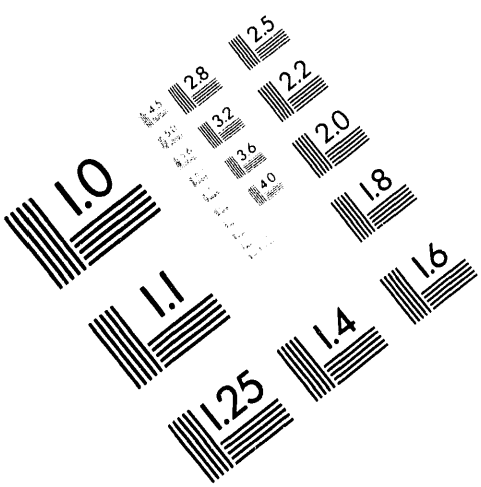

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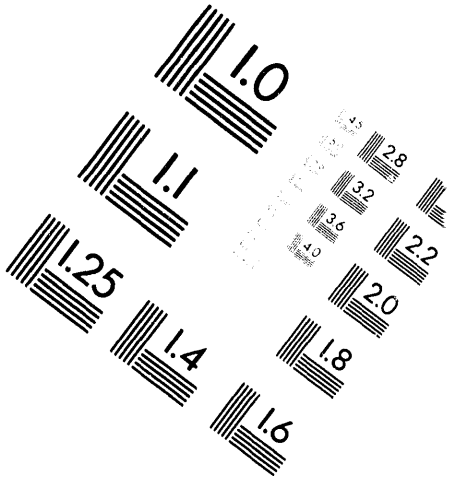
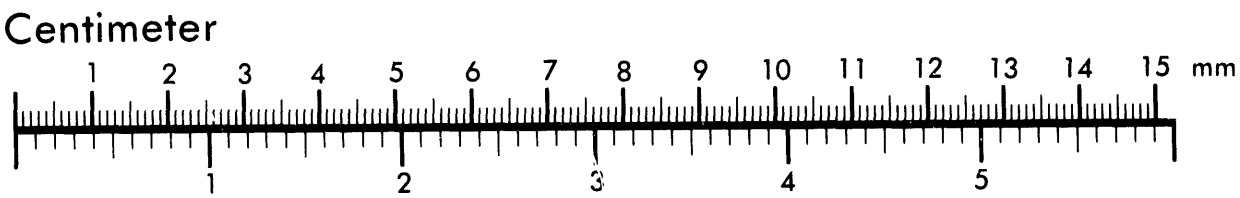
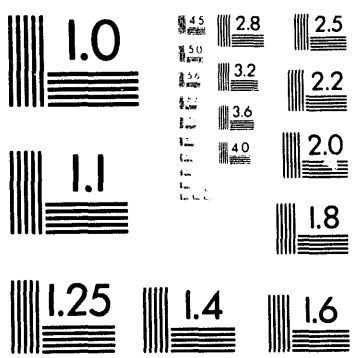
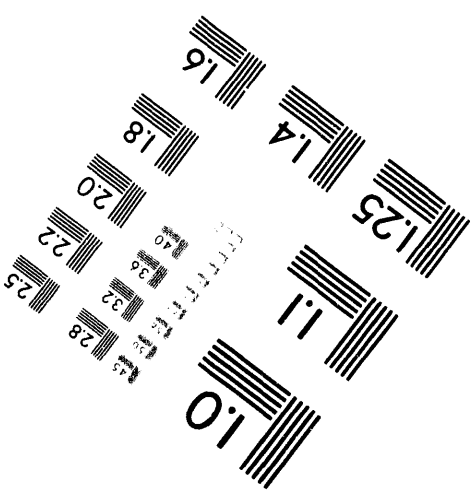
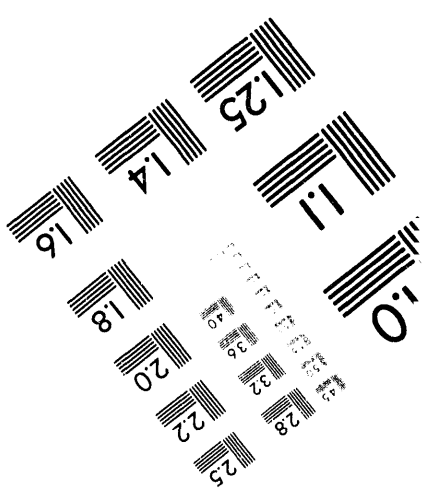










1 of 1

DOE/BC/14950--6

QUARTERLY TECHNICAL PROGRESS REPORT

TITLE: **ENHANCED OIL RECOVERY UTILIZING HIGH-ANGLE WELLS IN THE FRONTIER FORMATION, BADGER BASIN FIELD, PARK COUNTY, WYOMING**

COOPERATIVE AGREEMENT No. DE-FC22-93BC14950

UNIVERSITY/INSTITUTION/LABORATORY: Sierra Energy Company

DATE OF REPORT: 22 April 1994

AWARD DATE: 21 October 1992

ANTICIPATED COMPLETION DATE: 30 September 1995

GOVERNMENT AWARD (Budget Period 9/19/93 to 12/31/94): $922,287

PROGRAM MANAGER: John N. Augustine

PRINCIPAL INVESTIGATOR: Richard G. Fortmann

TECHNICAL PROJECT OFFICER (TPO): Ms. Edie Allison

REPORTING PERIOD: 1 January 1994 to 31 March 1994

"US/DOE Patent Clearance is not required prior to the publication of this document."

DISCLAIMER

QUARTERLY TECHNICAL PROGRESS REPORT

1 January 1994 - 31 March 1994

A. OBJECTIVES

Sierra Energy Company has significantly revised it's targeted goals for this Cooperative Agreement due to it's sale of the producing wells in Badger Basin field in the first quarter of 1994 to The Rim Companies. Sierra Energy has not assigned its interest in the Cooperative Agreement to Rim. However, Rim has an exclusive option until April 30, 1994 to accept assignment, subject to approval of the Department of Energy.

Sierra Energy, in consultation with Rim, concluded that additional work was required for Subtask 2.1.4 - Interpret data, of Task 2.1 - Acquire 3-D seismic data. The goal of this subtask was to interpret the 3-D seismic data, using a workstation, in order to locate the surface and subsurface positions for the slant and horizontal wellbores. Although this goal had been reached, more work was needed for plotting maps and seismic sections. Furthermore, it was determined that an additional look at the amplitude distribution in the Frontier sands would greatly benefit the interpretation.

B. SUMMARY OF TECHNICAL PROGRESS

TASK 2.1 - ACQUIRE 3-D SEISMIC DATA

Subtask 2.1.4 - Interpret data: Interpretation of the 3-D seismic survey was reviewed on a Sun Sparcstation10 workstation (UNIX based), using Landmark Graphics latest version of Seisworks 3D software. After editing the picks for the three Frontier horizons on a 10 by 10 (inline by crossline) grid, it was necessary to rerun the autopicking routine ("ZapIII") for the Frontier sands. These new horizontal interpretations were edited with the "Horizons - Areal Delete" capability in Seisworks 3D. A smoothing procedure was performed, with the crossline and inline filters both equal to 2. Then, fault-exclusion polygons were picked for each Frontier horizon after editing the normal and reverse faults. Horizon picks for the 1st, 2nd and 3rd Frontier sands were converted to map points in a northwest-southeast (i.e., crossline) direction, using an increment of 5. The fault polygons were then appended to the map-point files for the three Frontier horizons. The map points were gridded using the following parameters: 1) x-grid interval = y-grid interval = 400'; and, 2) search radius =1,000'. The grid was contoured using two smoothing passes. The computed contour map was converted to manual contours, where editing for the final time-structure contour map occurred. Additionally, amplitude extraction was performed on the three Frontier horizons. Finally, maps (Figure 1 and 2)

for the three Frontier horizons were plotted, combining the time-structure contours with a color-coded amplitude display.

Seismic displays of crossline (i.e., northwest-southeast) #121 (Figure 3) and inline (i.e., northeast-southwest) #100 (Figure 4) were plotted of the section between the Cody marker and the Lakota Conglomerate. The high-angle reverse fault, cutting up through the Frontier and Cody sections, is best displayed by inline #100. The northeast-trending normal faults are best seen on crossline #121. It shows a complex faulting pattern. The 1st Frontier horizon is broken by two faults. One (the main normal fault) has offset down into the Mowry Shale whereas the fault to the southeast dies out before penetrating the 2nd Frontier. Both the 2nd and 3rd Frontier horizons are cut by the main normal fault and a fault to the northwest, which has offset down through the Lakota.

Displays of amplitude for the Frontier horizons shown well-defined high-and low-amplitude trends, cutting across the axis of the anticline in a northeasterly direction as well as paralleling the hingeline of the main anticline and a subsidiary nose plunging to the south from the southeast end of the main structure. This amplitude pattern is most prominently displayed by the 1st Frontier. It is also easily seen in the 3rd Frontier. However, due to the low-quality reflector associated with the 2nd Frontier, this pattern can be more difficult to demonstrate.

An attempt was made to correlate productivity of individual wells to trends of low amplitude. Although the are numerous examples of better productivity correlated to low amplitude (e.g., #7 and #9 BBFU wells; and, the #3 BBFU - the best well in the field, if one believes the bottomhole location of the well deviated southeasterly to TD just on the downthrown side of the main normal fault). There are examples of poor wells in low-amplitude areas (e.g., #10 BBFU). However, a common situation is to find both good and poor producers in an area with no well-defined amplitude trend, particularly for the 3rd Frontier.

Two possible causes may explain these observations, assuming that there is a relationship between low amplitude and productive fractures. First, the less than full correlation of low amplitude and productivity may be due to the difference in scale between seismic and well data. The 3D seismic survey has a horizontal resolution based on the bin size of the subsurface points. The bin dimension in a northwest-southeast direction, perpendicular to the normal faults, is 165'. It is felt that these northeasterly-trending normal faults and associated fractures are the features providing permeability in the reservoir. Thus, the seismic can only resolve horizontal features that are at least 165' apart. A wellbore through the Frontier is normally drilled using a 7-7/8" bit. The direction of any stimulation (e.g., hydraulic fracturing) is controlled by the local stress field that also controls the direction of the open, permeable fractures, causing stimulations to propagate in a direction parallel to the fracture set. Thus, stimulation will not significantly increase the number of open fractures which the wellbore has encountered. Productivity of an individual well is first of all a function of the open fractures penetrated during drilling (and possible stimulation); and, subsequently, of the extent to which the penetrated fracture is connected with an extensive fracture system. It is conceivable that a poor well in a low-amplitude zone may have not encountered any open fractures. Likewise, a good

well in a mixed area of amplitude trend my have drilled into a narrow fracture zone that is well connected to a fracture network.

The second possible reason for the imperfect correlation of low amplitude and productivity may be due to completions in multiple Frontier sands by both open-hole and cased wellbores. Evidence for high productivity can be shown for all three Frontier sands. However, only the amplitude maps of the 1st and 3rd Frontier display clear patterns. An example of the interpretational problem this situation may cause would be a well with significant production from the 2nd Frontier, but associated with high amplitude in the 3rd. Unfortunately, producing practices did not allocate amount of production to individual zones.

The most recent work on the 3-D seismic survey supports the location for the slant and horizontal wellbores picked by Sierra Energy in December 1993. However, reasonable arguments can be made for one or two alternate locations. A final decision on which location to drill remains to be reached.

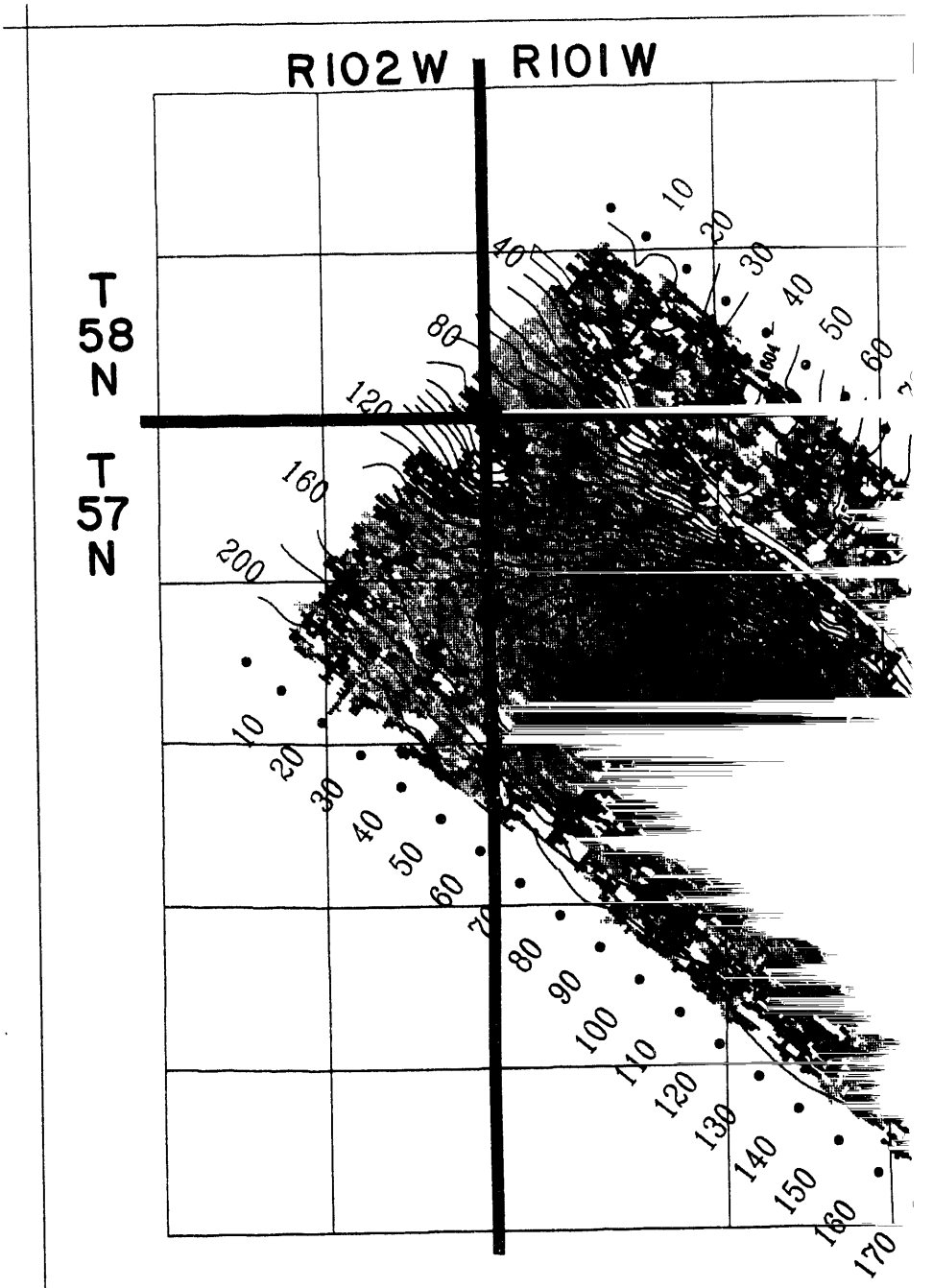
C. REFERENCES/PUBLICATIONS

None.

D. ATTACHMENTS

Figures

No. 1 - Amplitude and Time-Structure Map of the 1st Frontier Horizon
No. 2 - Amplitude and Time-Structure Map of the 3rd Frontier Horizon
No. 3 - Seismic Panel of Crossline (Trace) 121 between the Cody and Lakota
No. 4 - Seismic Panel of Inline (Line) 100 between the Cody and Lakota
No. 5 - Time-Structure Map of the 1st Frontier Horizon, with Location of Seismic Displays



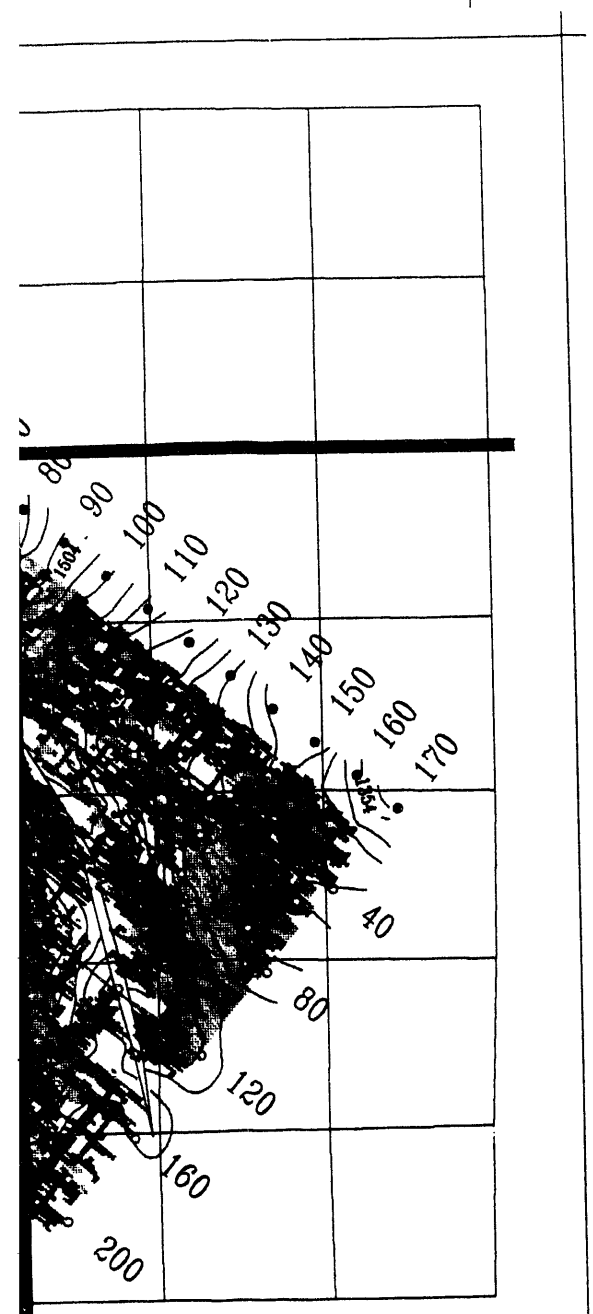
AMPLITU

C.I = 1

Note: The bottom
absence of

HRZ:Amp2_Kf1 (1.00,131.88)

AMPLITUDE and



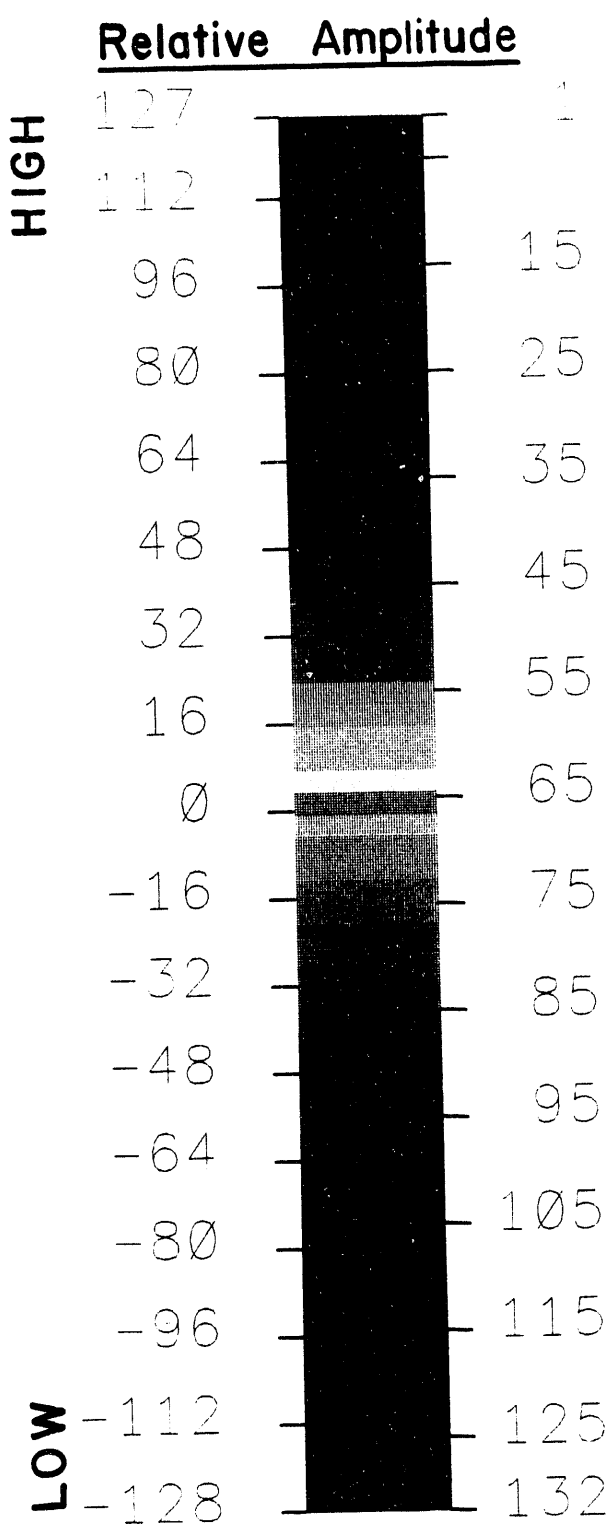


FIGURE No. 1

E & TIME-STRUCTURE: 1st FRONTIER

Badger Basin Field

Park County, Wyoming

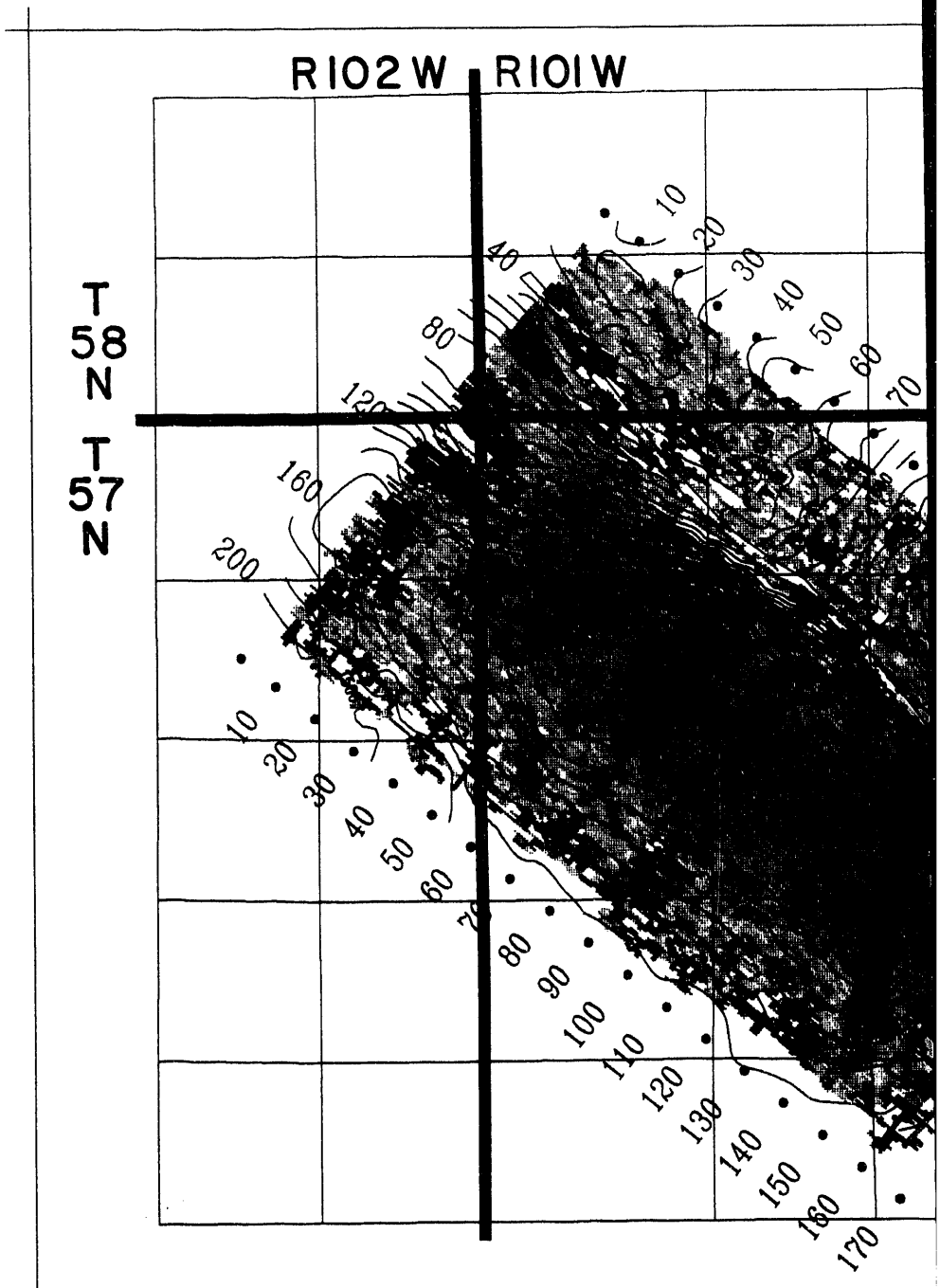
milliseconds Horizontal Scale: 1" = 6,000'

JPW March 19, 1994

e location for the #3 BBFU is an estimate based on expected dips and mal faulting in the Cody Shale or Frontier Fm. in the #3 well.

IME STRUCTURE: 1st FRONTIER SAND

0' 6000' 12000'



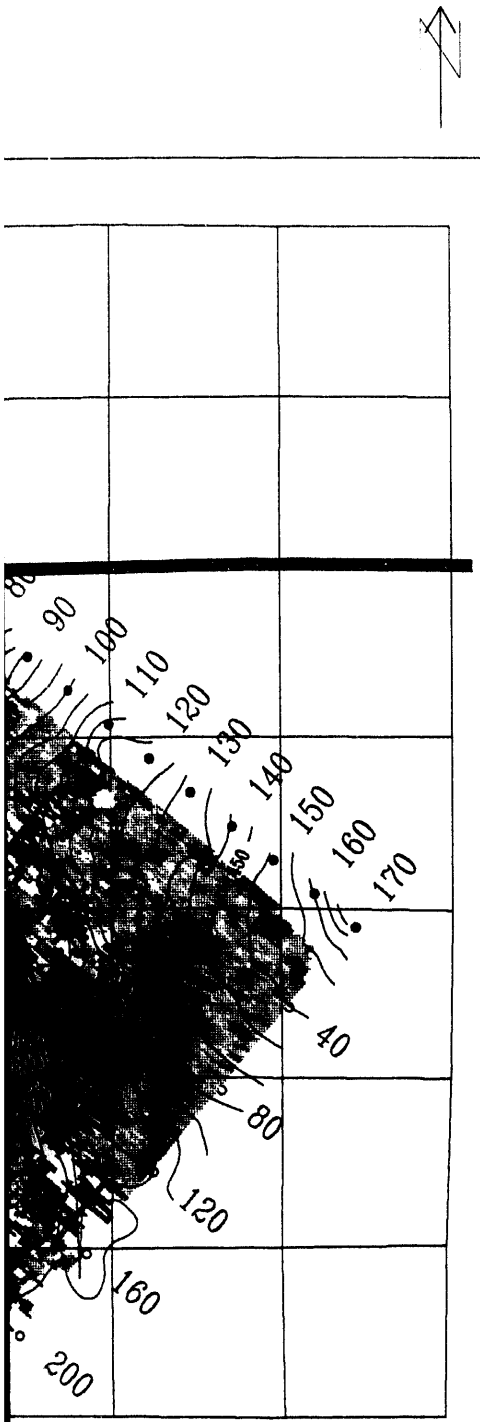
AMPLITUDE &

C.I. = 10 mi

Note: The bottomhole lo
absence of normal

HRZ:Amp2_Kf3 (1.00,132.62)

AMPLITUDE and T



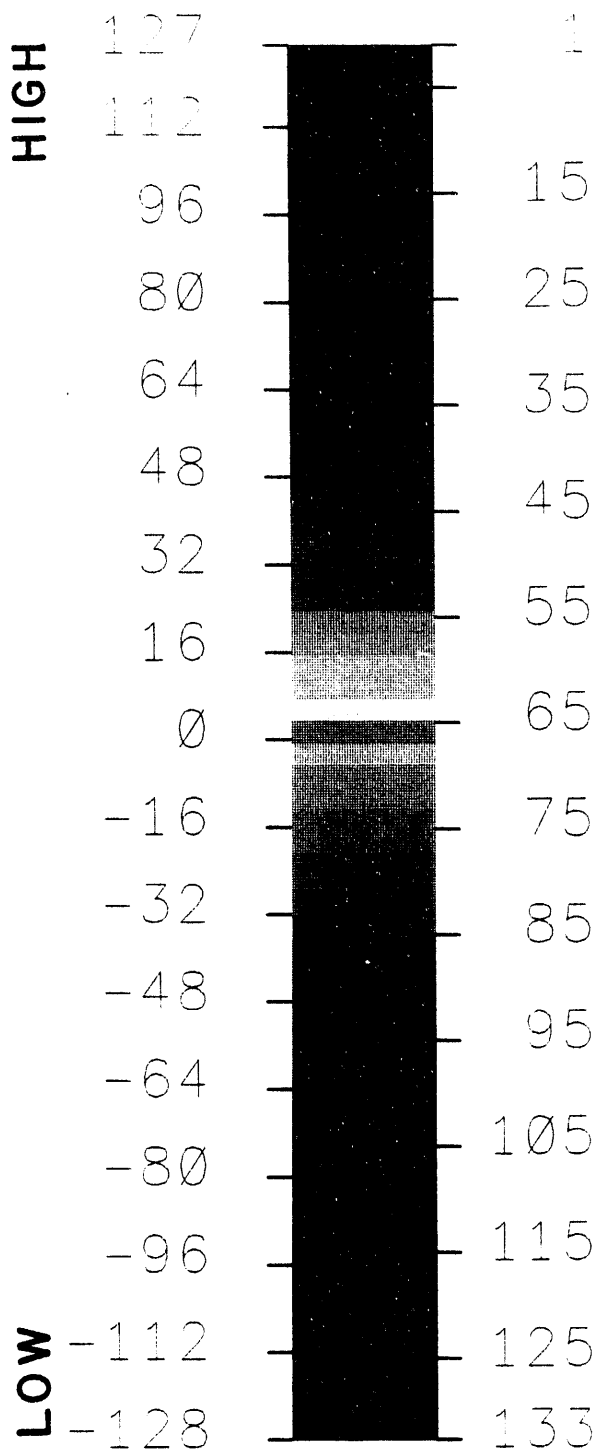


FIGURE No. 2

TIME-STRUCTURE: 3rd FRONTIER

Badger Basin Field

Park County, Wyoming

liseconds Horizontal Scale: 1" = 6,000'

JPW March 19, 1994

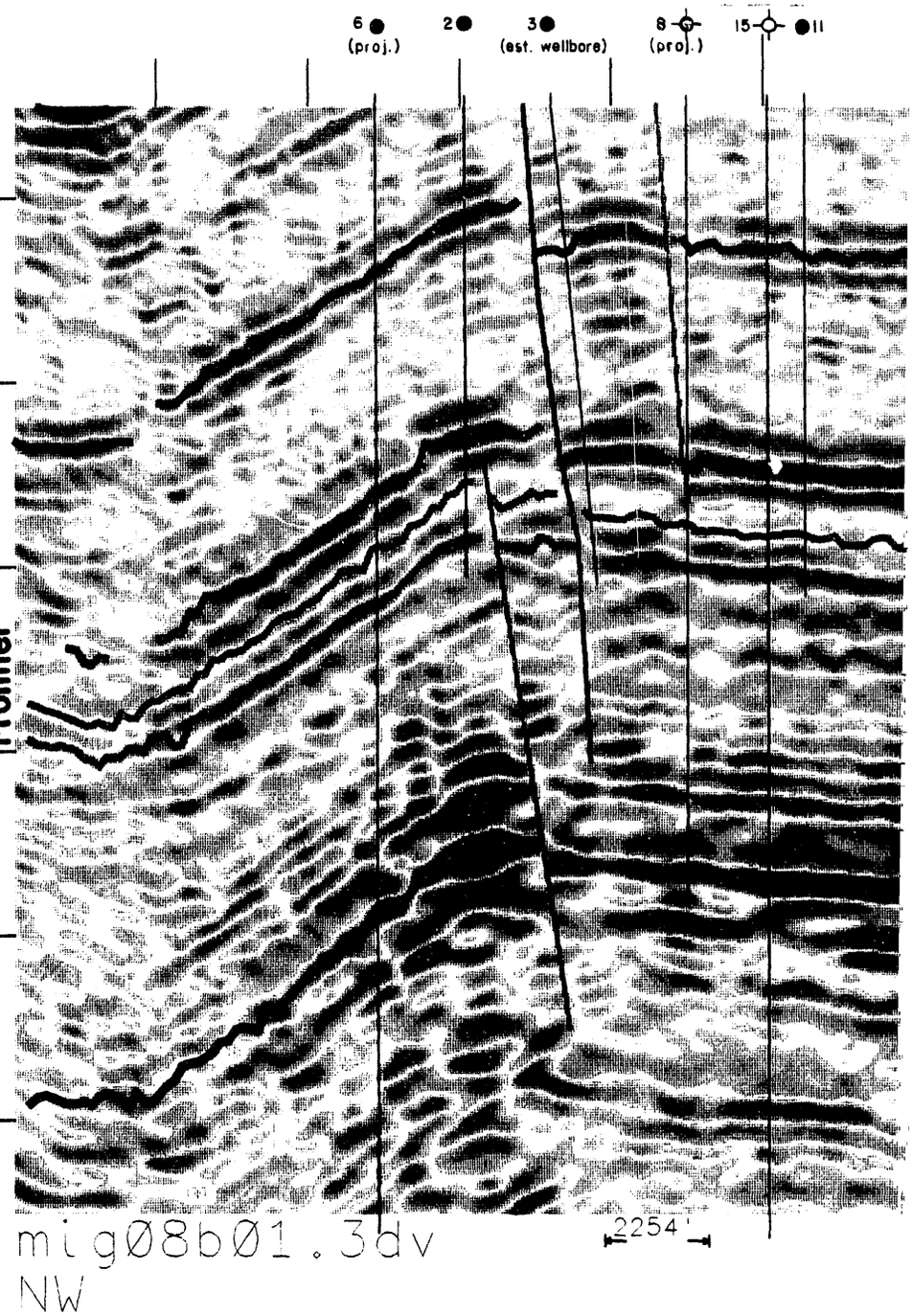
ation for the #3 BBFU is an estimate based on expected dips and aulting in the Cody Shale or Frontier Fm. in the #3 well.

ME STRUCTURE: 3rd FRONTIER SAND

0' 6000' 12000'

LINE 20

TRACE



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Vertica

Note: The
abs

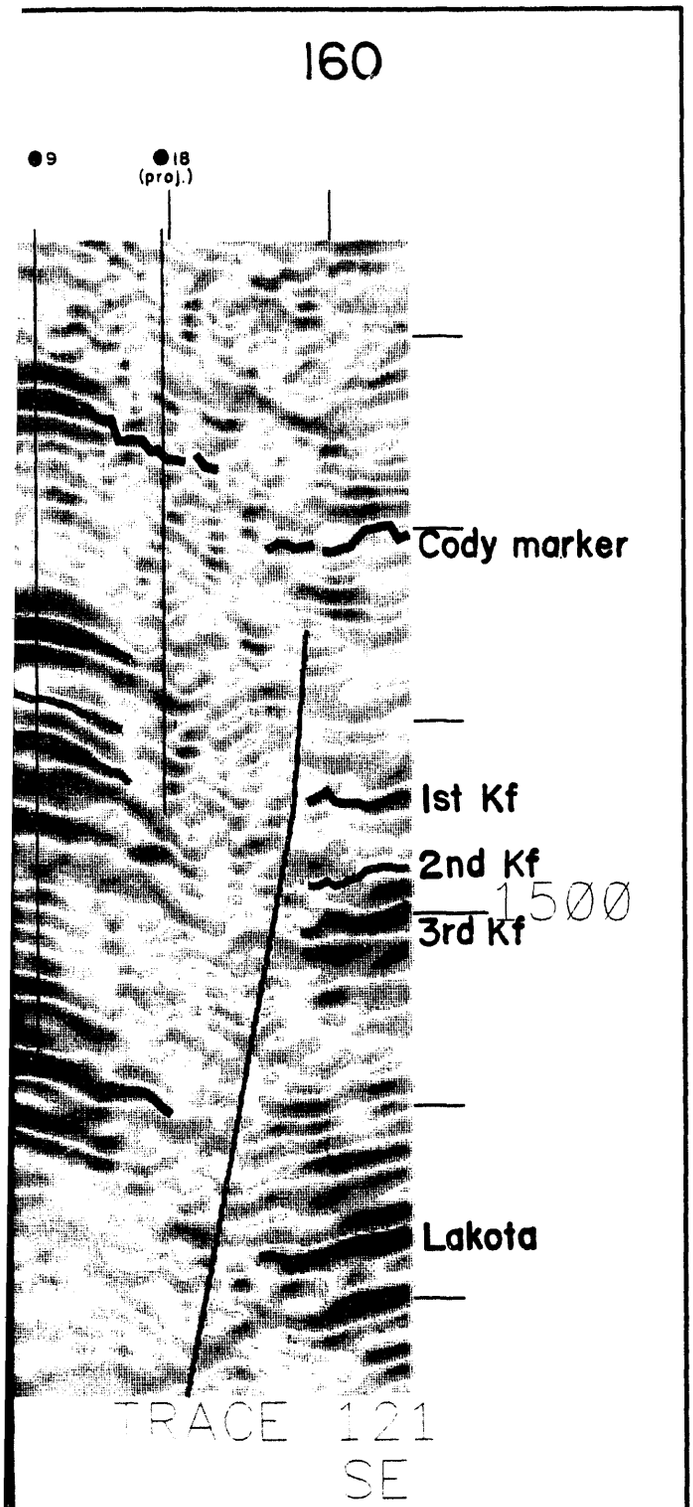


FIGURE No. 3

W-SE Seismic Panel of Crossline (Trace) 121

Badger Basin Field

Park County, Wyoming

Scale: 10 inches/seconds Horizontal Scale: 1" = 4,000'

JPW March 19, 1994

wellbore path for the #3 BBFU is an estimate based on expected dips and ce of normal faulting in the Cody Shale or Frontier Fm. in the #3 well.

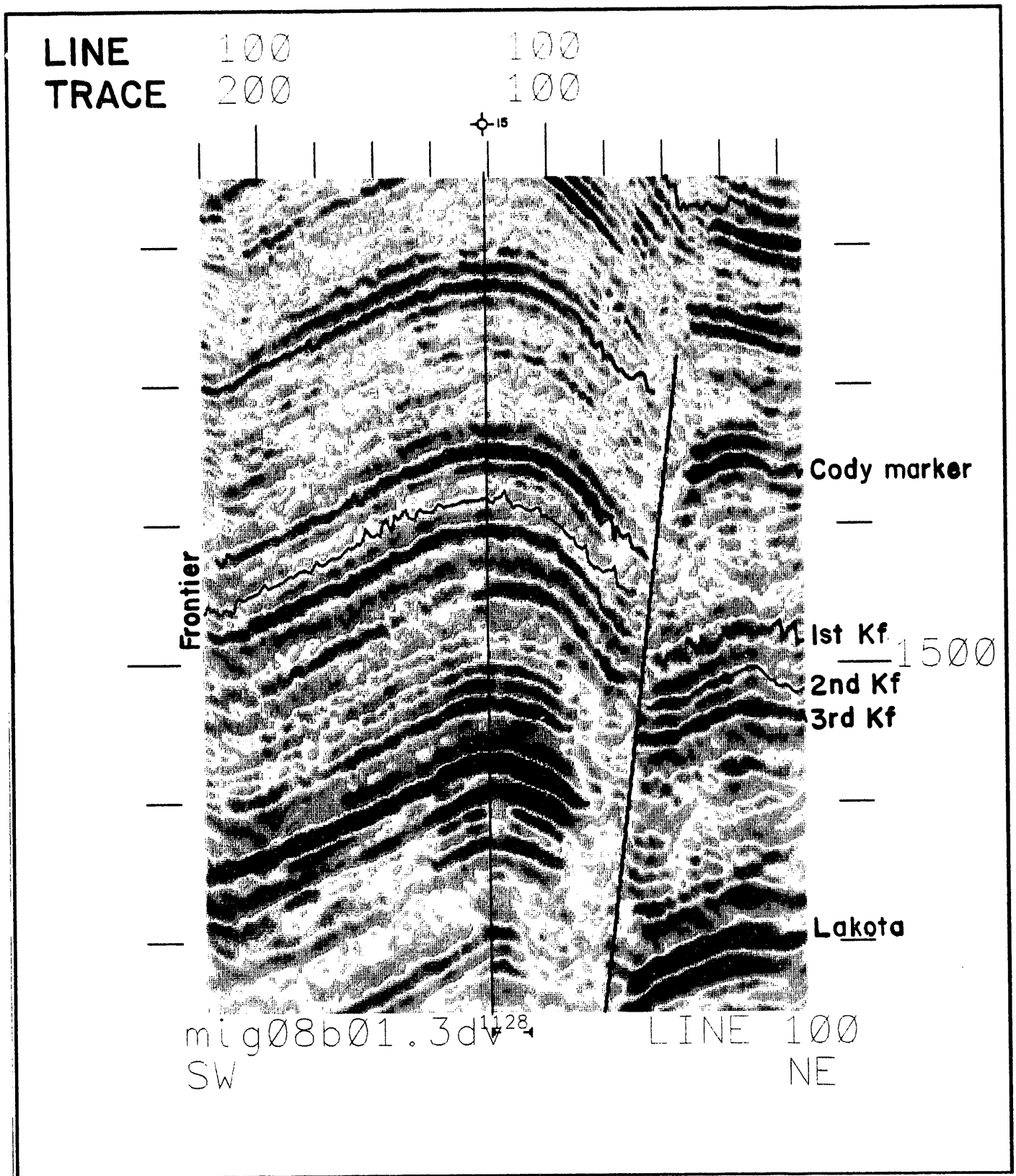


FIGURE No. 4

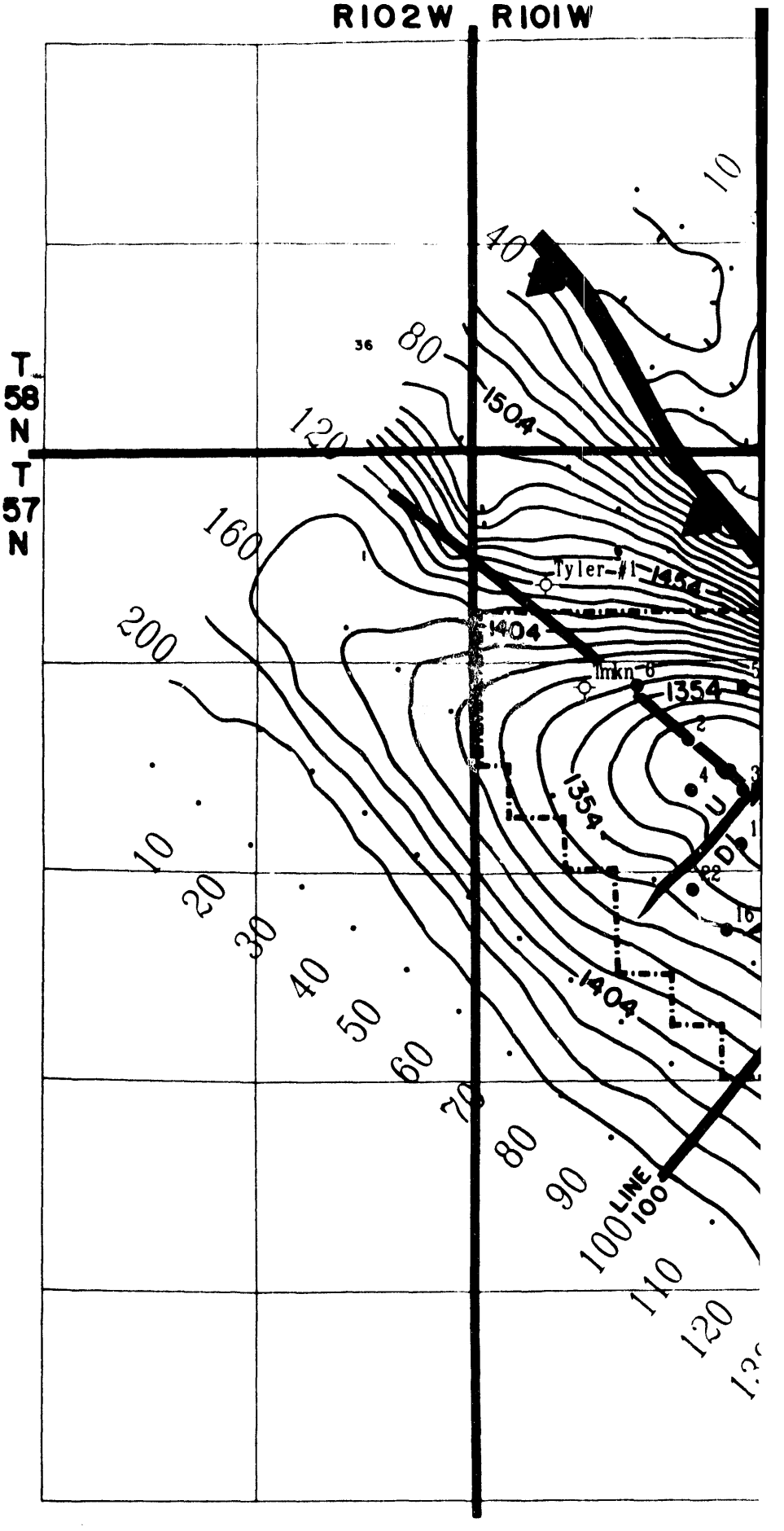
SW-NE Seismic Panel of Inline (Line) 100

Badger Basin Field

Park County, Wyoming

Vertical Scale: 10 inches/seconds Horizontal Scale: 1" = 4,000'

JPW March 19, 1994



Note: The bottomhole location for the #3 BBFU is an estimate based on expected dips and absence of normal faulting in the Cody Shale or Frontier Fm. in the #3 well.

BADGER BAS

0' 2000' 4

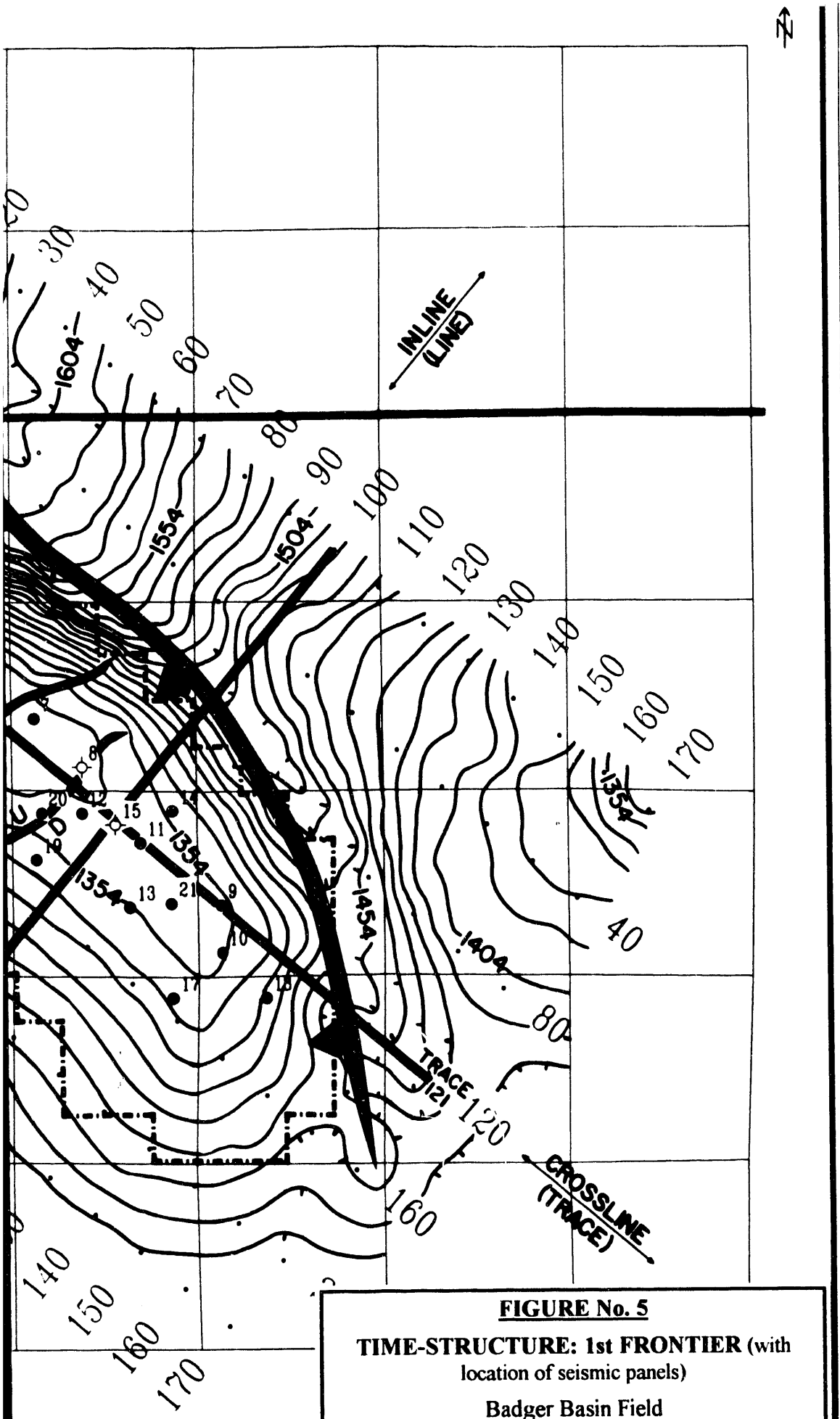


FIGURE No. 5

TIME-STRUCTURE: 1st FRONTIER (with location of seismic panels)

Badger Basin Field

Park County, Wyoming

C.I. = 10 milliseconds Horizontal Scale: 1" = 4,000'

JPW April 22, 1994

DATE

FILMED

7/13/94

END