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Integrating Seismic and Subsurface Data - An Interactive Interpretation Case History from Sterling County, Texas

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SUMMARY

The interactive interpretation system provided a unique and useful method for detailed evaluation of the subsurface and seismic data. The capability to try out different interpretation concepts quickly, zoom on windows, build perspective maps and fence diagrams, dynamically change the color control, do seismic instantaneous phase analysis, as well as the map building tools provided multiple cross-checks on the prospect interpretation.

Although the example presented could have been evaluated using traditional techniques, this paper illustrates the additional views and cross-checks available using an interactive system. Quality interpretations, using the latest tools, are required in order for us to reduce the number of dry holes.

INTRODUCTION

A set of well and seismic data from Sterling County, Texas was integrated using an interactive workstation. This paper discusses the process and the interpretation results. Subsurface control consisted of nine wells and five seismic lines. The well tops were provided as a table from a popular spread-sheet program. The seismic data were provided on SEG-Y format tapes.

SUBSURFACE INTERPRETATION

The tops for each horizon were typed into a file that was read into a mapping package that linearly interpolates control points for a first approximation and then allows interactive hand contouring. Tops from up to 13 horizons (some wells had fewer than 13 well top picks) were triangulated (Nelson and Hildebrand, 1986) and displayed in map and perspective to give a feel for trends at different geologic times. For example, Figure 1 shows the Wichita-Albany well top map after binning. The location of the five available seismic lines are also shown. The original map is colored, going from bright colors for shallow to dark colors for depth. In addition, each color is graded to black over about a 60 foot interval. Notice how using just the well control the reef is centered over the LJA Harris #1 well, but still noses to the southeast.

The arbitrary line drawn down the nose of the structure shows the location of the depth cross-section shown in Figure 2. Starting at the top, this depth cross-section shows the projected structure of the following horizons: Greyburg; San Andres; San Angelo; Upper Clearfork; Lower Clearfork; Wichita-Albany; Base Coleman Junction; Swastika; Cisco Shale (also called Base Wolfcamp); Cisco Sand; Breckenridge Line (also called Top Canyon); Canyon; and the Penn Lime. The process of entering the tops and gridding each map, which allowed generation of depth cross-sections in any direction through the project area, took less than four hours.

The new well, the Harris #1, showed a porous and prospective, but wet, carbonate section at the Wichita-Albany. Time velocity pairs from this well were used to calculate interval velocities. Using layer-cake assumptions, these interval velocities were used to convert depth maps to time. The time horizons were projected onto five seismic lines that were available, to seed the seismic interpretation. These horizons were adjusted to fit the reflectors. The seismic time horizons were converted to depth using the same layer cake velocity assumptions. Depth values from the seismic and well control were gridded, smoothed and displayed as final depth maps. In addition, a sonic and density log from the LJA Harris #1 well were used to create a synthetic trace. Although the synthetic did not aid the interpretation, it illustrates the validity of another way to interactively tie subsurface and seismic data. Part of the reason the synthetic does not clearly tie is because the well was projected about 1000 feet to the east-west line and about 2000 feet to the north-south line.

SEISMIC INTERPRETATION

The seismic data allowed much more detail vertical and lateral evaluation than the well tops. The seismic data were evaluated using various softcopy options (Nelson, Hildebrand and Mouton, 1983), including black and white, wiggle-variable area, color, as well as attribute sections like instantaneous phase. Figure 3 shows an example of seismic control. This particular section consists of lines 4 and 6 as seen from the southwest (where the LJA Harris #1 well is located). The horizons and stratal patterns have been overlaid to highlight the interpretation.

The seismic data allows detailed interpretation of subtle stratigraphic or stratal patterns (Fritz, 1987). The stratal patterns were interpreted on the seismic between the Wichita-Albany and Base Wolfcamp horizons. These patters were tied between lines and

and displayed in cross-section and fence diagrams. Figure 4 shows the relative line locations, and a stratal pattern interpretation of each of the five lines. Line six is above the map, with south on the left and north on the right. The two highest stratal pattern picks are interpreted as a reef facies. Although it does not show up well at the small scale, there is an apparent velocity pushdown on several of the reflectors beneath this prospective area. The four west-to-east cross-sections are Line 1 at the top, then Line 4, Line 2 and Line 3 at the bottom. This data was combined into a single display in Figure 5, a perspective fence diagram of the stratal interpretation from the five seismic sections. This diagram looks at the sections from above and from the southwest.

Another important interpretation procedure was to flatten appropriate sections (Simson and Nelson, 1984) on the San Angelo to study the shape of the proposed reef at San Angelo geologic time. The sags, that could be due to velocity pushdowns, were more evident under the prospect in the flattened section mode. Horizons were displayed in map, cross-section and perspective to cross-check the interpretation in as many ways as possible. In addition, a synthetic section was made along a critical line using an advanced ray trace modeling package. This cross-section extended the critical east-west line (line 4) beyond what was originally available, based on the projected geologic control. Additional seismic data is being obtained to check this projection.

MAPPING

The key horizons were used to make several different depth maps. Each map is based on control not only from the seismic, but also integrating in the well top information. Maps to be presented include depth structure maps, isopach maps, and perspective maps where horizons are colored as a function of depth and as a function of color. Figure 6 is a final map of the Wichita-Albany, after the seismic and well control has been integrated. The block boundaries, seismic line location, and well location information are also posted on the map. The original map was in color, with bright colors for the shallowest portion and darker colors for the deeper portion of the surface.

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