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North American Explorationists
Dinner Meeting

by ***Victor H. Vega, Greg Partyka, Christopher J. Christensen, and Dennis L. Cox***
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Jonah Field Area: Seismic Coherency Cube Technology Used to Define Trap Boundaries and Stratigraphic Features

Jonah Field, Sublette County, Wyoming, is expected to produce at least 1.5 TCF of natural gas from lenticular, over-pressured, tight formation gas fluvial sandstones of the Cretaceous-age Lance Formation. Depth of production is 7,500 to 12,400 feet and the gross producing interval is 1500 to 3200 feet. Jonah was indicated to be a significant field in early 1993 (Robinson, 2000) and now produces more than 400 MMCFD from more than 200 wells (Fig. 1). In-fill drilling on 40-acre spacing has been underway since mid-2000. Entrapment may result from a combination of dip reversal and fault zone deformation associated with faults that intersect up dip to form a wedge-shaped compartment. Apparent throw on the bounding faults is variable, but commonly is less than 200 feet.

Advanced seismic techniques, particularly amplitude-based coherency, have been applied to a proprietary 3-D seismic survey to define the trap boundaries and to optimally locate development wells at Jonah Field.

Seismic imaging of the Jonah Field is challenging because of complex fault throws and generally dim and discontinuous reflections within the producing interval. Reservoir heterogeneity is the result of both depositional and tectonic processes. First-order and second-order heterogeneities were created by a direct interplay of tectonics and deposition. Third-order and forth-order heterogeneities reflect depositional details within channel-fill and channel-belt facies.

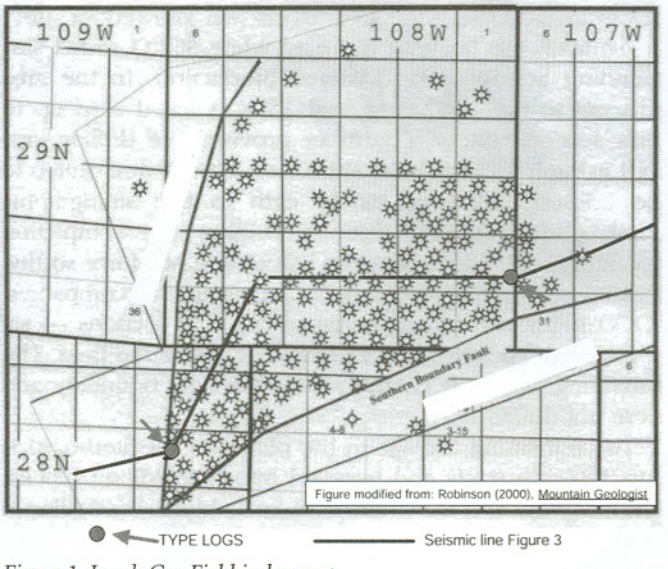

Figure 1. Jonah Gas Field index map.

Tectonics, including regional asymmetric subsidence in front of the Wind River allochthon and local syndepositional movements, are associated with three important unconformities at Jonah Field. These unconformities range in age from Late Cretaceous (Campanian) to Middle? Paleocene. From oldest to youngest the unconformities are base of Ericson Formation, base of Lance Formation, and base of the Fort Union Formation. The Lance Formation thickens northeastward across Jonah Field from 2500 to 4000 feet as a result of changing accommodation space induced by flexural loading of the crust during emplacement of the Wind River Uplift (Fig. 2). Conversely, the updip thinning is accomplished by basal onlap, intraformational truncation, and gradual convergence of strata. In the eastern part of the field, down dip from section 27, we interpret local southwestward onlap of the basal Lance Formation onto the eroded top of the Mesaverde Group. Separately, a thick interval of younger lower Lance Formation strata is beveled southwestward towards the apex of the field in the area updip from section 27. Erosion of the Lance Formation at the base of the Fort Union Formation becomes important west of Jonah Field. Figure 3 is an arbitrary seismic line traversing Jonah Field in the direction of regional dip. ➢

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Depositional processes are believed to be the most important contributors to third and fourth order reservoir heterogeneities in Jonah Field. Integrated well log, core, seismic, and regional geologic data support the interpretation that Jonah reservoirs are primarily lenticular channel fill and channel belt sandstones deposited by low-sinuosity fluvial systems that flowed southeastward along the rapidly subsiding basin axis toward the Interior Cretaceous seaway. Within the Lance Formation the more continuous reflections are usually associated with flood basin mudstone bodies. Questions of well spacing and well density are probably most dependent upon the depositional fabric of fluvial facies in addition to the degree of compaction and diagenetic occlusion of the intergranular pores.

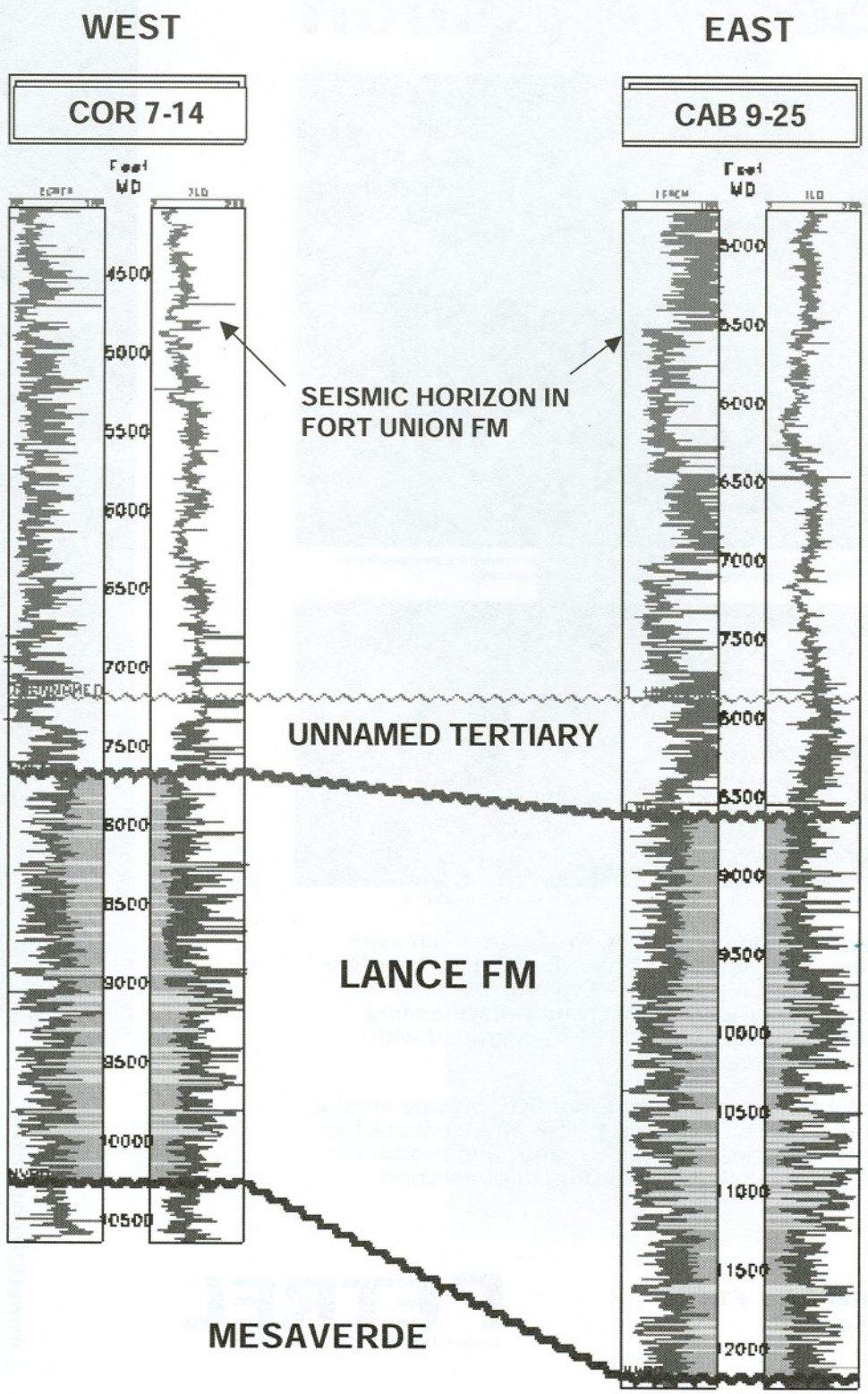

Figure 2. Type logs for west and east parts of the Jonah Field. See Figure 1 for location of these wells.

Advanced seismic techniques have been applied to a proprietary 3-D seismic survey to define the trap boundaries and to optimally locate development wells at Jonah Field. One of the main tools used for our interpretation has been a 3-D broad-band amplitude-based coherency algorithm (Marfurt and Kirlin, 2000) that has edge detection capabilities. This algorithm looks at the reflector amplitude gradient and captures the lateral change in amplitude with azimuthal angle. This allows the interpreter to "illuminate" a particular feature from the optimal angle to see the maximum detail within the data. On the southern part of the Pinedale Anticline east of Jonah Field, this technology allows us to visualize large Fort Union Formation sandstone bodies comprised of coalesced fluvial (meander belt) channel fill. These sandstone bodies abruptly terminate along the west flank of the anticline suggesting a mid-Paleocene phase of structural development although most of the folding of the southern part of the Pinedale Anticline clearly affects the Early Eocene Wasatch Formation. ■

Biographical Sketch

VICTOR VEGA is currently the project manager of Jonah Field for BP. Victor started with ➢

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Amoco in 1994 as a geophysicist and has worked all over the world doing interpretation for exploration and development work, regional studies, and AVO analyses. He received his MS in geophysics from the University of South Carolina in 1993 after having completed a BS in geology from the Universidad Nacional de Colombia. Victor is a member of the AAPG, SEG, and ACGGP (Colombian Association of Petroleum Geologists and Geophysicists). He is the International Coordinator for the VIII Simposio Bolivariano in Cartagena next year.

References

Marfurt, K.J., and Kirlin, R. L., "3-D Broad-band Estimates of Reflector Dip and Amplitude", Geophysics (2000) Vol 65, 304-320.

Robinson, J. W., "Discovery of the Jonah Field, Sublette County, Wyoming", The Mountain Geologist (July 2000), Vol 37, No. 3, 135-143.

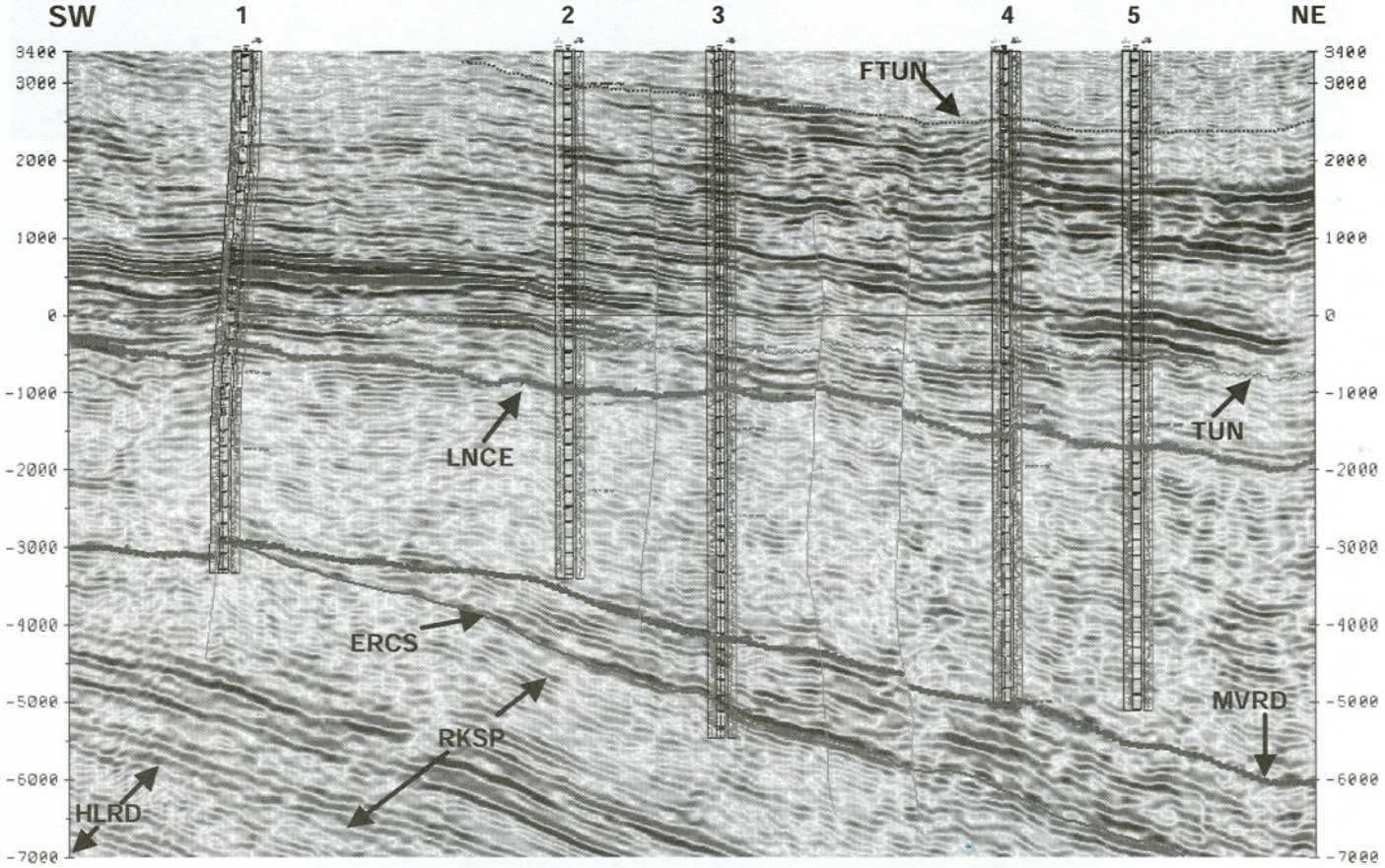

Figure 3. Arbitrary 3-D seismic line displaying five key well logs including Wells 1 and 4 shown on Figure 2. This seismic line is oriented generally northeasterly in a dip direction extending from a point 1.7 miles west of Jonah Field to the syncline near the eastern down dip extent of Jonah Field. Total length is approximately 12.1 miles (64,000 feet). Well 1 is directionally drilled along the western boundary fault of the field. The fault is obscured by the well log overlay. Well 3 is located near the center of the field and penetrates the Ericson Formation. Well 4 is located on the up-thrown side of an important fault and the well log overlay obscures much of the fault. Well 5 defines the down dip limit of production as presently known in this area. Elevations are shown along the side of the seismic line at intervals of 1000 feet.

Stratigraphic horizons are as follows:

FTUN	*Fort Union Formation top*
TUN	*Unnamed Tertiary Unit top*
LNCE	*Lance Formation top*
MVRD	*Mesaverde Group top*
ERCS	*Ericson Formation top*

The following stratigraphic units are approximately located:

RKSP	*Rock Springs Formation*
HLRD	*Hilliard Formation, base lies below bottom seismic data*