Crosswell Seismic Imaging for Horizontal Drilling of the High Porosity Sand. Crystal Viking Pool, Alberta, Canada.

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Summary

TomoSeis Inc. (a division of Core Laboratories) acquired a crosswell seismic survey for Numac Energy Inc. in the Crystal Viking Oil Pool, in Alberta Canada, about 300 kilometers northwest of Calgary. The goal of the survey was to delineate a high porosity (F1) sand (as described in Reinson et al 1988, fine to medium grained sandstone) within the incised valley system of the Viking Formation for horizontal development drilling. Two crosswell profiles were acquired, modeled, processed and interpreted to help design the trajectory of a planned horizontal well. (See Figure 1).

Well log data indicate the F1 Sand is present in well 14-36. Data from surrounding wells suggest the F1 Sand could be present between wells 6-1 and 7-1. The northern profile was shot to confirm or deny this suspicion, while the southern profile was shot to locate the western boundary of the F1 Sand.

Interpretation of the crosswell reflection images indicate the presence of the F1 sand between wells 6-1 and 7-1 as well as a western boundary 200 meters west of 14-36. A horizontal well was designed based on the results of the crosswell survey. The well was drilled and confirmed the interpretations.

Introduction

The geology of the Crystal Viking Pool has been thoroughly studied (Reinson, 1988). The facies within the Viking Formation in the incised valley system are quite complex ranging from tight sands and shales to porous sands and conglomerates of varying quality. Thicknesses vary from 10 meters to 30 meters. Prior surface seismic surveys were not able to distinguish between the intra-valley and regional Viking because the acoustic difference was so small and maximum frequencies were of the order of 80-100 Hz. Surface seismic could not interpret the various facies within the incised valley complex. Crosswell seismic afforded the opportunity to acquire high frequency data, which enabled facies interpretation.

The assumed extent, based on well data, of the high porosity F1 Sand in the survey area is shown in Figure 1. The facies distribution (also based on well log data) of the Viking Formation for the northern profile is shown in Figure 2, and the facies distribution for the southern profile is shown in Figure 3.

The inter-well data provided by the crosswell seismic images allowed for further understanding of these facies, and provided valuable depth data on the various parasequence tops and bases, which have been used quantitatively in the structural-stratigraphic 3-D reservoir model developed for the pool.

Theory/Method

Each crosswell profile is acquired by positioning a 10 level hydrophone receiver tool stationary in one well bore while a broadband borehole piezoelectric source is placed in the other. The source, operated while in motion, traverses the planned logging interval past the receivers. The receiver tool is moved to the next position and the source again scans past the receivers. Both direct and reflected P-wave arrivals are recorded, yielding velocity and reflectivity information respectively (See figure 4).

The Crystal Viking Pool crosswell profiles were acquired in August 2000 using 200-1200 Hz frequencies, a sample period of 250 microseconds, and 8 sweeps per shot. The receiver tool was placed in the 4-1 and the 6-1 well bores, and the source tool was placed in the 14-36 and the 7-1 well bores.

Data processing involves deriving inter-well velocities from the direct P-wave travel times using a 3-D travel time tomography, which is based on a polynomial surface model framework (Washbourne, 1999). The resulting tomogram is then used as a velocity model for the VSP-CDP mapping operation (Lazaratos, 1993). The data were enhanced for first break P-wave travel time picking by noise burst editing, tubewave filtering and band pass filtering. The reflection data was spectral whitened, bandpass filtered and wavefield separated (as in VSP processing). After VSP-CDP mapping, the data is sorted by reflection incidence angles and stacked over a limited range of incidence angles from the vertical (60-70 degrees).

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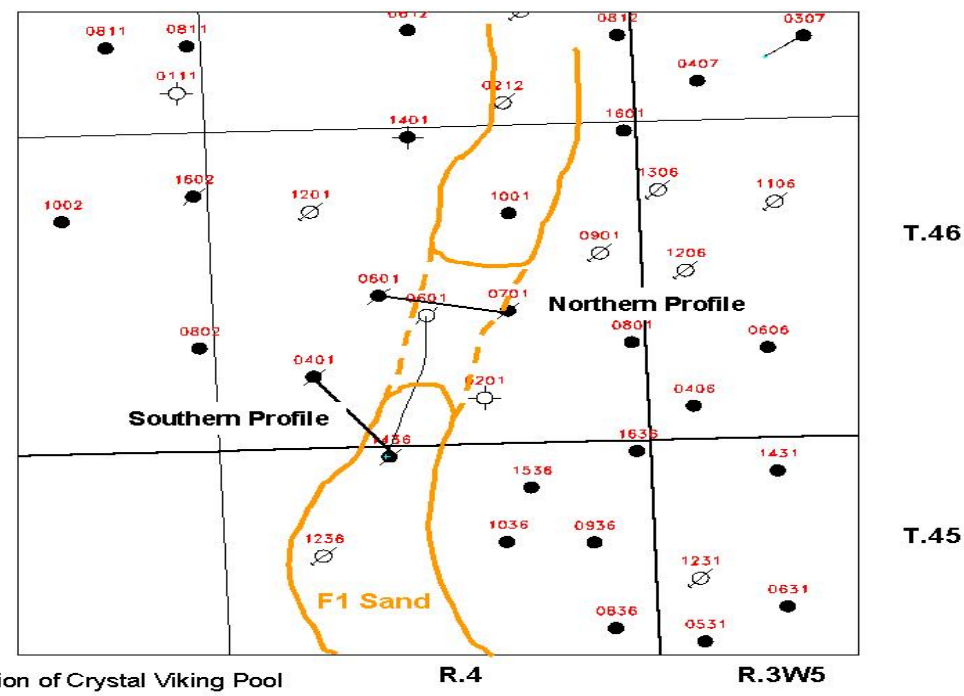
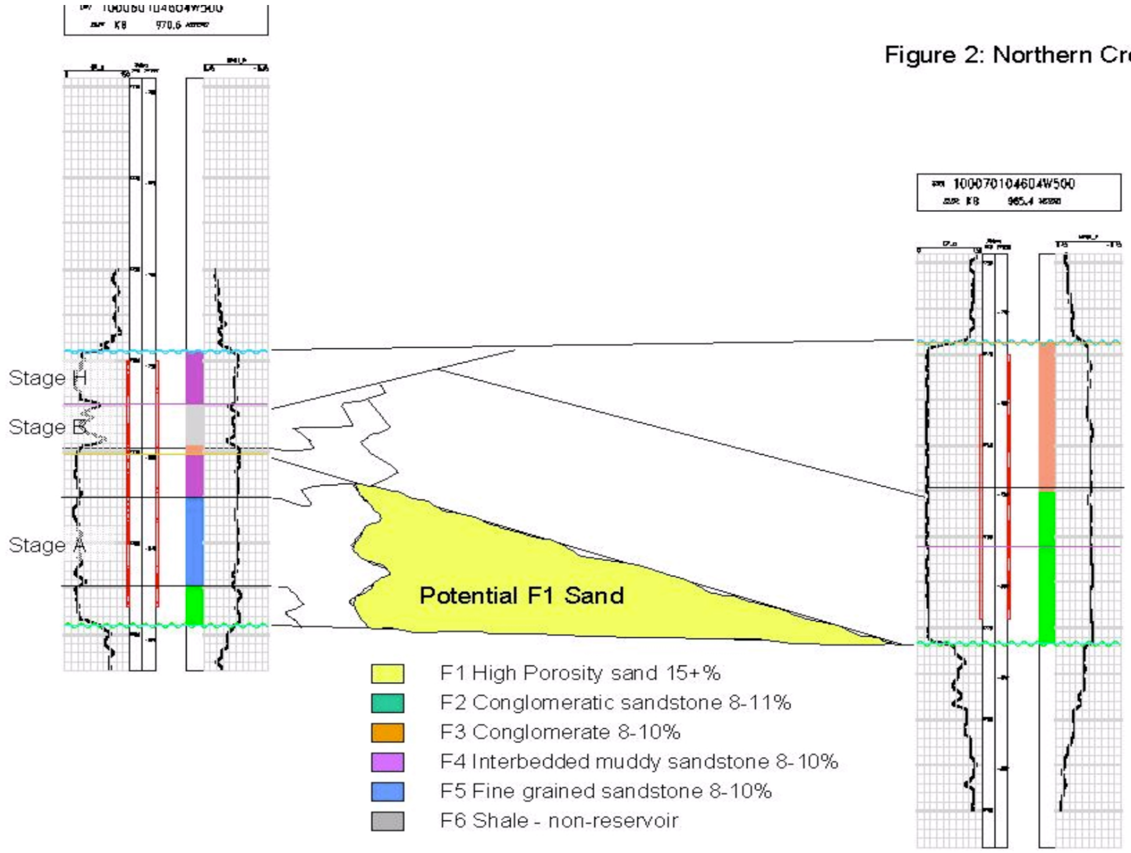


Figure 1: Portion of Crystal Viking Pool

Figure 2: Northern Crosswell Profile



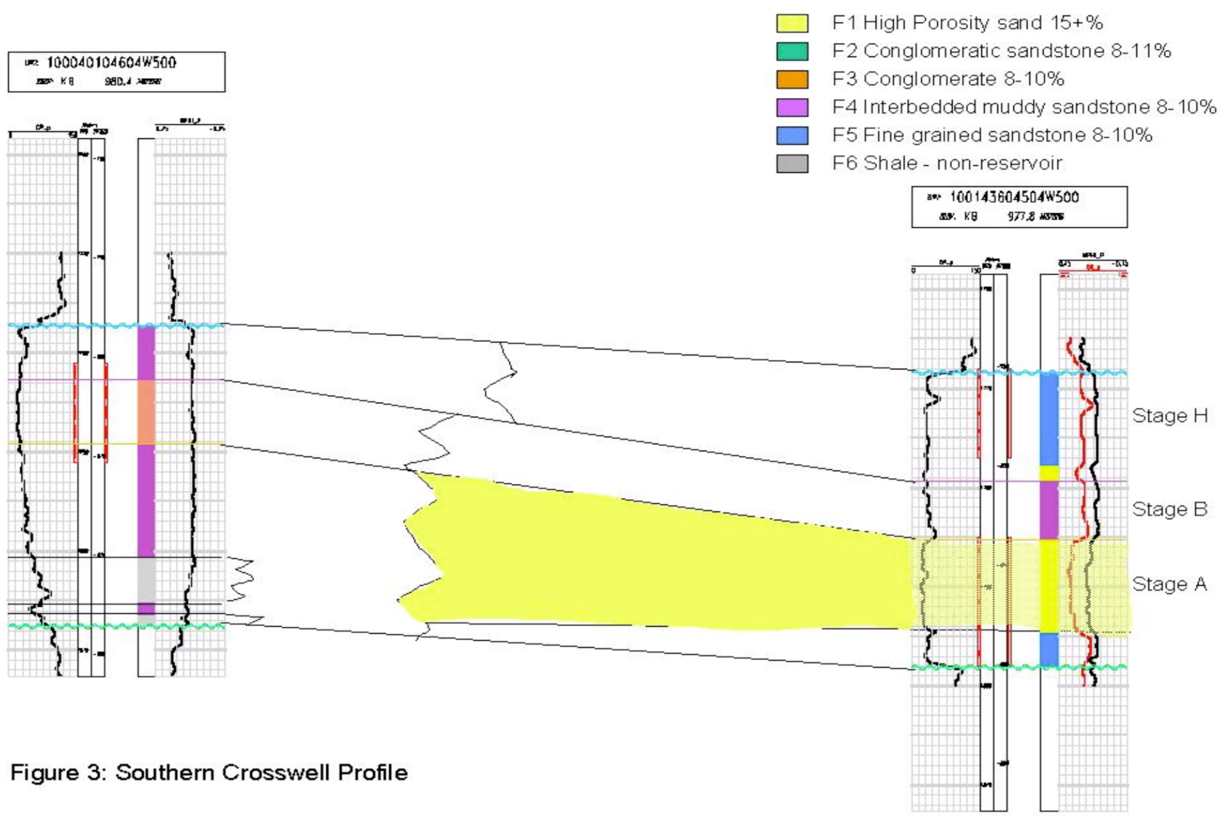


Figure 3: Southern Crosswell Profile

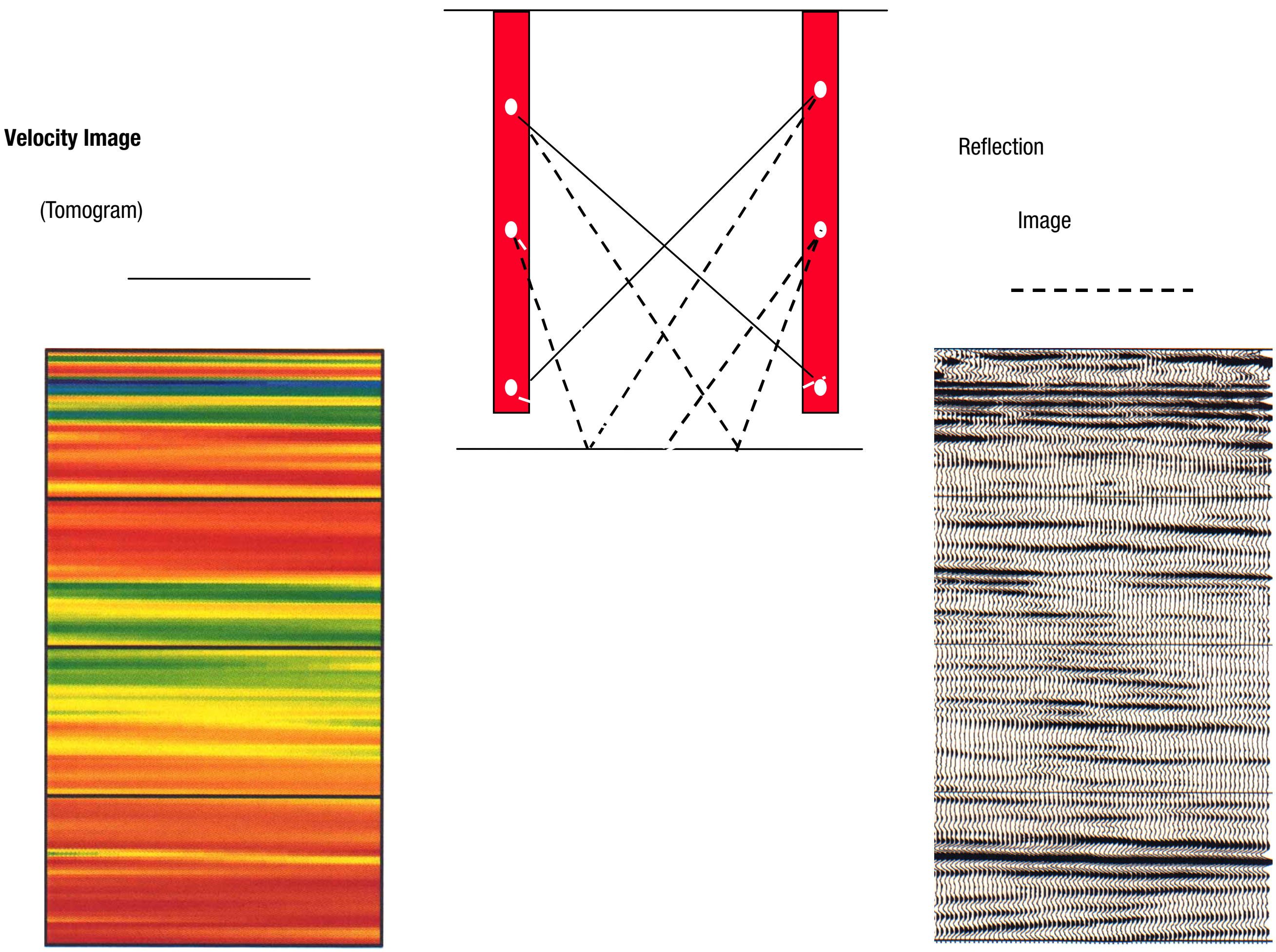


Figure 4. Typical raypaths for direct and reflected arrivals.