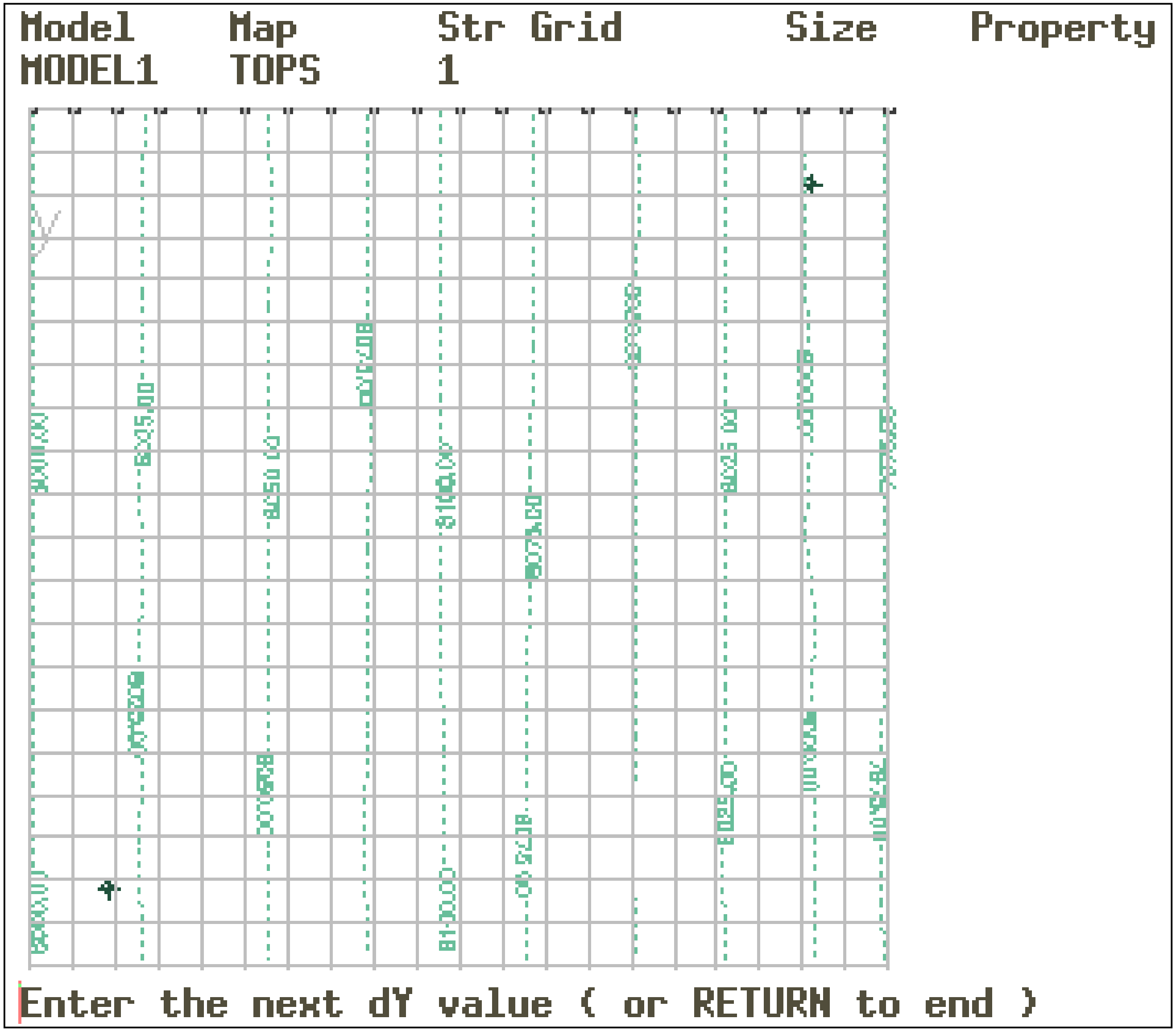
Verify the grid.



```
Enter name of map or RETURN for TOPS
```

```
Enter stratum number or RETURN for 1
```

```
Please select an option
```

The 20 x 20 vector grid is now complete.

The next slides uses the N x M menu to create an identical grid.

GRID knows a grid already exists.
We must fool GRID before making another.
Rename MODEL1V.FNODE (to fool GRID.)

CAUTION:
MODEL1.FFEATURE still records the existence of a grid named MODEL1V.
MODEL1.FFEATURE still records the number of existing grids.

Type 3 P.3.0.3

```
Enter depth units for grid or RETURN for FEET
```

```
Enter origin as MAP coords, or G for grid default or D to digitize...&
```

"MAP" is **recommended** for new grids.
"GRID" forces grid parallel to map boundaries.
"DIGITIZE" with mouse may lack precision.

```
Enter MAP coords or option (g/D)  0    1320
```

```
Enter coordinates of a point in x-direction  1320  1320
```

```
Do Y coordinates increase down the page ? (Y/n)  Y
```

```
Okay to continue with these axes ? (Y/n)  Y
```

```
Enter MAP coords of any corner or RETURN to digitise  0  0
```

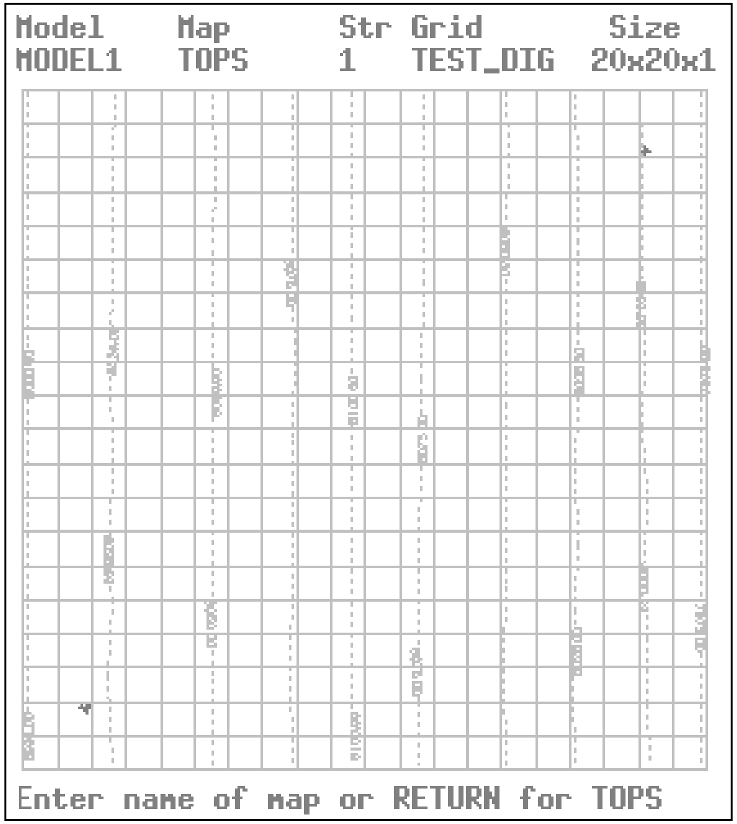
```
Enter MAP coords of opposite corner  1320   1320
```

Select any corner to be moved

Type 2 (Box Ready)

Enter number of cells in X direction 20

Enter number of cells in Y direction 20



<cr>

```
Enter stratum number or RETURN for 1
```

Type 2 (Box Ready)

```
Please select an option
```

The 20 x 20 vector grid is now complete.

However, P.3.7.2 shows that depths (from TOPS) are undefined.

The next slides overview the grid-population process.

Had I been able to use P.3.8.5 to create properties, I could have avoided the work-around with P.2.4.9.4.7, etc. to save property values in *.GRDECL.

P.3.8.5 did work after I exited and re-started Grid.

Type 1 (Return) P.3

```
Save the changed grid ? (Y/n)  Y
```

Writing MODEL1.FNODE to file

```
Enter history file comment(s) :
```

```
Please select an option
```

```
Enter number of layer or RETURN for 1T
```

```
Select option to edit an area of the grid...
```

Type 2 (Edit Layer Area) P.3.2

Type 2 (Define Layer Depth) P.3.2.2

The details seem intuitive, so details are scarce at this point.

```
Enter depth ( or S to sample map or I to intersect map )  S
```

"S" gives an opportunity to specify a different map name and a different layer (strata) number.

```
Enter name of map or RETURN for TOPS
```

```
Enter stratum number or RETURN for 1
```

```
Change all layers below current layer ? (Y/n)  Y
Change all layers above current layer ? (Y/n)  Y
```

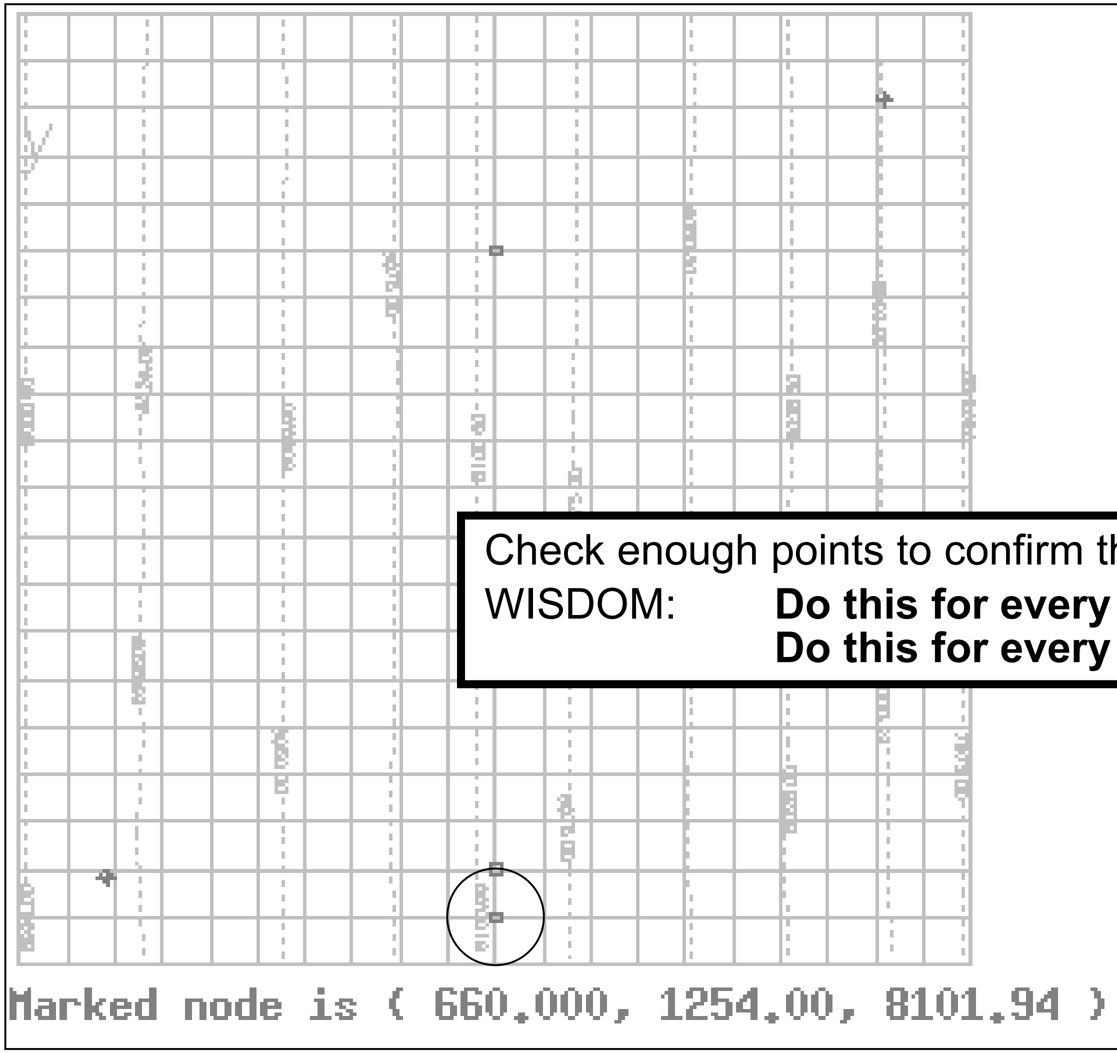
"Yes" **only applies** when depths (of layer tops) & layer thickness change.

Layers should not physically overlap.

Answer **NO** when using the property-definition work-around.
Permeability and porosity do NOT change depths.

XYZ positions will be in FEET relative to grid origin...&

Select the required node...



Check enough points to confirm the cell values are reasonable.
WISDOM: **Do this for every property**.
Do this for every property.

<cr>

Type 1 (Return) P.3

Type 1 (Return) P

```
Save the changed grid ? (Y/n)  Y
```

Writing MODEL1.FNODE to file

```
Enter history file comment(s) :
```

```
Please select an option
```

That's all for now.

Summarize the grid-population steps

Type 3	(Edit Grid) P.3
Type grid	(Name the Grid)
Type <cr>	(Accept TOPS as map)
Type <cr>	(Accept Strata 1)
Type 2	(Edit Layer) P.3.2
Type 2	(Define Depth) P.3.2.2
Type <cr>	(Accept 1T)
Type S	(Sample the Map)
Type <cr>	(Confirm TOPS as map)
Type <cr>	(Confirm Strata 1)
Type Y	(Change depths below)
Type Y	(Change depths above)
	(Interpolating)
	(Are there any nulls?)
Type <cr>	
Type 99.9999	(Enter Unique Null Value)
Type Y	(Continue)
Type <cr>	(Interpolation Complete)
Type 1	(Return) P.3
Type 1	(Return) P

Use the process to populate the other properties for each layer

The Grid-Property Population Process

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This is a good time to discuss the grid-population process.

This is a way to determine whether there is an adequate distribution of contour points.
- Are the number and location of null values acceptable?
  - See menu P.2.4.9.4.6.4
- Are the (interpolated and extrapolated) cell values reasonable?
  - See menu P.2.4.9.4.7.3

Caution: menu P.2.4.9.4.9 claims it can save block values as properties.
In reality, this canNOT be done until properties have been defined.

The work-around is to create 1 + 5n separate grids
- 1 grid for structural tops.
- n grids (1 /layer) for: porosity, horizontal permeability, vertical permeability, gross thickness, and net thickness.

The good news is that you can copy the 5n grids from the TOPS grid.
- There is no need to copy the well locations.
- The scope of this tutorial does NOT address the need to copy faults.
  - It is likely that faults will need to be copied because faults affect contouring.

Then save the block (cell) values to *.GRDECL using menu P.2.4.9.4.7.6.
- Keep *.GRDECL open until all the properties for all layers have been saved.

Return to the primary menu.
- Save the changed grid.
- Edit another grid (for the next property layer.)

Menu P.3.8.5 should have allowed me to create properties.
- It didn't (at least not until after I exited Grid and re-started Grid.)
- This was probably a novice's error.

Grid output defaults to corner-point geometry.
It may be possible to average the corner points into a cell-center value.

It appears necessary to have a separate grid for each property layer.
Thus, a 2 layer model appears to need 11 populated grids:

- top
- gross thickness (2)
- net thickness (2)
- porosity (2)
- horizontal permeability (2)
- vertical permeability (2)

Number of grids = 1 + 5 * number of layers

It appears adequate to have one map for each property.
Thus, a 2 layer model appears to need 6 maps:

Number of maps = 6
    Maps may have multiple layers.

Other maps may be created in the same way.

- Gross thickness
- Net-to-gross thickness ratio
- Porosity
- Horizontal permeability
- Vertical permeability

Here is a typical block of data from a *.grdecl file (for a 5 x 5 x 1 grid.)

MANUALLY COPY this GRID output to the *.DATA (Eclipse input) file.

The structural tops are for the center of each cell. (Corner-point geometry is also an option.)

The first entry is for I=1, j=1. The second entry is for I=2, j=1, etc.

```
-- GRID Version 99A_1        Date: 16/08/00   Time: 16:24:47
--                           Model: MODEL     Grid: GRID
--- Grid dimensions are    5 x    5 x     1
--- Sampled values from TOPS     contour map of model stratum    1

--- Current sampling parameters are
---  Search rad frac   No. octants   Null value
---     2.0500             7        0.10000E+07

---    IX1  IX2  JY1  JY2  KZ1  KZ2
BOX
          1    5    1    5    1    1   /

--- Block values
TOPS_FT
   8021.0       8012.4       8005.4       8012.4        8021.0
   8021.0       8012.6       8006.1       8012.6        8021.0
   8021.0       8012.6       8006.2       8012.6        8021.0
   8021.0       8012.6       8006.1       8012.6        8021.0
   8021.0       8012.4       8005.4      0.13201E+06   0.13202E+06
```

Congratulations.

You remembered to review every single GRID output for reasonableness.

Your review revealed the bad data in cells i=4,j=5 & i=5,j=5.

There are several ways to deal with this.

One way is to review and modify the control contours and control points.

Another way is to adjust the search radius and adjust the octant criterion.

The best input for contouring comes from a coordinated study of all available data.

Typical data includes outcrops, cores, electric logs, buildup, and seismic analyses.

The best information comes from directly from the pay zone (*e.g.*, cores and logs.) This provides sparse data along the wellbore trajectories.

Sparse data challenges contouring packages. It is possible to get spurious (extreme and unacceptable) property values when extrapolating sparse data.

Buildup, seismic, and geostatistic analyses provide guidance between wellbores. This helps add control contours and control points.

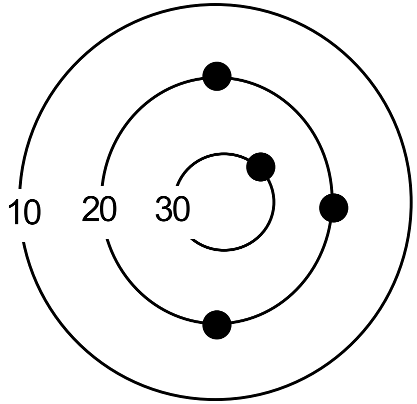
Wise use of control contours and control points compensates for sparse data.

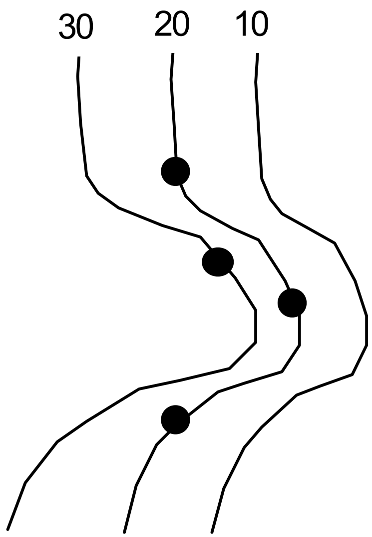
Wise simulation teams create coordinated control data. The interpreted controls must consistently fit the data from all the disciplines.

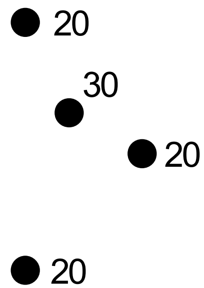
The next slide provides a simplified, yet practical example.

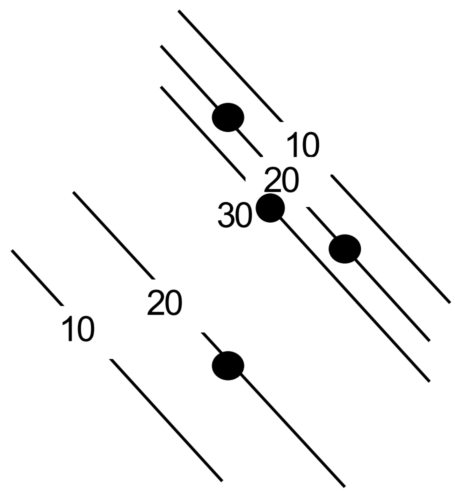
Spare-Data Contour Maps

It takes cooperation between the geologist, the geophysicist, and the petroleum engineer to identify the correct contours. The following example may have more than the three interpretations shown.









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The interpolation routine uses the property values (data points) surrounding the point in question.

Each data point is located some finite distance (and direction) from the center of the interpolation.

The search radius defines the size of the search circle.

Interpolation works best when the available data is evenly distributed within the circle.

The empty-octant criterion is a good measure of how evenly the data is distributed.

The empty-octant criterion subdivides the search circle into eight equal wedges.

Allowing more empty octants increases the probability that the data points are unevenly distributed about the center of the search circle.

See GeoQuest's GRID manual for details on menus:

P.2.4.9.5	Search Radius
P.2.4.9.7.5	Search Radius
P.2.4.9.3	Empty Octants

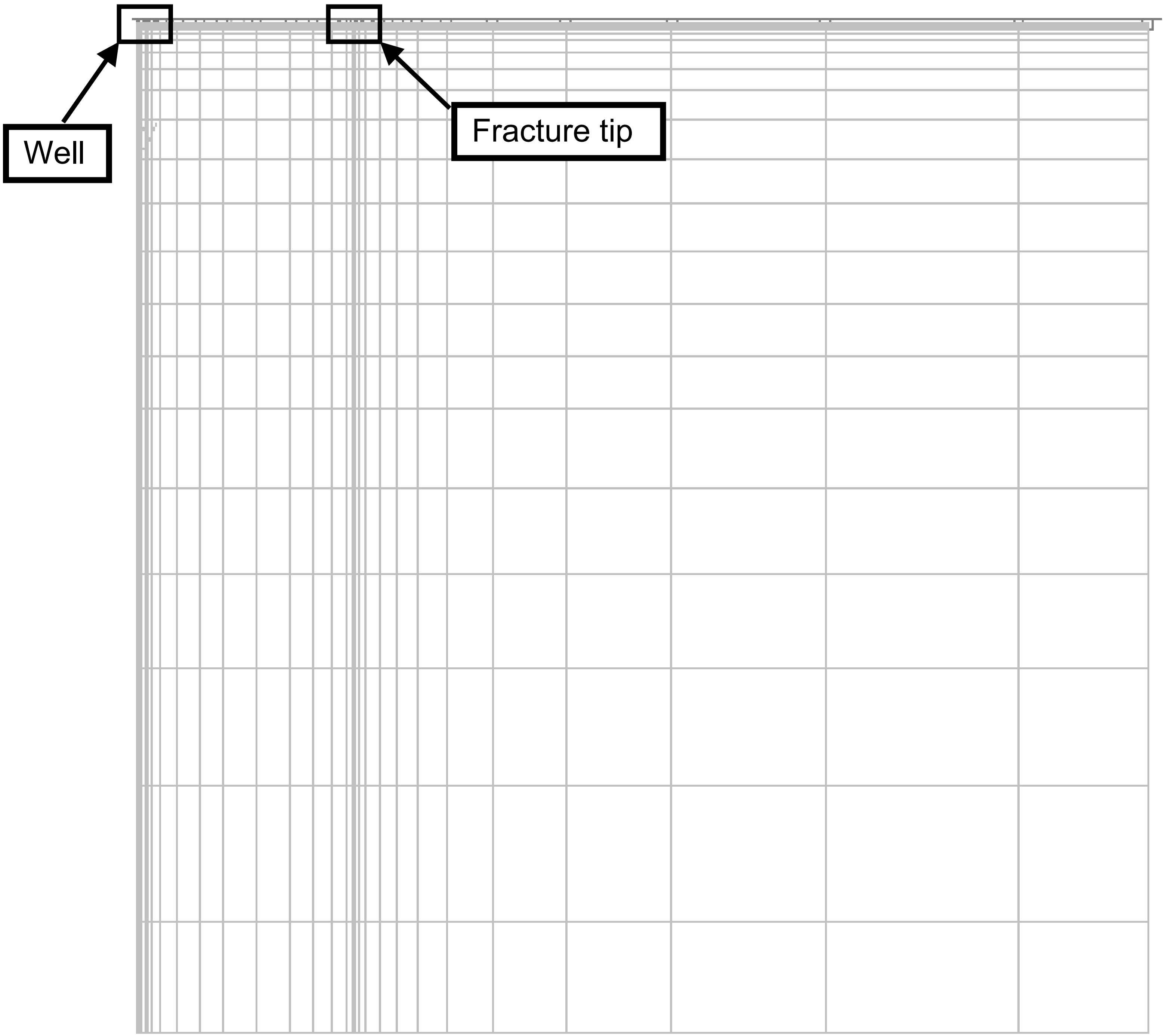
Supplemental Index for Grid Manual (2 of 2)

Fracture Grid

The next slide shows an areal plot of a grid intended for a fracture.
The fine grid along the length of the fracture is at the top of the map.
The fine grid through the wellbore is along the left edge of the map.
The fine grid through the tip of the fracture is near the left edge.
The areal grid was created as a vector grid (P.3.0.2)
The creation required manually entering 33 dx and 31 dy values.
See SPE 11030 and 11029 for details.

I	DELX	J	DELY
1	0.042295	1	0.042295
2	0.155083	2	0.070492
3	0.281968	3	0.070492
4	0.563936	4	0.070492
5	0.719020	5	0.070492
6	1.029186	6	0.140984
7	2.058372	7	0.211476
8	3.087558	8	0.281968
9	4.116744	9	0.422952
10	6.175116	10	0.563936
11	10.29186	11	0.845905
12	20.58368	12	1.409841
13	28.19682	13	2.819682
14	28.19682	14	5.639364
15	42.29523	15	8.459046
16	42.29523	16	14.09841
17	28.19682	17	21.21811
18	23.9673	18	28.19682
19	16.91809	19	35.24603
20	8.459046	20	49.34444
21	4.229523	21	56.39364
22	4.229523	22	59.34444
23	8.459046	23	66.39364
24	16.91809	24	64.34444
25	21.91809	25	66.39364
26	24.91809	26	99.34444
27	36.91809	27	106.3936
28	56.91809	28	119.3444
29	91.91809	29	146.3936
30	131.9181	30	169.3444
31	191.9181	31	138.0864
32	241.9181		
33	161.1889		

Plan View of 33 x 31 Fracture Grid



Thank you for visiting www.EricLaine.com.

The primary purpose of this document is to serve as a memory aid for the author. Thus, the author is also the target audience. (In other words, the quality of the composition is 100% sufficient for me to understand what I wrote.)

The secondary purpose is to share this tutorial with the public. I appreciate the possibility that the general public may have some difficulty understanding the my personal abbreviations and my intuitive logic.

Please send your questions and your suggestions to EricLaine@compuserve.com.

Part of this tutorial is about PSEUDO. PSEUDO is Schlumberger - GeoQuest software for calculating rate-dependent pseudo relative permeabilities (Kr) and rate-dependent pseudo capillary pressures (Pc.)

Part of this tutorial is about the cost effective use of pseudo curves.

This tutorial improves the author's personal productivity by serving as a memory aid that demonstrates how to use GeoQuest's Grid software to either create or import contour lines.

Well data and contour points are a special case of contour lines. (It takes two points to define a line.)

It is important to understand the differences between mesh maps and simulation grids. These are fundamental GeoQuest definitions.

Maps are converted into populated property grids. The minimum required number of grids is:

1 + (the number of properties -1) * (the number of layers)

where

Structural tops (which is included in the number of properties) requires the single grid, and the other properties each need one grid per layer.

Several grid-creation options are covered (Vector, N x M, and Irregular) Grid-property population is covered in detail.

An essential step is validating Grid's output. The user must "prove" that Grid's output is valid. This means it is necessary to review each and every property for each and every grid block (or corner point) for reasonableness.

Goofy Grid output is more likely during the early stages of property population. The competent professional uses control contours and control points that support the team's geological, geophysical, and petrophysical interpretations. Judicious adjustment of the search radius and the number of empty octants can improve the quality of the grid-property populations (provided there are a sufficient number of mesh-map contour lines and points.

Grid's output is stored in *.GRDECL files. These data must be copied into Eclipse's *.DATA files.

GeoQuest's Grid manual is an essential, and it is well written. The author finds it helpful to use his supplemental index when using the manual.

Finally, the author included an example of a grid intended specifically for modeling a hydraulic fracture.