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An Integrated Study of the Liuhua 11-1 Field Using an Ultra-High Resolution 3D Seismic Dataset: South China Sea

Introduction

The Liuhua 11-1 fField, located 130 miles southeast of Hong Kong in 1000 feet of water, is a vuggy carbonate reservoir at shallow depths (3850 feet subsea), producing 16-22 degree API oil under a very strong bottom-water drive. The field was discovered in 1987 and is currently being developed with 25 long-radius horizontal wells drilled from a floating production system. Project success is dependent on limiting water production with the heavy oil, which in turn makes an accurate reservoir description critically important.

To better define reservoir heterogeneity, a 3D seismic survey of the Liuhua Field was acquired in July 1997. A very high resolution dataset (200+ Hz) was obtained and has been used in an integrated field study to evaluate the future exploitation potential of the 1.2 billion barrels of oil in place in the reservoir.

The seismic data were converted to acoustic impedance using geologically-constrained inversion techniques and converted to porosity based on a linear impedance vs. porosity relationship. Drilling data were integrated with the seismic data to create detailed maps of reservoir structure and stratigraphy. Petrophysical data and modeling coupled with the seismic inversion were used to create a spatial distribution of porosity, permeability, and saturation. Faults, fractures, and oilfield karst collapse phenomena in the reservoir were analyzed using coherence technology. Complex attribute analyses added an additional understanding of rock matrix continuity. This information was used to build reservoir characterization and simulation models that were tuned and validated using historical performance to predict future reservoir performance.

Conclusions

Much of the prior geoscience understanding of the Liuhua reservoir was revised significantly as a result of this work. The structural location of the wellbore is a critical factor along with the internal faulting, fracturing and solution collapse, the porosity and permeability of the flow units, and the integrity of the tight zones. A significant finding, demonstrated by the porosity model, is the heterogeneity and lack of continuity in the tight layers as called for in the original pre development plan. The Liuhua reservoir is riddled with porosity soft spots and suspected fracture swarms in the baffle zones that were originally required to be spatially competent as tight protection from early aquifer influx. Solution collapse and gas chimneys are also critical factors affecting reservoir hydraulics, and the associated vertical water movement was simulated successfully using attribute analyses during flow modeling around the horizontal wellbores.

Biographical Sketch

Chip Story holds a B.S. degree in geological engineering from the South Dakota School of Mines and an M.S. degree in geophysics from the Colorado School of Mines. His career began with Amoco in 1977 with early efforts in the Wyoming thrust belt. Subsequent projects in Denver included work in the

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Paradox and Williston basins. Project assignments in New Orleans and Houston starting in 1983 involved the Gulf of Mexico Pleistocene, onshore and offshore Norphlet trend, the Tuscaloosa trend, the Hackberry trend, the Santos basin offshore Brazil, and the Liuhua field offshore China. Chip is currently working as a consulting geophysicist on Norphlet/Smackover projects in the Mississippi Interior Salt basin and on the Tuscaloosa formation in the Tuscaloosa Trend for CAEX Services of Houston. His professional interests include 3D seismic interpretation, visualization, and reservoir characterization technology. Chip holds active membership in the Geophysical Society of Houston and the Society of Exploration Geophysicists. □

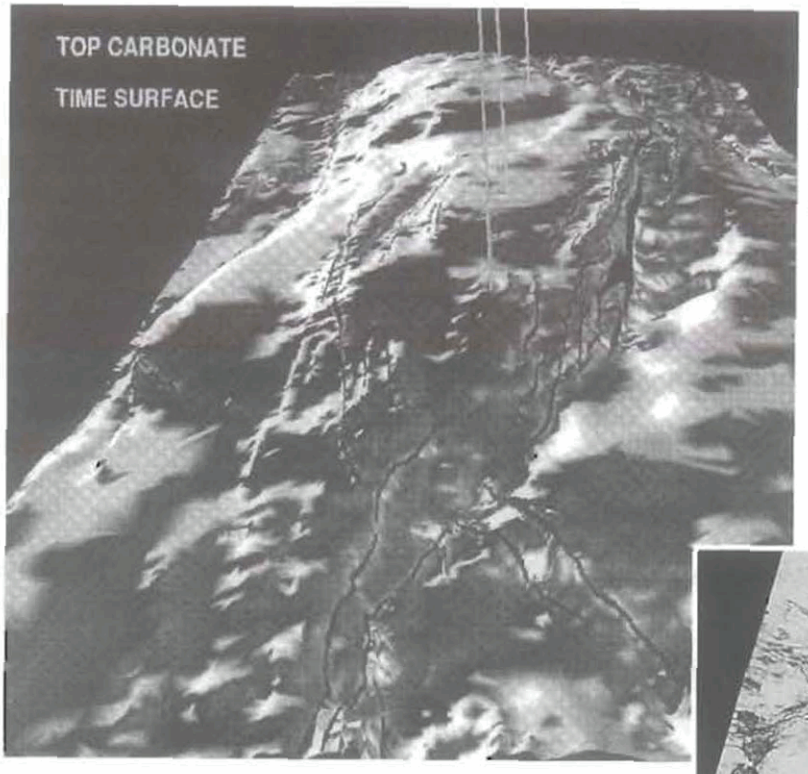

Figure 1. *3D image of the top of the Liuhua reef complex. Fault breaks shown as gaps; karst features as deep holes.*

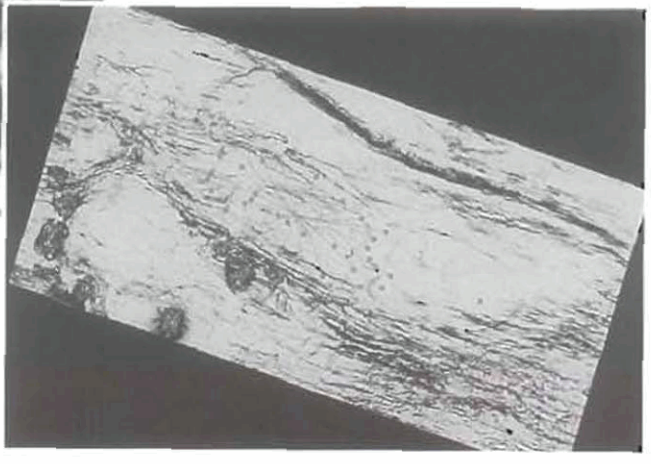

Figure 2. *Coherence image of the reservoir top. Large circular features are karst collapse zones; linear features are faults.*

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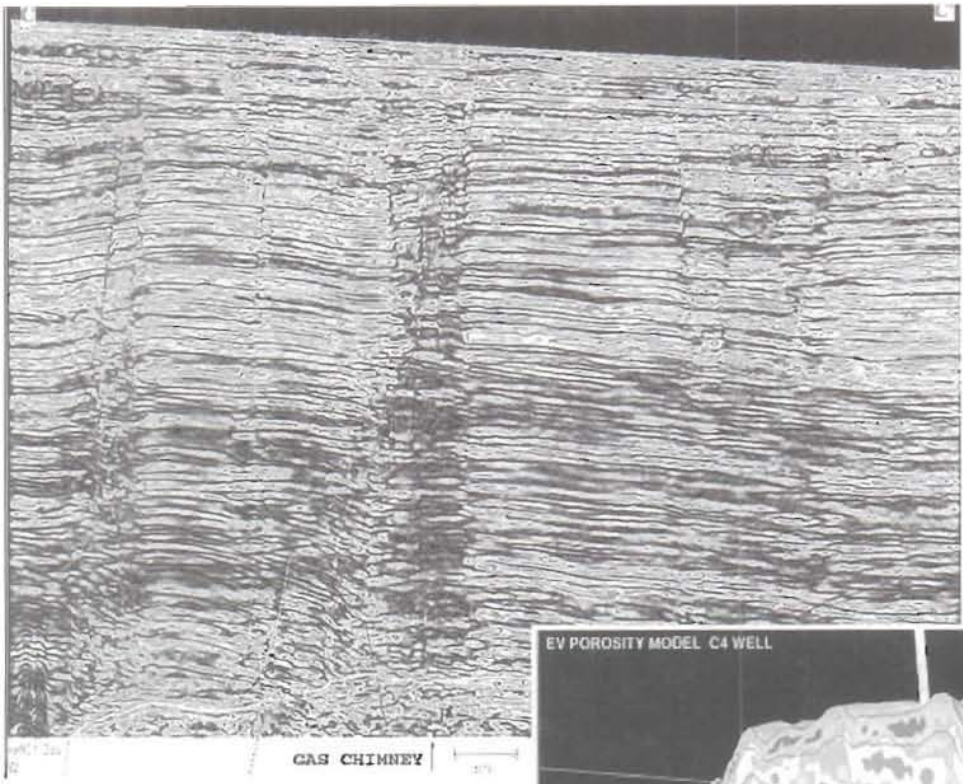

Figure 3. *Reflection strength attribute section showing amplitude loss in the gas chimney zones within and above the reservoir. Vertical water flow associated with the oilfield karst features was modeled in the reservoir simulation.*

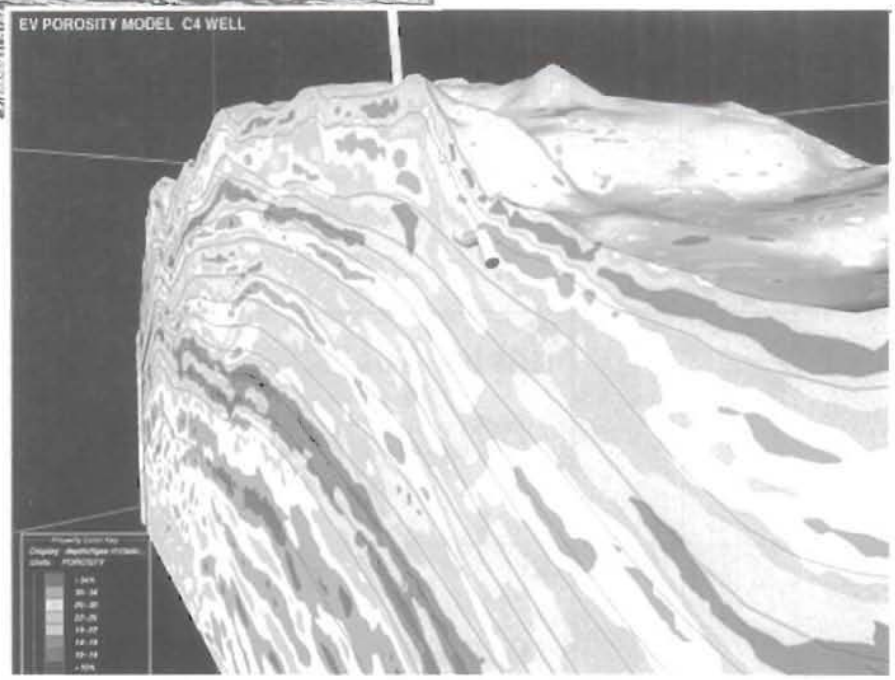

Figure 4. *Combined structure and property model in depth showing carbonate porosity flow units input to reservoir simulation.*