SEQUENCE OF USING INTERPRETATION TOOLS TO INTERPRET A 3D SEISMIC SURVEY

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NOTE: It is important to realize that only a small fraction of a seimsic interpreters time is spent doing interpretation.

Most of the time is spent looking up backup reference material, locating the data, getting sections copied and together, marking section tie points, timing horizon picks, posting these times on maps, making show maps and seismic sections with well information and colored horizons for presentations, showing the results to management and partners, and writing up prospect reports. Most of this work is clerical work. Often good interpreters will have clerical assistants that will take care of a lot of this busy work, so that he can color the horizons and make the contour maps.

The main goal of the Landmark Graphics Interpretation Station is to provide interpreters with a computer to provide the clerical assistance and rapid data handling, which allows the interpreter to do what he does well, which is pattern recognition.

O. Review of prospect related information stored as digital information:

(No real application until workstation usage is fairly mature within an organization, although with proper planning this could happen relatively quickly)

A. Library search for related information:
(Most companies have computer library listings, or the workstation could be tied into library search systems like the source for rapid identification of reference material needed for a project)

TOOLS: Library and network access (alpha-numeric listing display and hardcopy).

B. Directory listing; and

(Specifically to look at the data sets already in storage related to a specific prospect area)

TOOLS: Directry search and information exchange between different users.

C. Recall and hardcopy reference of cross-referenced map information.

(This includes review of regional gravity, magnetics, geologic outcrop, well horizon, geochemistry, fault trend or seismic maps)

TOOLS: Display of digital map files; zoom, pan and scroll to isolate areas related to the prospect; then digitally store for later retrieval on the workstation or hardcopy relevant portions of map display for later reference.

I. Organizing new data to be interpreted or integrated from other sources into digital files:

A. Data restrictions:

1. Well log input format definitions;

2. Seismic data format definitions:

a. For display of various types of seismic trace gathers during processing (SEG B, C, etc.); and

b. For display of individual sections, grids of sections, or volumes of sections (SEG Y, VAX internal format, etc).

3. Map display format definitions.

TOOLS: Format specifications.

B. Establish data quality check and editing procedures:

1. Quality check that data is properly loaded on the workstation; and

2. Editing of data sets to:

a. Remove irrelevant information;

b. Put the hooks in to tie different data sets together.

(For example: marking line ties on a 2D seimsic survey, locating well logs in space and depth in relation to a 3D survey, or tieing the lat/long information from two different maps together)

TOOLS: Trace, section and map display, procedure definition, and data editing package.

C. Sort and name each sorted section of a processed 3D survey into display animation files (i.e. EW-32, NS-14, etc.):

1. Three orthogonal sets of data along the major axes of the survey;

2. Sort unique animation sequences:
(The first pass would be limited to an (a) type sort, but it is important to be able to come back to this procedure at any stage of the overview or interpretation and set up a background batch operation that will set up other display sequence files)

    a. Parallel sections at an angle to the direction of data collection;

    b. Parallel horizontal sections that dip in time;

    c. A sweep of vertical sections over a defined arc;

    d. Datumized horizontal sections, flattened to a horizon or geologic time period; and

    e. Rotation sequences of fence diagrams, cut-away sequences, etc.

TOOLS: Volume sorting routines, datumizing routines, and perspective definition routines.

II. Display of parallel sections for overview:

(Either vertical or horizontal seismic sections)

A. Determine and call up the data to evaluate next;

TOOLS: Directory of data available, and default data display parameters (ie. scale, color map, etc.).

B. Scrolling, panning, and animation;

(For a 2D survey or a subset of a 3D survey the interpreter will want to pan along a line until he comes to a cross-line, and then have the option to pan to the left, right or continue straight)

TOOLS: Equivalent of track-ball, joy- stick or function buttons (Refer to SAL V. 8, pp. 368-384), and a digital note pad to keep track of where possible prospects are located.

C. Zoom for close evaluation;

TOOLS: Ideally an interpolation package tied to the array processor, however it will be more realistic to initially do this with pixel replication.

D. Changing trace format and color map reassignments:

1. Variable density;

2. Wiggle; and

3. Wiggle Variable Area.

(Assumes a polygon fill and color assignment as a function of say seismic trace attributes)

TOOLS: A switch that allows backup screen display of different trace display option, and a color scale that allows interactive color scale reassignment.

III. Display of volumetric data for overview:

(It would be apprortiate to be able to apply the steps defined in II. above to each display on the screen, i.e. color map, trace format, etc.)

A. Mixing vertical and horizontal sections (refer to SAL, V. 9, pp. 409-421), and cut-away animation sequences;

TOOLS: Sequence of steps to input section names, trace numbers, times, spatial coordinates, animation rate, etc., in order to define the data to be displayed. It also requires a method of controlling what data is brought up on the screen. In the case of a cut-away cube this could include defining a specific surface that is to be animated.

B. Displaying 3D views, like a fence diagrams of specified sections in a data volumes.

TOOLS: Same as III. A. above, plus information about the preformatted rotation sequences that are available in the cartooning mode.

C. Displaying variations of the data volume, for instance a sweep of vertical sections from parallel to the x-axis to parallel to the y-axis.

TOOLS: Same as III. B. above.

IV. Structural interactive 3D interpretation:

(Each step assumes that the options in II. above can be applied to any display that is on the screen, i.e. color map reassignment, trace reformat, scale, scroll, pan, etc.)

A. Synthetic well log overlay to tie seismic to geologic horizons;

TOOLS: Overlay plane, and well log display capability.

B. Fault picking:

1. Manual picking of faults;

2. Pick two windows on either side of a fault, put these windows on the secondary screen, have the ability to scroll the windows (possibly to pan or drag them around also) in order to visually correlate across faults. Also will want to be able to mark similiar events on both windows in the overlay plane. A more serious problem occurs in growth fault areas, where there is a need to stretch the traces on the upthrown side of the fault in order to be able to tie events.

3. Building of map view and 3D fault plane maps through the prospect area;

4. Color code different faults.

5. A modification of Dolmans automatic fault picking that might work with a 3D survey, would be to pick the same fault on say every tenth parallel line by overlaying a previous fault pick on a section for guidance on the next pick. An interpolation routine based on linear non-data between these two picks could create a fault plane surface (see C.3. below).

TOOLS: Digitizing fault picks, overlay planes, scrolling, panning, trace stretching, map integration, color map assignment, and fault interpolation.

C. Seismic horizon picking:

1. Manual event picking;

2. Automatic event picking; and

3. Turn the overlay of picks from an interpreted section on or off on a parallel section to guide picking events on this second section (refer to SAL, V. 6, Section G).

4. Color assignment of different horizon picks.

TOOLS: Digitizing capability, ability to overlay horizon picks on a different section, an automatic picking routine, and color map reassignment.

D. Calculation of isochron, isopach or isolith information.

TOOLS: Approbriate algorithms.

E. Automatic posting of times to base maps or for input to other processing:

1. Manual contouring:

2. Data file entry into a computer contouring package (files generated this way need to have a method of being edited: and

3. Surface display and generation, particularly with 3D surveys that are not spatial ailiased.

TOOLS: Ability to scale up screen to read the posted pick values, ability to draw and edit on this display, file formatting package that can be used to to set up horizon picks for input into computer contouring packages, a package to edit a computer generated contour map on the screen, and a surface display package.

F. Depth conversion.
G. Map migration.

V. Stratigraphic interactive 3D interpretation:

(Each step below makes the same assumption as in IV. above)

A. Seismic trace attribute analysis:

1. Amplitude analysis.
2. Instantaneous phase.
3. Instantaneous or weighted average frequency.
4. Apparent polarity.
5. Velocity.
6. Attribute variations with offset.
7. Combinations of any of the above.

TOOLS: Attribute analysis programs, interactive color map reassignment, offset sorting algorithm, attribute mixing algorithms.

B. Statistical evaluation of attribute information.

TOOLS: Statistical routines.

C. Overlay of structural interpretations on section displays of attribute information and the ability to pick geologic information on stratigraphic displays.

TOOLS: See section IV.C. above.

D. Isochron, isopach or isolith calculations.

TOOLS: Appropriate alogrithms.

VI. Preparation of final report:

A. Reservoir calculations:

1. Define gas/oil and oil/water contacts, and integrate under the contour or horizon surface to calculate the volume.

2. Define sand/shale ratio, and other factors to be able to quickly calculate expected reservoir recoverable volumes.

TOOLS: Reservoir package, and procedure description.

B. Finialized sequence of maps and show sections:

1. Hardcopy versions for written report (color or black & white).

2. Video versions for remote presentations to management or partners.

3. Softcopy versions for interactive presentations that allow management or partners to do an interactive evaluation of critical portions of the interpretation.

TOOLS: Hardcopy devices, video encoders, package that allows the user to set up a sequence of show sections that can still be manipulated on the interpretation station.

C. Text preparation.

TOOLS: Word processing package.

D. Graphical support preparation.

TOOLS: Slide making capabilities, and the ability to use the screen like an artist canvas with a palette of color to draw on.

VII. Presentation of results (see VI. B. above).

Meeting
9-3:00 Monday -
Lunch

Tool kit, diagrams of which tool is used when.

9-3:00 Wed.

1-5 Fri.

4. Interactive seismic data interpretation.
    1.1 Redisplay ~~seismic~~ directory.
    1.2 Seismic display. working with
        1.2.1 Digitize horizons.
            1.2.1.1 Select new horizon.
            1.2.1.2 Select digitized data from parallel surface.
            1.2.1.3 Manual digitizing.
            1.2.1.4 Automatic.
        1.2.2 Well overlay.
        1.2.3 Picture control.
            1.2.3.1 Viewport display.
                1.2.3.1.1 Viewport select: <current value>.
                1.2.3.1.2 Mode select: <current value>.
                1.2.3.1.3 Window size select: <x size, y size>.
                1.2.3.1.4 Drag window.
            1.2.3.2 Pan/scroll.
            1.2.3.3 Scale.
            1.2.3.4 Color control.
            1.2.3.5 Line-to-line control.
        1.2.4 Frame control.
    1.3 Horizon display. working with
        1.3.1 Redisplay horizon directory.
        1.3.2 Select working data subset.
        1.3.3 Single horizon display.
            1.3.3.1 Display contours.
            1.3.3.2 Display vector drawing.
            1.3.3.3 Solid model.
        1.3.4 Section view display.
            1.3.4.1 Scale control.
            1.3.4.2 Frame control.
        1.3.5 Compute isochron/isopach.
        1.3.6 Surface extrapolation.
        1.3.7 Velocity mapping, depth conversion and map migration.
        1.3.8 Horizon editting functions.
    1.4 Bright spot analysis.
    Research 1.5 Stratigraphic analysis.
    1.6 ~~Exploration graphics.~~
2. Interpretation input and processing functions.
3. Seismic picture file and animation sequence creation.
4. Log synthetics and interpretation.
5. Forward modelling.
6. Communications
7. Disk and file maintanence functions.

0.J SESSION SEQUENCE

0.0 HELP
0.1 RECALL STEPS
0.2 RECREATE STEPS N→M

1.1.2.R VECTOR DISPLAYS

1.1.2.0 HELP
1.1.2.1 Filename. Horizon
1.1.2.2 Filename. Horizon RANGE
1.1.2.3 Filename. Contours
1.1.2.4 Filename. Raytrace

1.1.3.S OVERLAY FILE DISPLAYS

1.1.3.0 HELP
1.1.3.1 Raster filename
1.1.3.2 Vector file name
1.1.3.2 Well log Filename

1.J.KL.M DISPLAY ...

1.J.KL.0 HELP
1.J.KL.1 COLOR ASSIGNMENT + SCALE
1.J.KL.2 DISPLAY SCALE (...)
1.J.KL.3 VARIABLE ...
1.J.KL.4 WIGGLE
1.J.KL.5 WIGGLE VARIABLE AREA
1.J.KL.6 ANALOG INPUT

1.3.W HOST OPERATIONS

1.1.0 HELP
1.1.1 SORTING DISPLAY FILES
1.1.2 IMAGE PROCESSING
1.1.3 ATTRIBUTE ANALYSIS
1.1.4 SEISMIC PROCESSING
1.1.5 MAP MIGRATION
1.1.6 CALCULATE DEPTH/VELOCITY

1.1.1.Q RASTER DISPLAYS

1.1.1.0 HELP
1.1.1.1 Filename. Section
1.1.1.2 Filename. Volume

1.1.K DATA DISPLAY

1.1.0 HELP
1.1.1 RASTER DISPLAYS
1.1.2 VECTOR DISPLAYS
1.1.3 OVERLAY FILE DISPLAYS
1.1.4 DISPLAY DEFINITION
1.1.5 DISPLAY WINDOWS
1.1.6 ANIMATION DISPLAYS

1.1.4.T DISPLAY DEFINITION

1.1.4.0 HELP
1.1.4.1 HOST OPERATIONS (1.3)
1.1.4.2 SORT ORTHOGONAL VIEWS
1.1.4.3 SORT PLANE (3 POINTS)
1.1.4.4 SORT CUT-AWAY FILES
1.1.4.5 DATUMIZE FILE

1.4.X COMMUNICATIONS

1.4.0 HELP
1.4.1 VAX
1.4.2 CDC 800
1.4.3 ETHERNET
1.4.4 TIME SHARING INTERFACES

1.J SYSTEM OPERATIONS

1.0 HELP - SYSTEM INSTRUCTIONS
1.1 DATA DISPLAY
1.2 INTERPRETATION
1.3 HOST OPERATIONS
1.4 COMMUNICATIONS
1.5 WORD PROCESSING
1.6 ACCOUNTING / MATHEMATICS

1.1.6.V ANIMATION DISPLAYS

1.1.6.0 HELP
1.1.6.1 File. VERTICAL SECTION RANGE
1.1.6.2 File. HORIZONTAL SECTION RANGE
1.1.6.3 File. Volume cuts
1.1.6.4 MANUALLY STEP
1.1.6.5 Automatic STEP • RATE
• 1ST
• LAST

1.1.5.U DISPLAY WINDOWS

1.1.5.0 HELP
1.1.5.1 DEFINE WINDOW 1
1.1.5.2 DEFINE WINDOW 2
1.1.5.3 SCROLL 1 BY 2
1.1.5.4 CHANGE DISPLAY FORMAT
1.1.5.5 SCROLL, PAN, AND ANIMATE WINDOW, DISPLAYING NEW DATA SETS

1.5.Y WORD PROCESSING

1.4.0 HELP
1.4.1 WS
1.4.2 WSD
1.4.3 etc.

1.2.1.A MANUAL

1.2.1.0 HELP
1.2.1.1 PICKING (1 DIRECTION)
1.2.1.2 CONTOURING (1.2.4.D)
1.2.1.3 SCROLL FOR LINE TIES
1.2.1.4 FAULT PICKING & CORRELATION
1.2.1.5 POST VALUES
1.2.1.6 EDIT PICKS

INPUT TO AUTOMATE CONTOURING AND/OR SURFACE FITTING ALGORITHMS

1.2.L INTERPRETATION

1.2.0 HELP
1.2.1 MANUAL
1.2.2 AUTOMATIC
1.2.3 DETAILED ANALYSIS
1.2.4 CONTOURING
1.2.5 PROSPECT OVERLAYS

1.2.5.E PROSPECT OVERLAYS

1.2.5.0 HELP
1.2.5.1 RASTER MODE POLYGON FILL
1.2.5.2 VECTOR MODE POLYGON FILL
1.2.5.3 DISPLAY ANNOTATION
1.2.5.4 DISPLAY

2.1Z I/O

2.1.0 HELP - OPTIONS
2.1.1 COLOR HARDCOPY
2.1.2 PRINTER/PLOTTER
2.1.3 VIDEO OUTPUT

1.2.2.B AUTOMATIC

1.2.2.0 HELP
1.2.2.1 MARK STARTING PICK
1.2.2.2 2D PICKING
1.2.2.3 3D PICKING
1.2.2.4 MARK QUALITY of PICKS
1.2.2.5 EDIT PICKS

• SMOOTH SURFACE
• PICK DIFFERENT EVENT (LEG)

1.2.3.C DETAILED ANALYSIS

1.2.3.0 HELP
1.2.3.1 BRIGHT SPOT ANALYSIS
1.2.3.2 STRATIGRAPHIC ANALYSIS

1.2.4.D CONTOURING

1.2.4.0 HELP
1.2.4.1 HORIZONTAL ... PICKS
1.2.4.2 POSTED VALUES
1.2.4.3 MANUAL
1.2.4.4 AUTOMATIC
1.2.4.5 EDIT CONTOURS