INTERPRETATION OF PHYSICAL MODEL TANK DATA WITH THE RASTER SEGMENT GENERATOR

H. Roice Nelson, Jr.
Seismic Acoustics Laboratory

Thomas N. Gardner
Adage, Inc.

Fred J. Hilterman
Geophysical Development Corp.

ABSTRACT

A combination of interactive raster and vector computer graphics is shown to be a useful tool in interpreting seismic data. The data displayed consist of several sets of vertical and horizontal seismic sections generated in a physical modeling tank. The display device is a three-dimensional vector refresh graphics system with a raster segment generator. The raster segment generator processes and displays data which can be packed with up to 16 data values per word. This increases the number of vectors that can be displayed at one time by a factor of at least 10 with a maximum of 240,000 data points. The procedures and programs used to display the data are explained. The procedures involved in making an interpretation and fitting a surface on the interpreted picks are shown. This is followed by a description of the interpretational value of being able to carry out such procedures as interactive map migration and wavelet processing.

The raster segment generator allows the display of 240 traces, each with 1000 samples and at a two level amplitude resolution. However, the vertical sections in this paper use a four level resolution and therefore only 120 traces will be displayed per section. The number of samples and traces to be displayed can be varied interactively. The same capacity can be used to display horizontal sections of 3D data that have 240 lines with 240 shotpoints on each line.

An automatic procedure has been designed to take the sections from the raw data tapes and put them in display format on the disc after the interpreter specifies the display parameters. Once a set of data is in the display format, the next section can be displayed in a cycle time of 1/30th of a second. When a set of horizontal time sections are displayed in sequence at this rate, the result appears to be a motion picture. Alternatively, these sections can be displayed one at a time and interpreted individually.

The ability to rapidly change from one display to another, when all of the vertical or horizontal sections are in display format, greatly assists the interpreter's mental picture of the subsurface. As sections are displayed they can be interactively interpreted using a cursor controlled by a digitizing tablet. By rotating and scaling the vector interpretation, an apparent three-dimensional picture of the interpretation up to that point is displayed. If there are then problems

with certain picks the interpretation procedure can be edited and the picks corrected. As a graphic example, a set of vertical sections across a Gulf Coast model with two asymmetrical domes and a curved fault are shown being picked. The problems associated with doing this interpretation are illustrated and discussed in relation to more complex interpretations.

A movie illustrating data taken across an asymmetrical Gulf Coast model summarizes the advantages of interactive 3D interpretation techniques.

INTRODUCTION

The raster segment generator (RSG) is shown to be a useful tool in interpreting phyical model tank data. An input sequence has been set up to convert standard tank data into display format for the RSG. Once a data set is transformed, a typical vertical section is evaulated to determine the parameters for the best display. With the parameters defined, an automatic procedure is started to take all of the vertical sections off of tape and put them on disc in RSG display format. These sections can be scrolled vertically, expanded for increased resolution, and interactively interpreted.

A three-dimensional (3D) vector line drawing representation of the subsurface is built as individual sections are interpreted. A mesh can be fit to the specific horizons defined by this interpretation. Analog dials allow this picture to be rotated. The dynamic motion and resulting motion parallax make the display appear to be in 3D.

There is a similar sequence for displaying and interpreting horizontal sections. A 3D volume of vertical sections is restructured into a set of horizontal sections in display format. These are rapidly moved through in a manner similar to animated plots of horizontal sections. These displays can be stepped through and appropriate sections contoured. The resulting 3D interpretation can be evaluated in a manner similiar to the vertical section interpretation.

THE DATA

Data were collected in the Seismic Acoustics Laboratory physical modeling tank at the University of Houston. The model, SALGLF, is a made of 3110 silicone rubber as described by French.[1] The model has two assymetrical anticlines and a curved fault with a sloping upthrown block. Two sets of common offset data were collected using standard system procedures.[2] The nine vertical sections are from the model labeled SALGLF-1. These sections are perpendicular to the major axis of the anticlines and equally spaced at 1200 foot scaled intervals (1.2 inches real model dimensions). Trace spacing was 70 feet (0.07 inches not scaled).[3]

The model was rotated 45° counterclockwise to collect the data volume for the horizontal sections. SALGLF-4 consists of 256 vertical sections collected where line 1, trace 1 is at the top left corner of the location map.[4] Figure 1 can be used as a referance. In this picture the lines run vertically down the model from left to right.[3]

The data were not migrated or filtered for this work.

THE DISPLAY EQUIPMENT

The work was done on an Adage 4145 graphics processor with a parallel interface to a VAX 11/780. There are 128k bytes of local memory for graphic program and vector storage. The system has hardware vector rotate, translate and scale for both 2D and 3D vectors. The peripherials include a keyboard, joystick, light pen, data tablet, function switches and a hardcopy connection to a 22 inch Benson-Varian electrostatic plotter.

THE RSG

The raster segment generator will allow the display of 240 traces with a 2 level amplitude resolution for each sample. Standard WVA (wiggle variable area) sections with 10 traces per inch will allow 20 levels of amplitude resolution for each sample. It is enlighting how much information is still visible with this factor of 10 data reduction. This information, of course, increases as the amplitude resolution is increased. The examples in this paper use a 4 level amplitude resolution for each sample and therefore 120 traces are displayed per section (Figure 2).

Because this is a line drawing device, temporal resolution can be increased beyond the bounds of high resolution raster graphics. Each trace (240 traces at a 2 level amplitude resolution, 120 traces at a 4 level etc.) can have 1333 samples displayed with little flicker at a picture refresh rate of 30 frames per second. Allowing the screen to flicker and only updating 20 frames per second means that 2000 samples can be displayed on each of these traces. The examples in this paper use a maximum of 1000 samples per trace.

The RSG works by packing up to 16 data values per word, and then moves the electron gun down the screen like on a raster scope. A series of horizontal vectors porportional to the amplitude of each sample is drawn for each trace. These vectors are drawn for the first sample on all of the traces before the second sample of any trace is displayed. The visual effect and trace-to-trace correlation is somewhat different than with a wiggle trace or a wiggle variable area seismic section. It would be a closer definition to refer to this as a modified variable density display.

CATALOGING BEFORE DISPLAYING MODEL DATA

The first step is to set up a catalog of the information that define a set of data. This is set up in a standard procedure. For the 25 lines of SALGLF-1 the questions and appropriate response would be:

MODEL NAME?	SALGLF
NUMBER OF LINES?	25
TRACES PER LINE?	225
SAMPLE RATE? (MS)	1
TRACE LENGTH? (S)	3

This catolog can be stored in advance for a whole series of data sets, like the SAL data catalogs. Assuming this was done, the procedure would start here. The model to be evaluated would be picked, the tape loaded, and the following steps taken:

MODEL NAME?	SALGLF	
LINE NUMBER TO BE DISPLAYED?	14	
FIRST TRACE TO BE DISPLAYED?	1	
LAST TRACE TO BE DISPLAYED?	240	
SPATIAL DECIMATION INCREMENT?	2	(Every other trace displayed)
FIRST SAMPLE TO BE DISPLAYED?	1	
LAST SAMPLE TO BE DISPLAYED?	2000	
TEMPORAL DECIMATION INCREMENT?	2	(2ms data displayed)

The program will then read the tape and create a file of raw data. This data is not in picture format and it takes about 90 seconds for the raster picture to be generated and displayed. There are two other questions asked at this point.

IS THIS A NEW VERSION OF A PREVIOUSLY DISPLAYED FILE?

If the answer is yes, the next question is:

WHAT IS THE VERSION NUMBER?
IS THIS FILE TO BE ADDED TO AN EXISTING DIRECTORY OR IS A NEW DIRECTORY TO BE CREATED?

PRMTRS, SELECTING DISPLAY PARAMETERS

The section that is displayed can now be interactively evaluated to set the best display parameters (PRMTRS) for this particular set of data. There are 12 function buttons used which allow the following changes to be made to the display instantaneously.

- See a display describing function key options.
- Display a directory of files available.
- Put up time intervals and shotpoint location labels.
- Spatially decimate the display (it might already be spatially decimated).
- Display various bit widths (amplitude resolution levels) for each sample.
- Change the sweep direction to turn the section on a side or upside down.
- Set the maximum and minimum thresholds of data values so as to map the level. Tank data normally falls between ± 2048. The best display range for four level amplitudes is from + 2048 to -1024 or -256.
- Invert the polarity of the display.
- Scroll through the data in time.
- Expand or shrink the data in time.
- Window down on specific traces or a trace.
- Save an output file in display format for rapid screen access.

INTRPT, INTERPRETING VERTICAL SECTIONS

Once a set of parameters are picked that fit a particular set of data, then an automatic procedure can be started to put this data in display format for quicker and easier interpretation (INTRPT). Again there are a similar series of questions to be answered to initiate the procedure.

MODEL NAME?	SALGLF	
FIRST LINE TO BE DISPLAYED?	1	
LAST LINE TO BE DISPLAYED?	18	
LINE DECIMATION?	2	(Every other line to disc)
FIRST TRACE TO DISPLAY?	7	
LAST TRACE TO DISPLAY?	248	
SPATIAL DECIMATION?	2	(Every other trace)
FIRST SAMPLE TO DISPLAY?	1	
LAST SAMPLE TO DISPLAY?	1000	
TEMPORAL DECIMATION?	2	
WHAT IS THE BIT WIDTH?	4	(Amplitude Resolution)
WHAT IS THE MAXIMUM THRESHOLD VALUE?	2048	
WHAT IS THE MINIMUM THRESHOLD VALUE?	-1024	

After this question the computer reads the first section in and starts creating a disc file. It has to transpose or multiplex the data in order to get it into display format. When the first section is finished it is flashed up on the screen. This section can now be interpreted while the computer is building the other display formatted sections. Figure 2 shows the display of line 14 from the SALGLF model.

Once a section is in display format many of the options described earlier can be applied to it. Namely: labeling time intervals and shotpoint range, scrolling, scan spacing, changing the sweep axis or sweep direction, increasing or decreasing the number of samples or the time window, inverting the display polarity, and listing the directory. There are some other options specified by hitting certain function buttons as described below for the listed switches:

2. Type in an 8 and section 8 is displayed.
3. Displays next section, in this case section 10 since section 8 is being displayed and every other line is stored.
4. Displays the previous section, in this case section 8, since section 10 is being displayed after hitting switch 3.
5. Allows the interpreter to pick events. When finished making a pick the event or horizon is labeled by the operator.
6. Erases the last interpretation segment picked.
9. Tells whether to display the events or not.
10. Displays the picks from the previous line. Figure 14 is an example of this for the SALGLF model line 14.
11. Displays all of the events that have been picked up to that point in their relative 3D position. Figure 5 is a front view of the interpretation of 9 lines displayed simultaneously. Figure 6 is a rotation of this same information.

There is also the ability to vary the intensity of the total rasterized section throught 64 levels of brightness to dimness while leaving the horizon picks at a constant intensity. A mesh can be fit on these horizon picks to creat what appears to be a more continuous 3D surface.

INTRCROP, HORIZONTAL SECTION DISPLAY AND INTERPRETATION

The horizontal section display and interpretation program, INTRCROP, work similar to INTRPT. The data is reformatted so that once a window of 240 traces time 240 lines is defined, a disc file of horizontal sections is built from the raw data. This disc file only stores the polarity of each sample. Therefore when horizontal sections are displayed (Figures 7 and 8) the information for each trace is a dot, either on (positive polarity) or off (negative polarity). The RSG, which by definition, does not store any intensity variations. Individual sample intensity variations would need to be simulated by showing fewer traces and increasing the length of the vectors.

The horizontal sections can be interactively interpreted in a similar manner to INTRPT discussed above. Figure 9 and 10 show an interpretation of SALGLF-4 with the raw data at two different times. There are some small changes in the function button options as described below:

- 2. Display a random record number, where each record refers to a specific time step.
- 3. Start or stop an animation from automatically moving through the data.
- 4. Step forward 1 frame or 1 time step.
- 5/6. Increase/decrease frame hold or animation time rate.
- 7. Define the sweep axis.
- 8. Define the sweep direction.
- 9. Mark events.
- 10. Erase last mark.
- 11. Enable dials for rotation, translation, etc.
- 18. Show the previous line marks.
- 19. Show all event marks. (Figure 11 is a top view of the interpretation of a series of horizontal seismic sections.)
- 20. Enable the seismic data display.
- 21/22. Zoom in and out on the seismic interpretation. (Figure 12 is a scaled and rotated view of the interpretation in Figure 11.)

THE VALUE OF 3D DISPLAY

The interpretation is stored as 3D information. An analog dial turns the line drawing for a different view (Figure 6 and Figure 12). The motion parallax of dynamic motion gives the interpreter a true 3D evaluation of his work.[4,5]

Once an event has been picked on two or more sections, a mesh may be fit across it to give a 3D feel for strutural attitude. Rotating the mesh gives an even better picture of the interpretation in 3D.

The ability to push a button and instantly flip from one display to another further improves the continuity of the interpreter's mental picture. The ability to go back, and edit the interpretation and replace problem picks gives the interpreter a tool for interactive 3D interpretation.

FUTURE PLANS

We anticipate begin able to expand on this work in many ways. For instance, it is feasible to interactively wavelet process the data, reinterpret and redisplay modified results.

Once an horizon is defined, the mesh could be map migrated and converted to depth with the interpreter using the vector display device as an interpretation aid.

For volumes of 3D seismic data it is reasonable to look at not just creating time slice display sections, but sections at specific azimuths to emphasize strike or dip sections across a structure or stratigraphic sequence.

ACKNOWLEDGEMENT

Richard Verm did the software development for the horizontal sections.

REFERENCES

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Figure 1. Physical Model SALGLF and line drawing display terminal with raster segment generator.

Figure 2. Vertical section RSG display showing 120 traces each with 1000 samples.

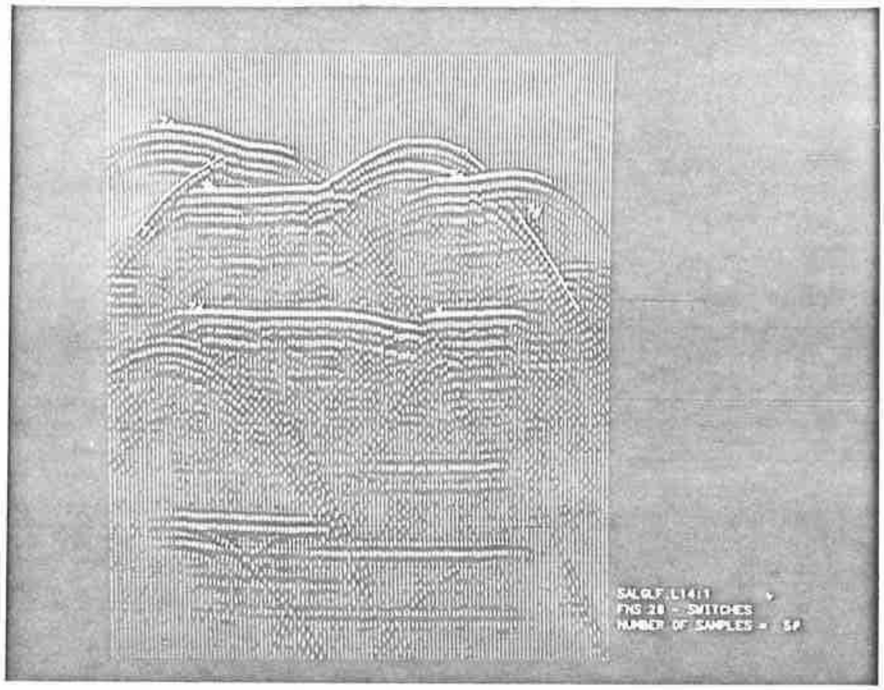

Figure 3. Interpretation picks overlain in the RSG display of line 14.

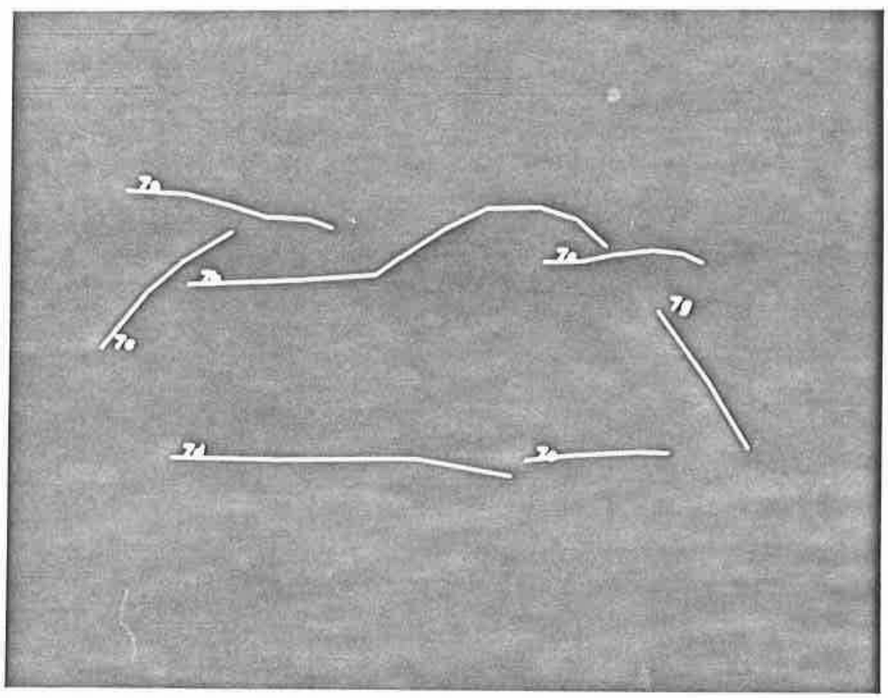

Figure 4. Interpretation picks for line 14.

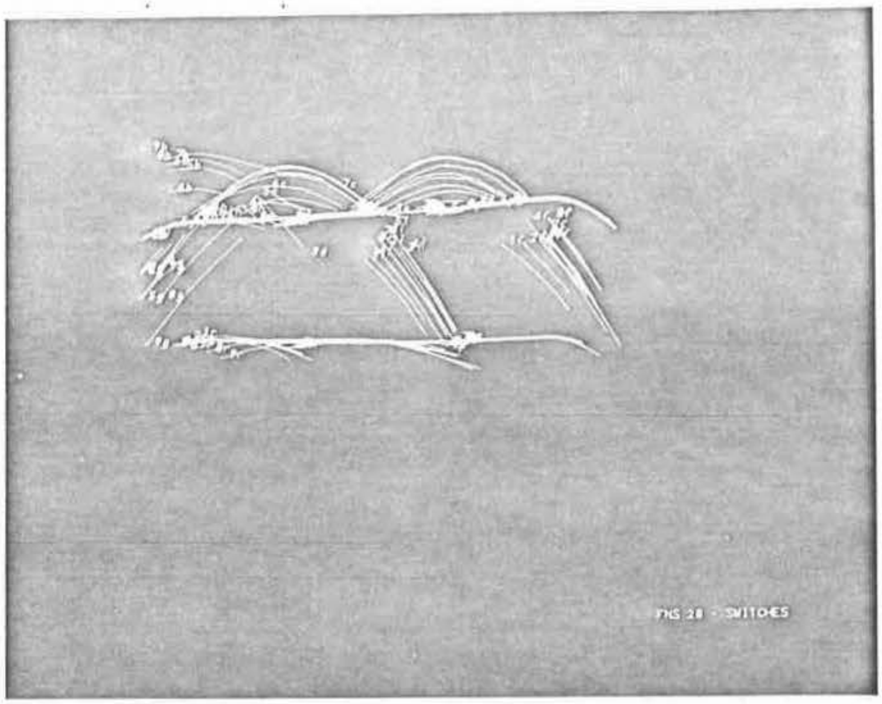

Figure 5. Interpretation of 9 lines displayed simultaneously.

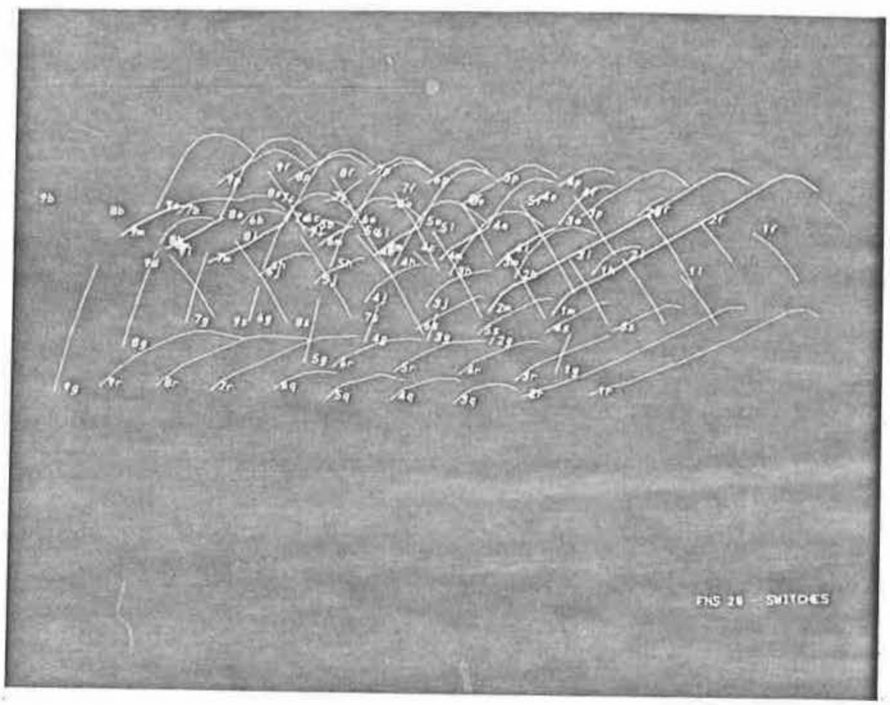

Figure 6. Interpretation of 9 lines rotated in 3D space.

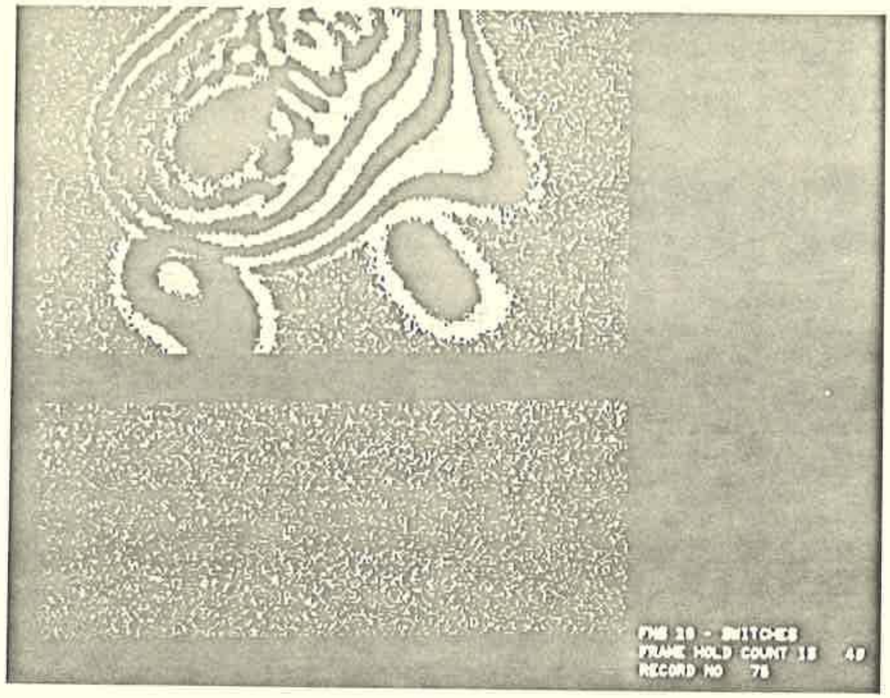

Figure 7. Horizontal section RSG display showing data from 140 traces on each of 140 lines at time 0.150 sec. The Black strip is from missing data because of a data collection error.

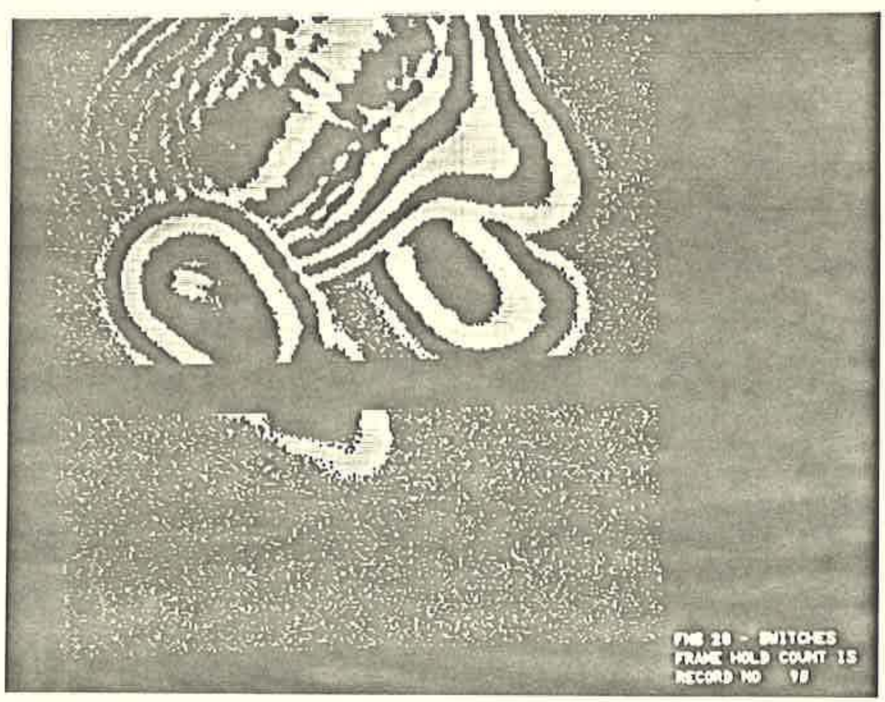

Figure 8. Horizontal section display at time 0.180 sec.

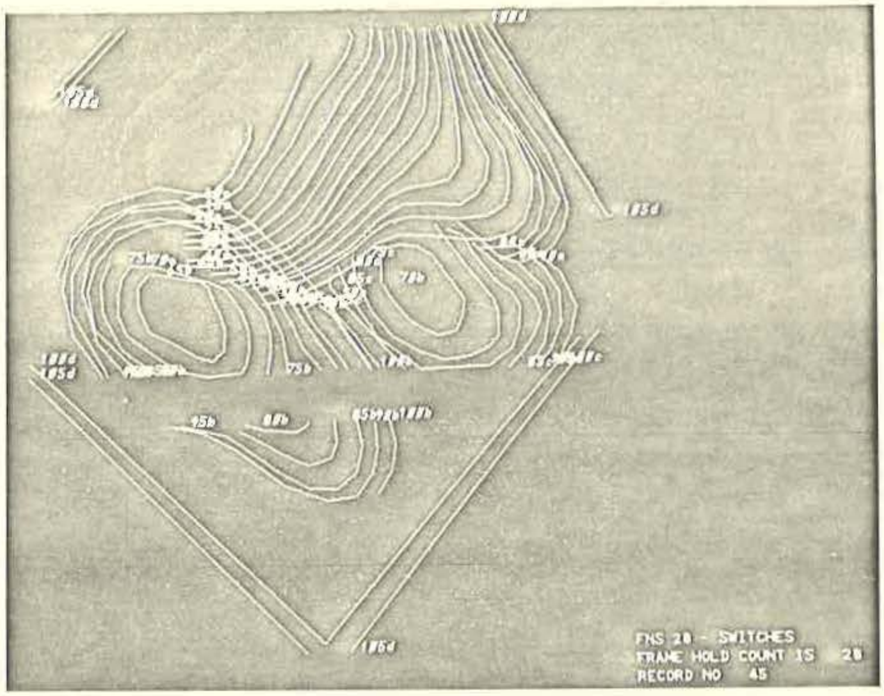

Figure 9. Interpretation drawn on horizontal section at time 0.090 sec.

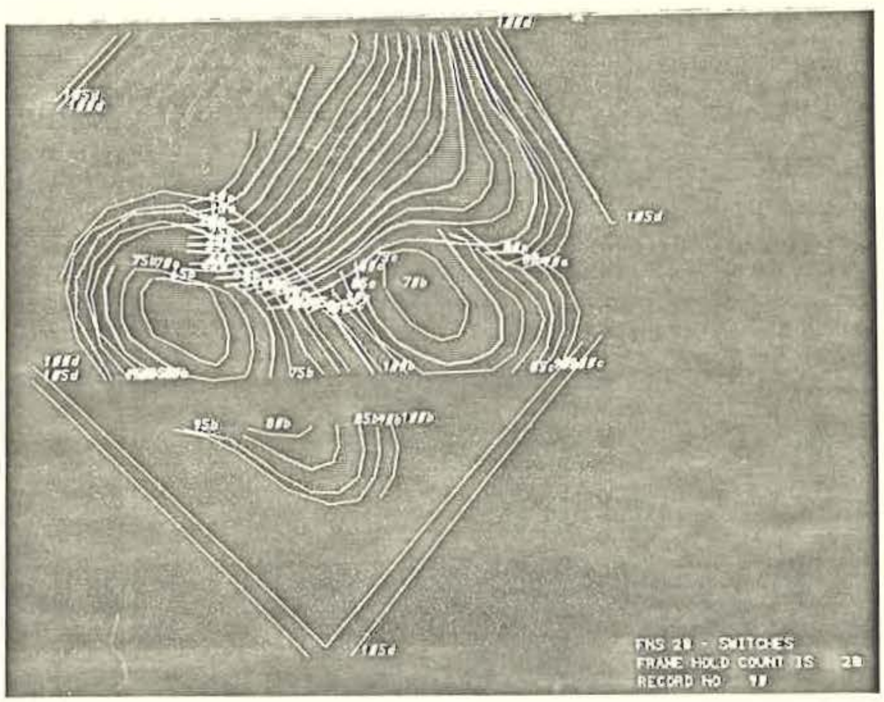

Figure 10. Interpretation drawn on horizontal section at time 0.180 sec.

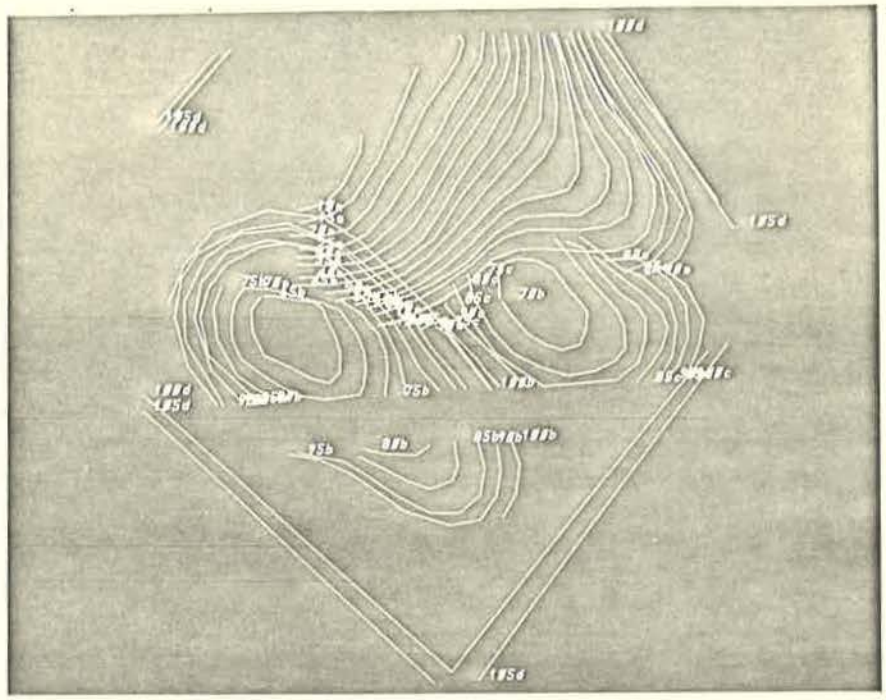

Figure 11. Top view of interactive 3D interpretation of horizontal sections.

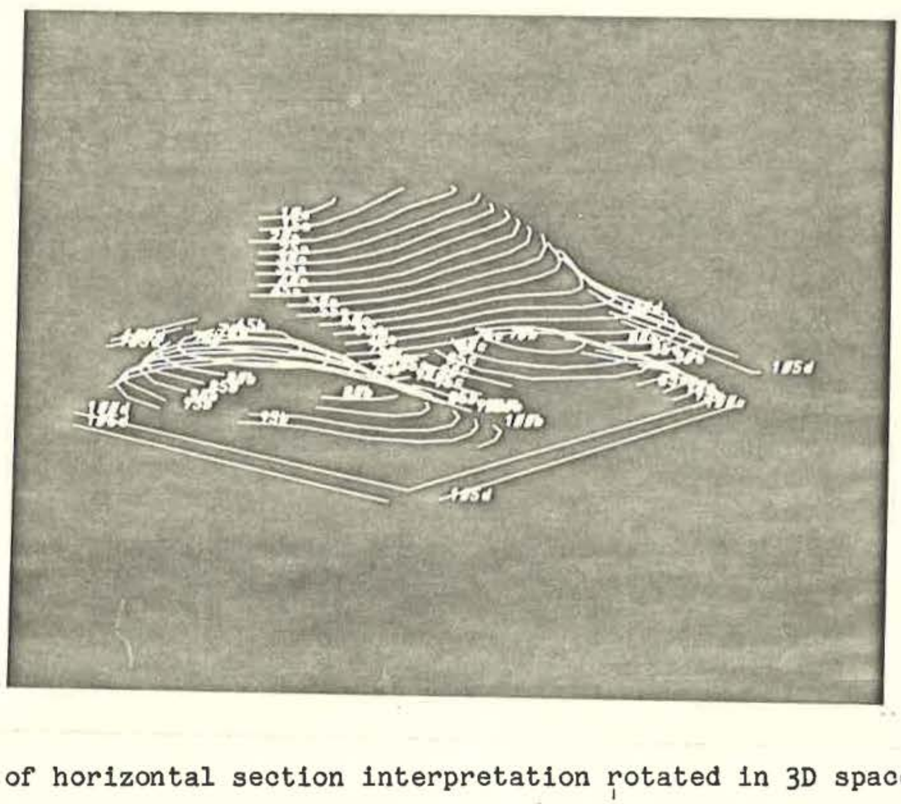

Figure 12. View of horizontal section interpretation rotated in 3D space.