Identification of Subtle Oil/Gas Reservoir in Junggar Basin of West China*

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Search and Discovery Article #40691 (2011)
Posted January 31, 2011

*Adapted from extended abstract prepared for presentation at AAPG International Conference and Exhibition, September 12-15, 2010

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Abstract

This article utilizes the spectral factorization technique, full 3-D visualization, and full 3-D data volume interpretation technique in the 3-D work zones of C43 well, G8 well, and SN4 well, situated in the east part, northwest margin, and "hinterland" of the Junggar Basin, respectively, of West China. Also, this article has effectively predicted the spatial distribution of channels and the lithologic body of reservoir and identified the boundary and size of the lithologic trap. The scale of lithologic oil/gas reservoir in SN31 well has been discovered after the successful application of these three techniques, which have provided a new idea for the exploration of subtle oil/gas reservoirs in Junggar Basin. The considerable importance of selecting appropriate approaches needs to be noticed when the study of subtle oil/gas reservoir is conducted; this approach serves as a vital part of achieving success in exploration.

Introduction

The Junggar Basin is located in West China, associated with Altai Mountains and the Tianshan Mountains, and is roughly triangular in shape. Junggar Basin is one of the richest oil/gas basins in China. The petroleum geological conditions are favorable but complex. After half a century of exploration in the basin, a large number of oil/gas fields around the basin or in the center of basin have been found. The target layers are the Upper Paleozoic to Tertiary, and reservoir types are structural and stratigraphic, as well as combination types. In recent years, reservoirs, especially the subtle reservoirs for which exploration is difficult, are significant exploration targets. The widespread application of seismic interpretation and associated advanced technology have become the choice to attain the breakthrough in the exploration of subtle reservoirs (Zhang et al., 1998). This article describes channels and lithologic traps by focusing on the use of spectrum decomposition, full 3-D visualization technology, and full 3-D data volume interpretation technology. The result has proved to be successful in revealing the desirable prospect of subtle oil/gas exploration in three test areas, including eastern basin, northwestern margin, and the middle of the Junggar Basin.

Application

With the application of all the geophysical techniques noted above, favorable results involving the channel and lithologic traps, as well as lithologic-body tracking, have been obtained in the 3-D seismic surveys of C43 well, G8well, and SN4 well areas. This method has provided a feasible method of subtle reservoir exploration in such areas.

C43 Well 3-D Work Area

The C43 well 3-D work area is located in the Baijiahai “heave” of eastern Junggar Basin and west of Cainan oil field. Sangonghe Formation, Jurassic in age, in this work area is delta-front deposits; the source of sediments in this work area is from north. The deposition of the “second” part of Sangonghe Formation is mainly distributary channel; the lithology is gray, fine sandstone, with a thickness of 8-25m. Log is bell-shaped. In the east- west direction, the well logs show sharp changes in sandstone thickness. In a south-north section, the sand is relatively uniform in thickness.

By applying the techniques noted above, higher resolution and clearer images were obtained, in particular sandstone lateral extents, as suggested in the literature (e.g., Partyka et al., 1999). In reservoir prediction in the local area, 30, 40, 50Hz tuning frequencies have been adopted. In the study area, superposition of different frequencies has been applied to predict the reservoir. In this method, the color of red, green, yellow represent different frequencies, and the intensity of color is in relation to amplitude; this is similar to satellite remote sensing technology that uses different bandwidth frequencies on surface terrain and interference generated (Zhu et al., 2003). Figure 1 is spectra decomposition amplitude map in the “second” part of Sangonghe Formation in C43 well 3-D work area. It is interpreted as distributary channel sand deposits, C39 and C36 wells, with bell shapes, are located near the west edge of the channel. The sand thickness in these wells is 16m and 12m, respectively. C016 well and C31 wells are located in the central part of the channel, with their box-like log curves. Sandstone thickness is 22m. C19 well in the eastern part of the channel, also with a box-like log, has thickness of 20m. C16 and C003 wells drilled between two channels show mainly finger-shaped logs. The seismic approach, calibrated to well logs, not only describes the spatial location of the reservoir, but also depicts the relative thickness of the reservoir relationship.

G8 Well 3-D Work Area

The G8 well 3-D work area is located in the Zhongguai area in the south part of northwestern Junggar Basin, where there are multiple sets of Jurassic reservoirs. Because of their limited thicknesses, it is difficult to conduct the usual investigation of reservoir prediction with a reasonable level of certainty. With the application of full 3-D visualization technique of Geoprobe in the Landmark system, geological targets have been identified rather quickly. Lenticular reflections, which prove to be sandstone in the impedance inversion sections, are illustrated in Figure 2, and maps of specific reflector is shown in Figure 3. Combined with sedimentary facies analysis and reservoir prediction, we think that there is a separate branch of channel sands.

East Part of SN4 Well 3-D Work Area

East part of SN4 well 3-D work area is located in the western region of the Junggar Basin. With the application of full 3-D visualization technique of Geoprobe in the Landmark system and adjusting the time window range and changing the perspective parameters, there is a lithologic body of interest in the southeast part of the work area (within the Toutunhe Formation). From the result of leveling Tk_1 from 0-38ms, the boundary of the lithologic body is clear. By continued processing, the main part of the lithologic body can be distinguished by its correspondence to a strong reflection in the seismic data (Figure 4). The thickness of this unit may be shown by the positive scaling vertically, and this seismic data can provide valuable information for well location and well trajectory design (Figure 5). The lithologic body shows pinch-out in the updip direction. In a comprehensive analysis, the lithologic body is sandstone, and there is thick mudstone developed to form an updip seal.

Conclusions

In this article, spectral decomposition, the full 3-D visualization technology, and full 3-D data volume interpretation technology have been applied to interpret 3-D work areas of the Junggar Basin, resulting in the identification and evaluation for subtle traps. The lithologic trap in the east part of SN4 well area had been discovered, in the “hinterland” of Junggar Basin. Drilling resulted in high-yield oil/gas flow. The area of this oil reservoir is 40.8km^2. Proven petroleum geological reserve is 2119×10^{4}t, recoverable reserves is 635.7×10^{4}t. This well, SN31, guided by stratigraphic oil/gas exploration ideas and methodology, has a strategic meaning during the transition period when exploration is being converted in emphasis from structure to stratigraphic in the Junggar Basin. This approach has also raised oil/gas exploration success rate for Xinjiang Oilfield Company. It is important to note that choosing the appropriate interpretation method can have a desirable effect when studying the subtle reservoirs.

References

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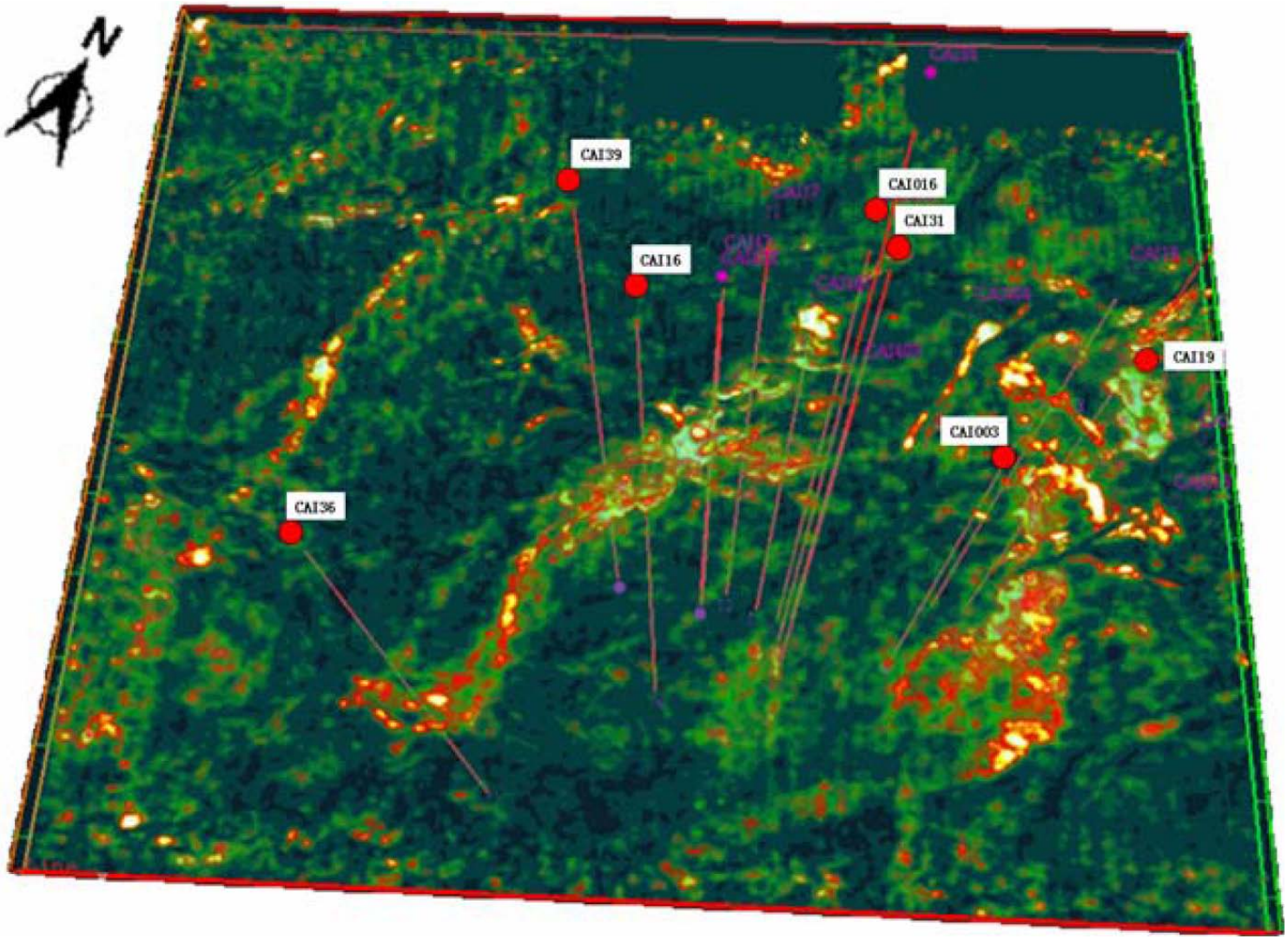

Figure 1. Spectra decomposition amplitude map in “second” part of Sangonghe Formation of C43 well 3-D work area.

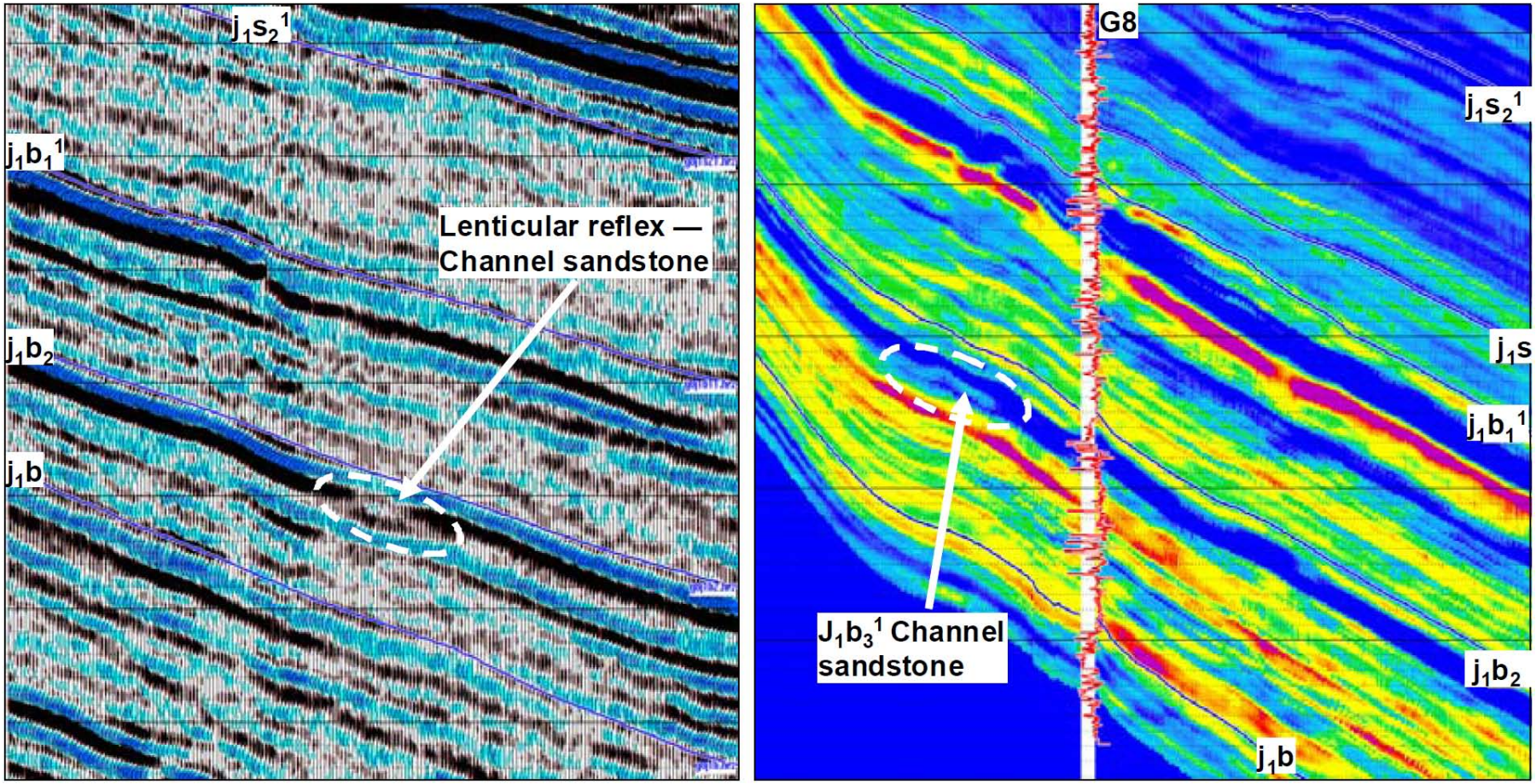

Figure 2. Seismic section in G8 well 3-D work area. Left. Line180. Right. Impedance inversion section through G8 well.

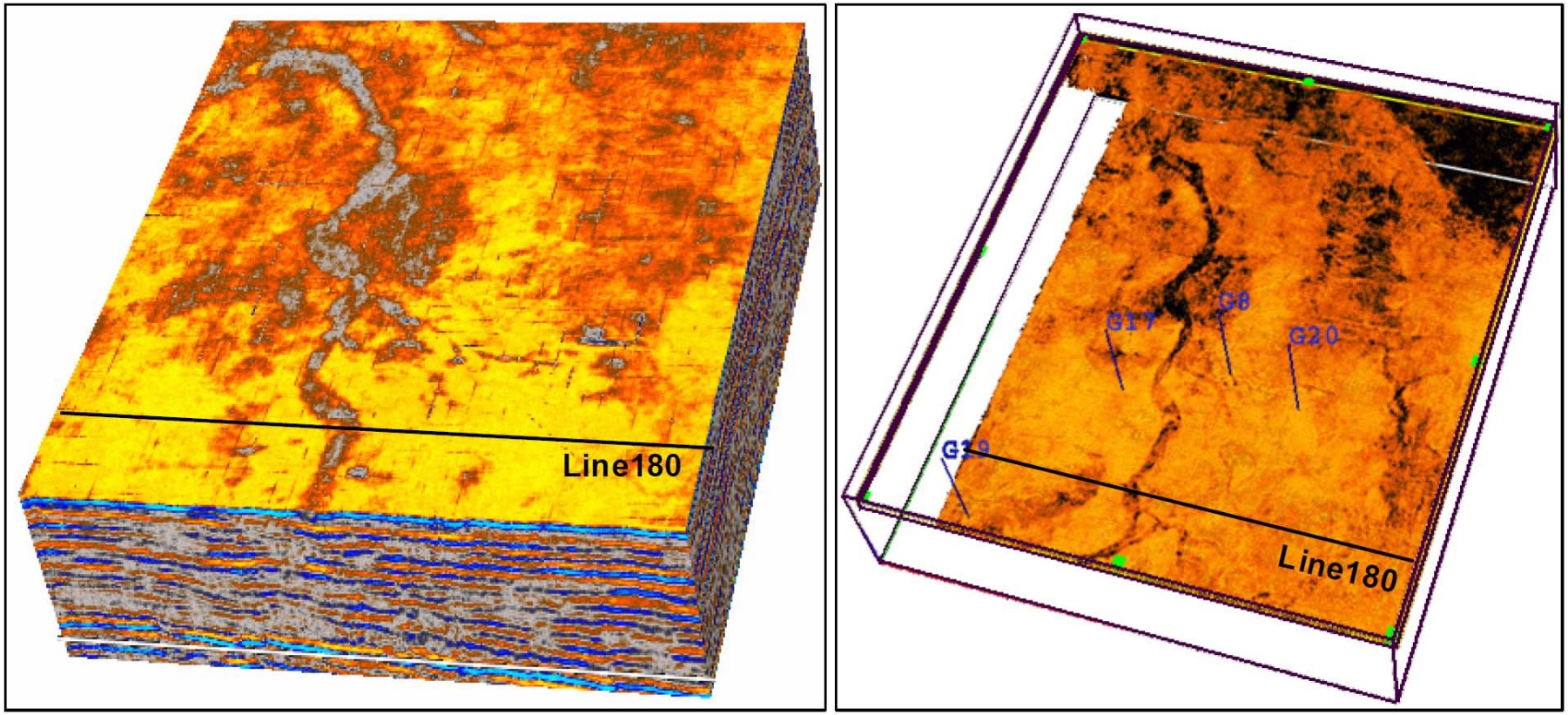

Figure 3. G8 well 3-D work area: channel identification. Left. Amplitude data volume visualization. Right. Along J_1b_2 level after leveling down 4-46ms.

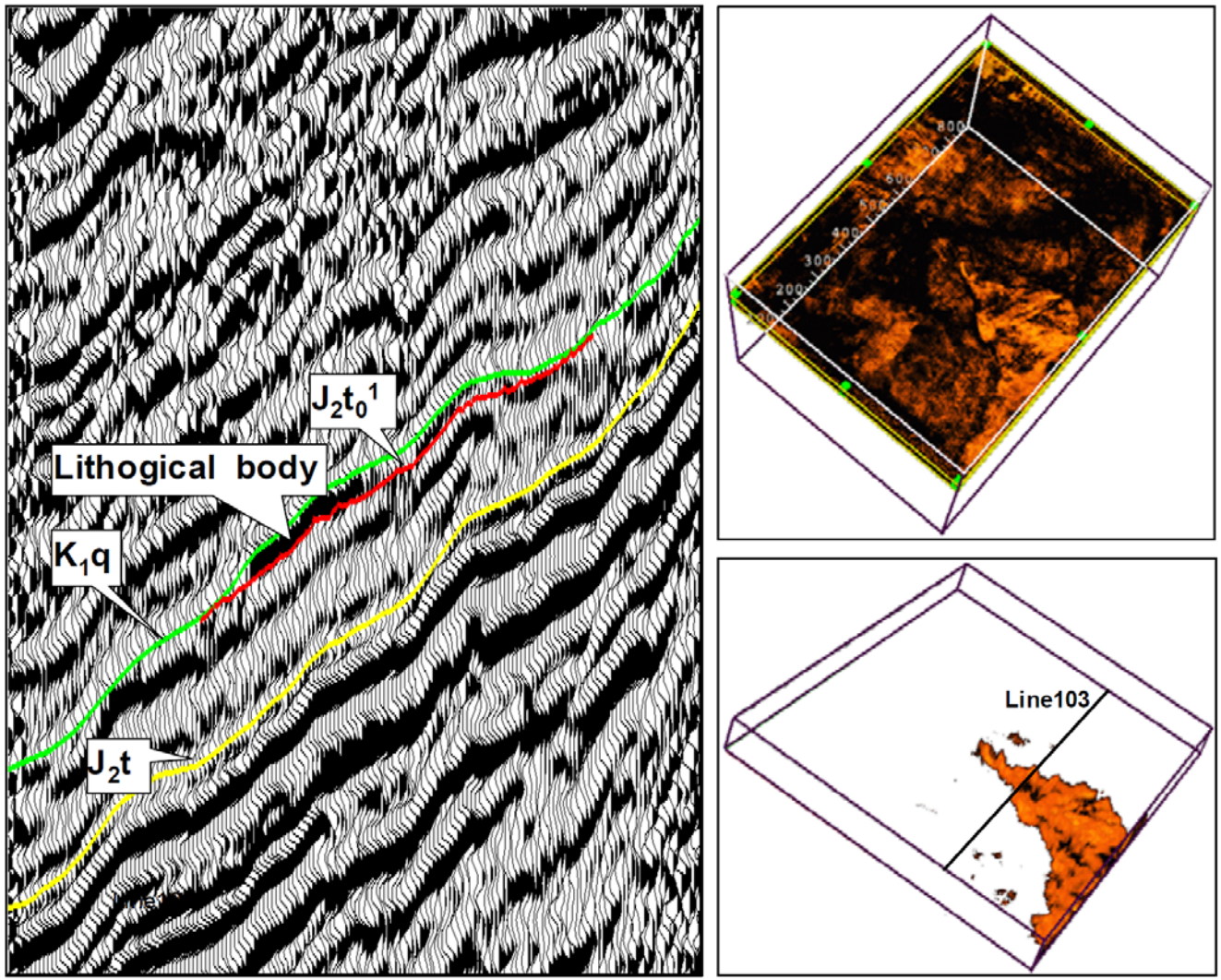

Figure 4. Trap identification, east part of SN4 well 3-D work area . Left. Line103 seismic section. Right. Full 3-D visualization plan. Upper right. After leveling. Lower right. After another leveling.

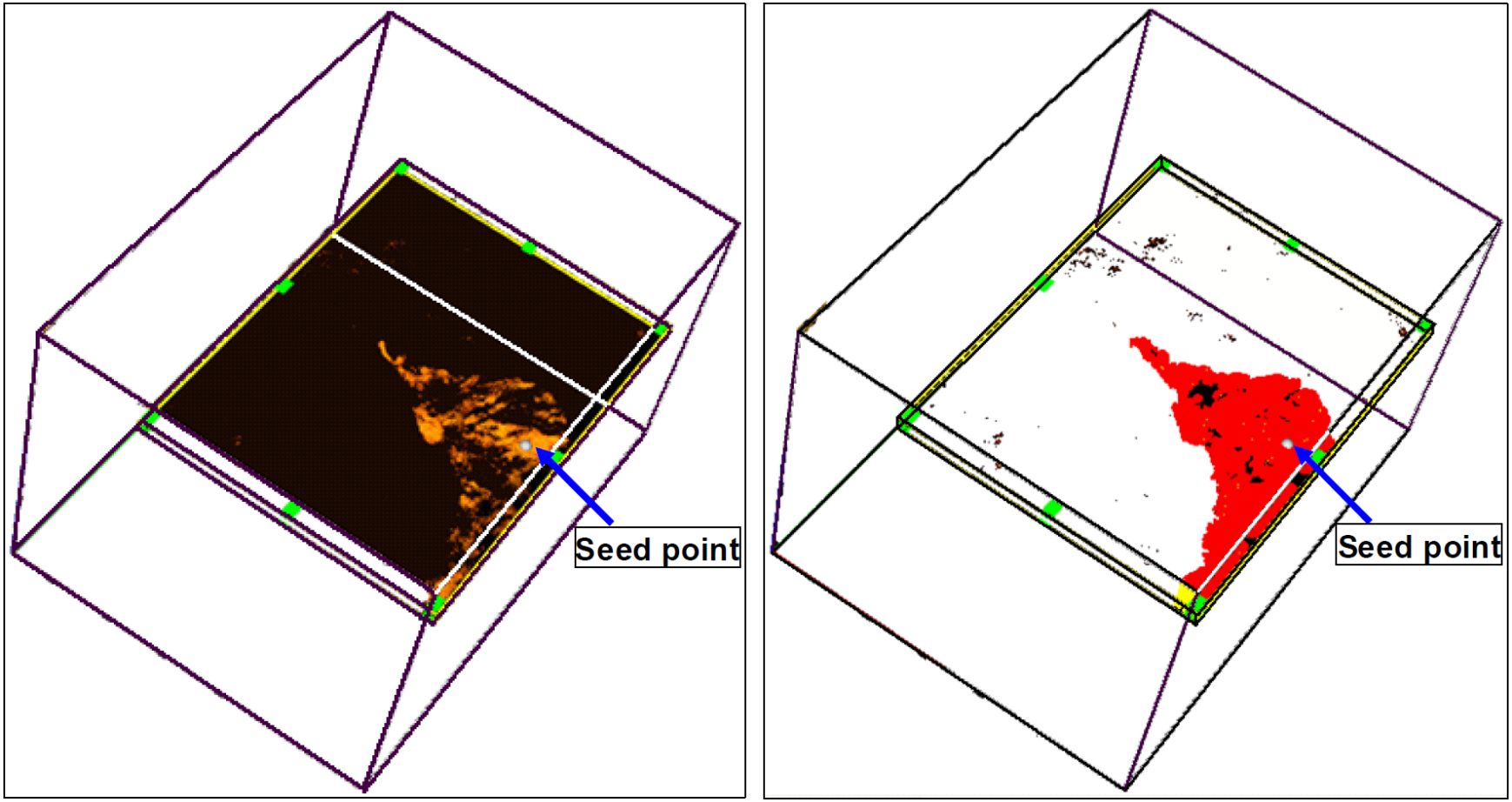

Figure 5. Interpretation, 3-D data volume in east part of SN4 well 3-D work area. Left. Before the full 3-D data volume. Right. After the full 3-D data volume.