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INTERACTIVE INTERPRETATION OF A SUBMARINE FAN OFFSHORE IRELAND, A CASE HISTORY

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H. Roice Nelson, Jr., Landmark Graphics

INTRODUCTION:
The Porcupine Basin is a large rift basin off the southwest coast of Ireland. Since it formed in the Lower Cretaceous, the sedimentary fill of the basin has reached a maximum thickness of between seven and eight kilometers. A wide variety of environments are present, which offers many stratigraphic plays and traps. This paper presents a detailed evaluation of one of these prospects, a large Eocene-age submarine fan.

GEOLOGICAL SETTING:
The basin opened lower-most Cretaceous over a 15 to 20 million year interval (Mason and Giles). Opening started in the Berriasian (144 million years ago) and continued through the Hauterivian (125 million years ago). Figure 1 is a map of Triassic and Jurassic Sedimentary Basins showing their postion relative to offshore Ireland. Stratigraphically there are 12 megaunits and some 60 individual sequence boundaries that can be identified in this basin. A Lower Cretaceous medial volcanic ridge marks the axis of the basin. Siliciclastic infill of the Cretaceous opening was accompanied by volcanic flows or sills. A series of alluvial fans or fan deltas along the eastern basin margin are a significant exploration objective (Macurda, 1986). These are followed by some carbonate buildups in the Upper Cretaceous, which also have exploration potential.

Deltaic progradation into the basin occured into the Tertiary. A significant deepening of the basin also took place at this time. The development of a series of prominent submarine fans provides a challenging exploration problem. Where are the reservoir-prone facies best developed? And where would the hydrocarbons be trapped? Amplitude and phase sections reveal significant variations within the fans and subsequent sealing by onlap fill deposits. Mapping of the sequences within the fans portrays their structural attitude and how drainage would occur. Channeling has continued until the present, as is recognized on the water bottom reflector.

SEISMIC INTERPRETATION:
The stratigraphic succession is divisible into 9 or 10 super-sequences, and there are 29 or 30 sequences in the Tertiary alone. Mapping these sequences by conventional techniques is a time consuming task. Once the sequence boundaries have been recognized and verified by loop tieing on CDP record sections, it is possible to use a workstation to greatly speed up seismic facies analysis and mapping procedures (Macurda and Nelson, 1987). Displays of both amplitude and phase bring out significant differences in the depositional history and facies of the sequences.

The sections in displayed in the poster session are variable density displays from an interpretation workstation, where each pixel is colored according to the seismic amplitudes. The color assignment chosen for this presentation is black for the peaks and browns for the troughs. Figure 2, a north-south seismic section, and Figure 3, an east-west seismic section, show the main unit that we studied. This is Megaunit 4 or the series of submarine fans that range from 2 to 3.5 seconds on the seismic sections. We named the fan we are describing the Clontarf Prospect after the famous battle of the Irish King Brian. The fan is about 40 km long north to south, and about 25 km wide east to west, with about 300 meters of thickness.

The main reflector at the base of these sections is from the Upper Cretaceous chalks or carbonates. On the opposite (east) side of the basin, there are carbonate buildups in this same interval. Above the Chalks is a Paleocene Delta, the top of which is a sequence boundary that marks the base of the system of Eocene submarine fans. The mounded units of Eocene age (the submarine fans) are developed basinward on the leading edge of the Paleocene Shelf Edge. Turbidites are the prime mode of transport forming the fan. Notice that the facies in the lower portion of the fan are planar, and the upper portions of the fan has more heterogeneous or hummochy reflectors.

The upper portion of the basin can be generalized around the fact that following the development of the submarine fans there was a deep water infill around the fans. The Late Tertiary is dominated by numerous thin sequences of deep water siliciclastic deposition associated with contourites, distal submarine canyons and basin plane deposition. It is important to note here that the Clontarf Prospect is nicely sealed by the overlaying deep-water fine-grain unit.

The picks of five major sequence boundaries within the fan are posted on Figures 2 and 3. The top of the Paleocene is colored red. The fan itself is defined by five sequences boundaries. Going up from the Top Paleocene these are labeled A (purple), B (green), C (orange), and D (blue). Figure 4 enhances the relationships of the sequence boundaries by flattening on the different sequence boundaries. In this case four windows are used to show the relative thickness of each sequence. Sequence D is at the top, with horizons D and C highlighted. Sequence C is in the second window down, showing horizons C and B. Sequence B is in the next to the bottom window, with horizons B and A shown. and Sequence A is in the bottom window, with horizons A and the Top Paleocene highlighted.

The relationship between the sequence boundaries was also highlighted in map displays, of which, Figure 5, a map of the top sequence, is an example. The process of creating this gridded map from the 2D control happened in three steps. First, a triangulated surface was fitted across the 2D control, which in this case represented an isochron map. Second, a grid was defined and the interpretation system wrote the interpolated isochron values into each grid point. The final step was to smooth the linear interpolated map. There are triangulation effects seen around the edges of the map, particularly to the north-west of the fan, where the seismic control does not confirm closure. This process was repeated to calculate the contours that define the total thickness of all of the sequences of the fan, and were overlayed on other maps to show the exact location of the fan. (Denham and Nelson, 1986).

CHANNEL SYSTEM

There are two kinds of closure represented on the Clontarf Prospect; namely (1) the updip closure of the mound itself and (2) channel abandonment. The updip closure is recognized on the cross-sections and map displays described above. However, the channel system is not obvious. Seismic attribute displays were used to highlight interpretation of this channel system. Figure 6 is an example of traditional wiggle as well as a variable density section across this channel system. If you follow Sequence D on line 44-A across the section, the bumps are interpreted as differential compaction-derived expressions of sand prone facies. Notice the dimming of the reflection amplitude is also highlighted on the wiggle trace sections. The fan isochron maps and an interpretation of the channel system defines the spatial extent of the Clontarf Prospect.

CONCLUSIONS:

The sequences go from a more distal to a more proximal environment as we proceed from the lower to the upper portion of the fan. The data does not allow us to know that we have closure at the northwest end of the fan. However, the fan is sealed by the overlying deepwater fill deposits. One of the other submarine fans in the Porcupine Basin has a direct hydrocarbon indicator in the uppermost portion of the fan in an analogous setting to the Clontarf Prospect.

The detailed seismic facies analysis and the differential compaction over channel prone facies suggest that proper conditions are present for the generation and entrapment of hydrocarbons in the Eocene submarine fans of Porcupine Basin. In May 1986 the Brazilians announced the discovery of over 2 billion barallels of oil from an oligocene submarine fan in the Campos Basin (Guardodado, 1986). To date this discovery is the single largest accumulation known in the submarine setting. Water depth is at 1500 feet. This suggests that submarine fans in present day deep water settings can harbor substantial reservoirs of petroleum, although we recognize this prospect is not economic today.

Possibly the Clontarf Prospect is a modern Innisfree, as described by the Irish Poet William Butler Yeats:

I will arise and go now
And go to Innisfree
And a log cabin build there
Of clay and wattles made

But the log cabin to test this submarine fan would be a rank wildcat, since the prospect sits in 4500 feet of water.

ACKNOWLEDGEMENTS:
The data was provided by Merlin Geophysical. The sequence boundary picking was done by Chuck Brede. Time made available by Landmark Graphics for interpretation of the data.

REFERENCES:
Denham, J. I., and Nelson, H. R., Jr., 1986, Map displays from an interactive interpretation: Geophysics, V.51, No. 10, p. 1999-2006.
Guardodado, Lincoln R., Wagner, E. Peres, and Souza Cruz, Carlos, 1986, Depositional model and seismic expression of turbidites in Campos Basin, offshore Brazil: AAPG Bulletin, V. 70, No. 5, p. 597.
Macurda, D. B., Jr., 1986, Sedimentary fill and stratigraphic traps of Porcupine Basin, offshore Ireland: AAPG Bulletin V. 70, No. 5, p. 614.
Macurda, D. B., Jr., and Nelson, H. R., Jr., 1987, Interactive Interpretation of a Submarine Fan Offshore Ireland, A Case History: presentation at EAEG meeting in Belgrade, June, 1987, the complete paper to be submitted to Geophysical Prospecting.
Masson, D. G., and Miles, P. R., 1986, Structure and Development of Porcupine seabight sedimentary basin, offshore southwest Ireland: AAPG Bulletin, V.70, No. 5, p. 536-348.

June 2, 1987

Mr. Richard Cole
Technical Program Chairman
1987 SEG Convention
Chevron U.S.A.
New Orleans, LA

Dear Dick:

Enclosed is the abstract we discussed over the phone this morning. The title is: "Interactive Interpretation of a Submarine Fan Offshore Ireland, A Case History," If the paper is accepted, we propose that it be presented in a poster session. We will need a 110 volt plug for a display device in the poster cubical to show some aspects of the interpretation.

Thank you for your consideration, and we look forward to your response.

Best Regards,

Roice

H. Roice Nelson, Jr.
Landmark Graphics Corpaoration

CC: Brad Macurda, Morris Covington, and Lisa Chiranky.

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First Author's Biography:

Title of paper: Interactive Interpretation of a Submarine Fan Offshore Ireland, A Case History

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Brief Employment History:

Dr. Macurda was a Professor in the Department of Geology and Mineralology at the University of Michigan in An Arbor, Michigan from 1963 to 1978. He worked at Exxon Production Research Company from 1978 to 1981, and since that time has worked for The Energists.

Academic History:
1956, B.S. Geology at the Univ. of Wisconsin.
1963, Ph.D. in Geology from the Univ. of Wisconsin.

Professional Honors and Awards:

Professional Society Affiliations:
Member: AAAS, AAPG, AGU, GSA, EAEG, Palaeontological Association, PS, SEG, SEPM, and Sigma Xi.

Areas of Professional Interest and Other Information:
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Brief Employment History:

Mr. Nelson was a founder of Landmark Graphics Corporation ln 1982. For the three years prior to that he was General Manager of the Allied Geophysical Laboratories at the University of Houston and a Senior Research Scientist at the Seismic Acoustics Labboratory. He worked at Mobil Exploration and Production Services, Inc. in Dallas, Texas, from 1974 to 1980, and had two summers experience at Amoco Production Co. (Pan American) in Denver, Colorado.

Academic History: B.S. Geophysics, U. of Utah
M.B.A., Southern Methodist University

Professional Honors and Awards:

SEG Research Committee, Who's Who in the South and southwest since 1979, speaker and instructor for various schools and professional society meetings, including: IHRDC, SEG, CSEG, SESEG, and PCSEG.

Professional Society Affiliations: SEG, EAEG, AAPG, GSH, and Norwegian Petroleum Society

Areas of Professional Interest and Other Information: Interactive interpretation, has over 75 written and professional presentations, including the book: New Technologies in Exploration Geophysics.

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Program Information

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LIST OF CAPTIONS:

Figure 1. Map of Triassic and Jurassic Sedimentary basins.

Figure 2. North-south seismic cross-section through the fan lobe.

Figure 3. East-west seismic cross-section through the fan lobe.

Figure 4. Flattening on the base of each of the four fan sequences.

Figure 5. Ribbon and gridded isochron map for the top fan sequence.

Figure 6. Seismic expression of the channel system at the top of the fan.

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Figure captions:

FIG. 1. ____________________

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FIG. 5. ____________________

FIG. 6. ____________________

Table captions:

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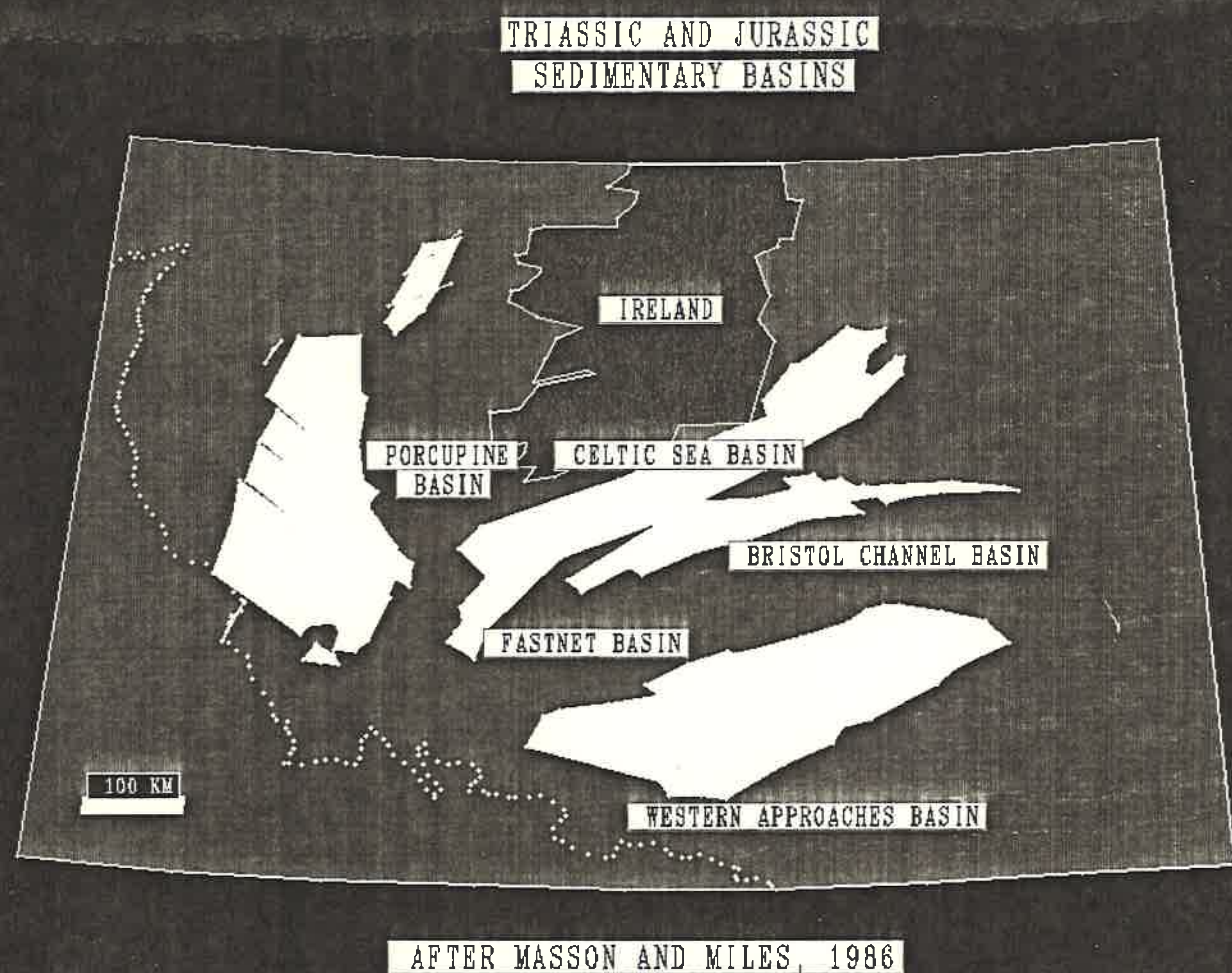
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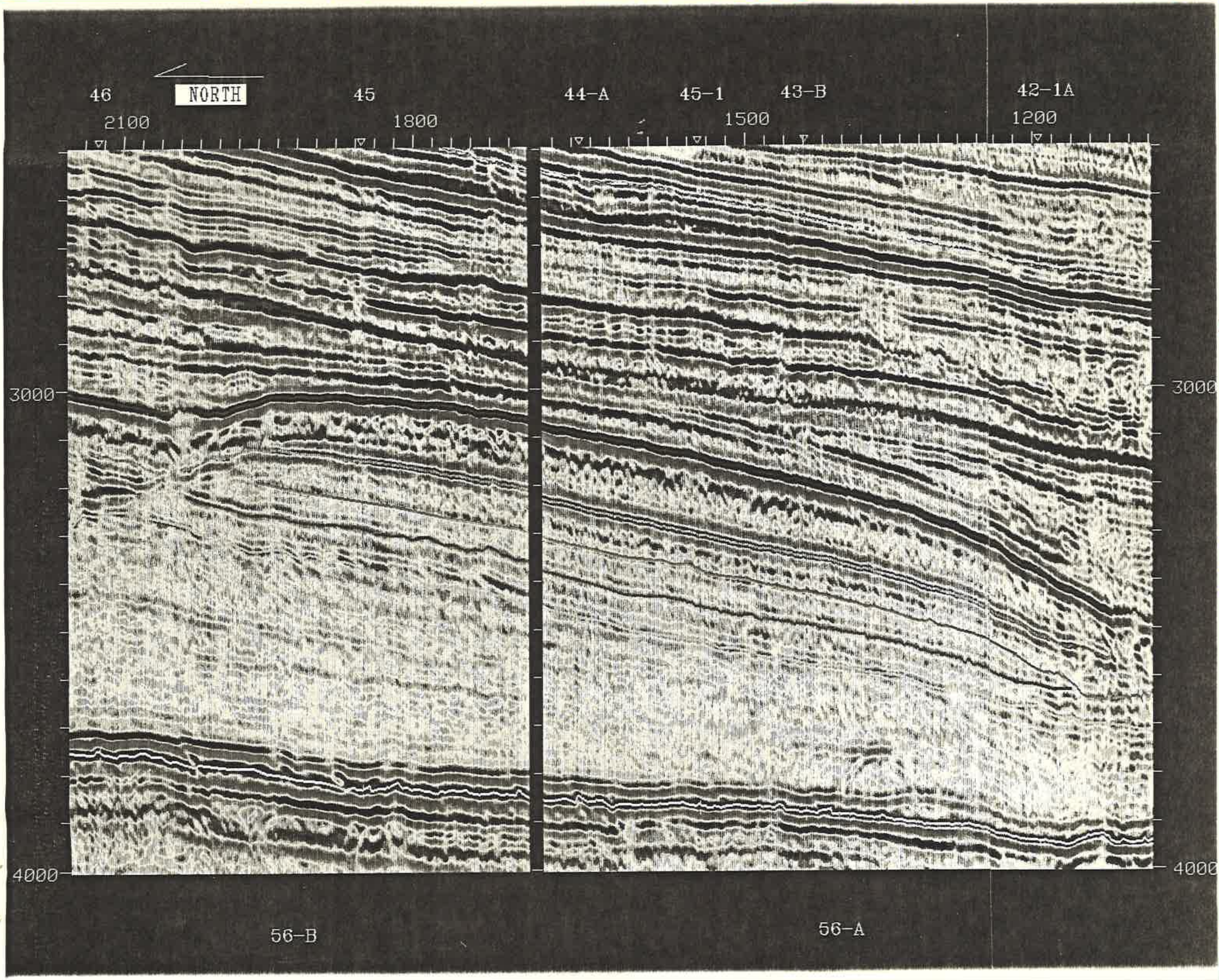
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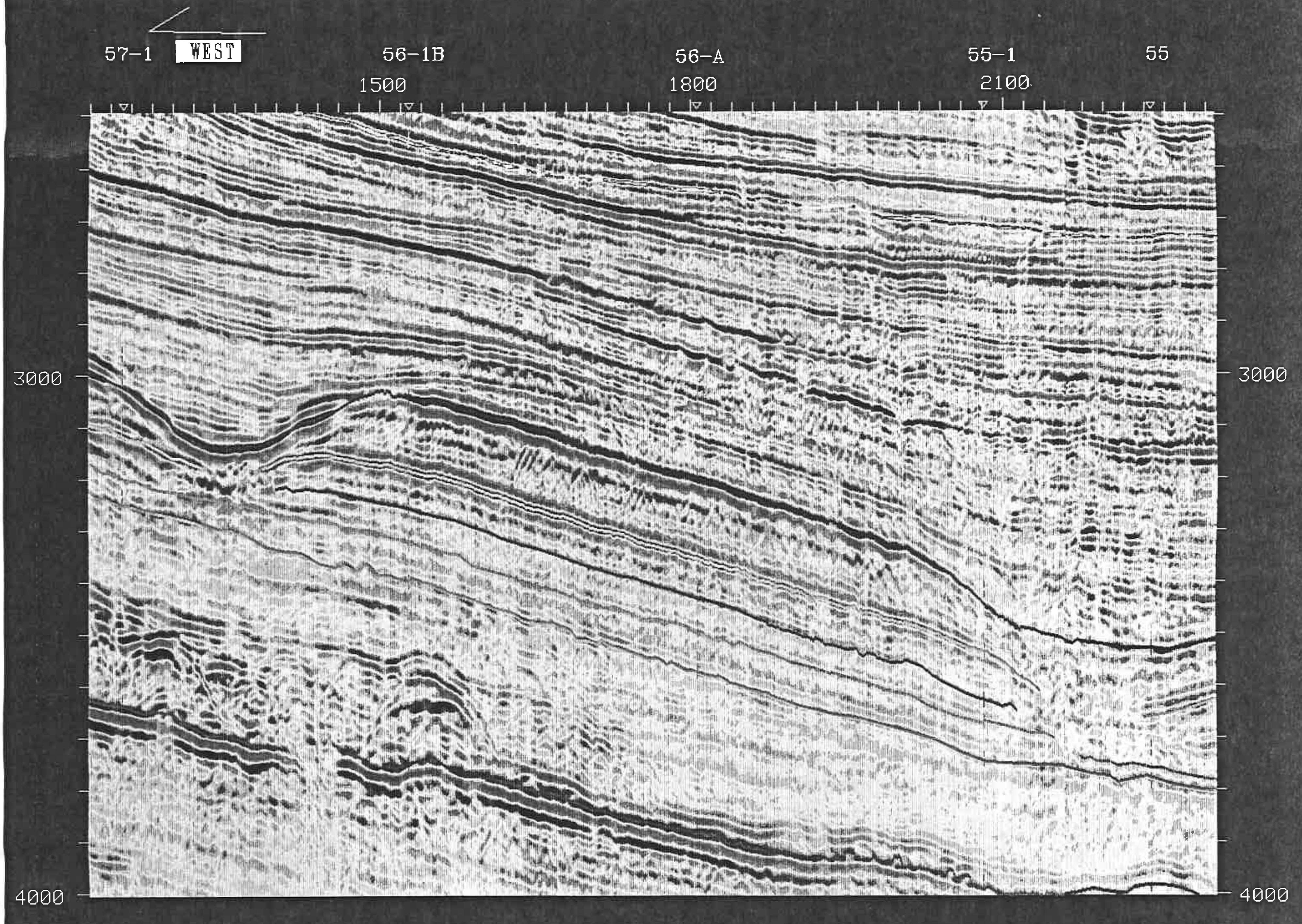

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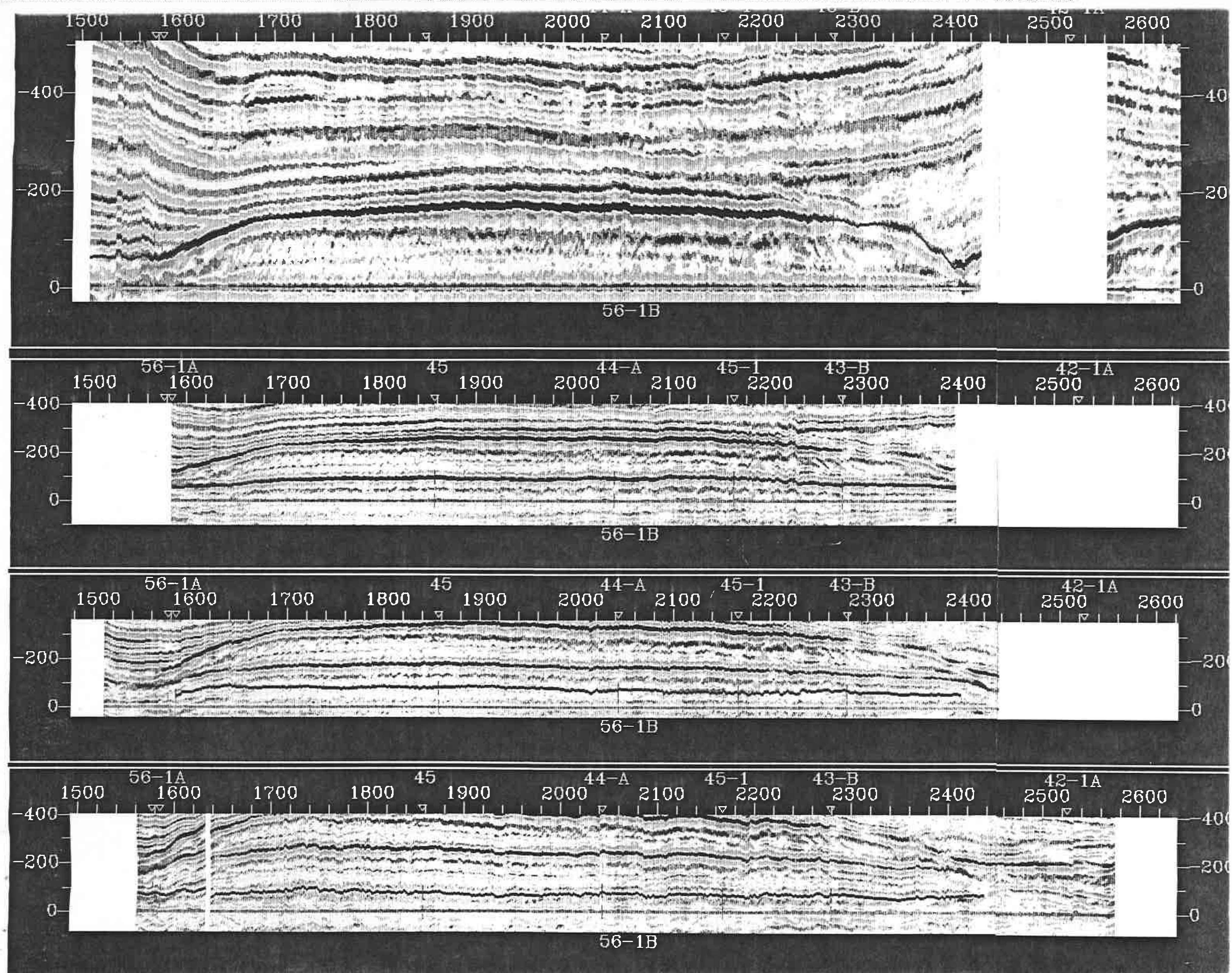
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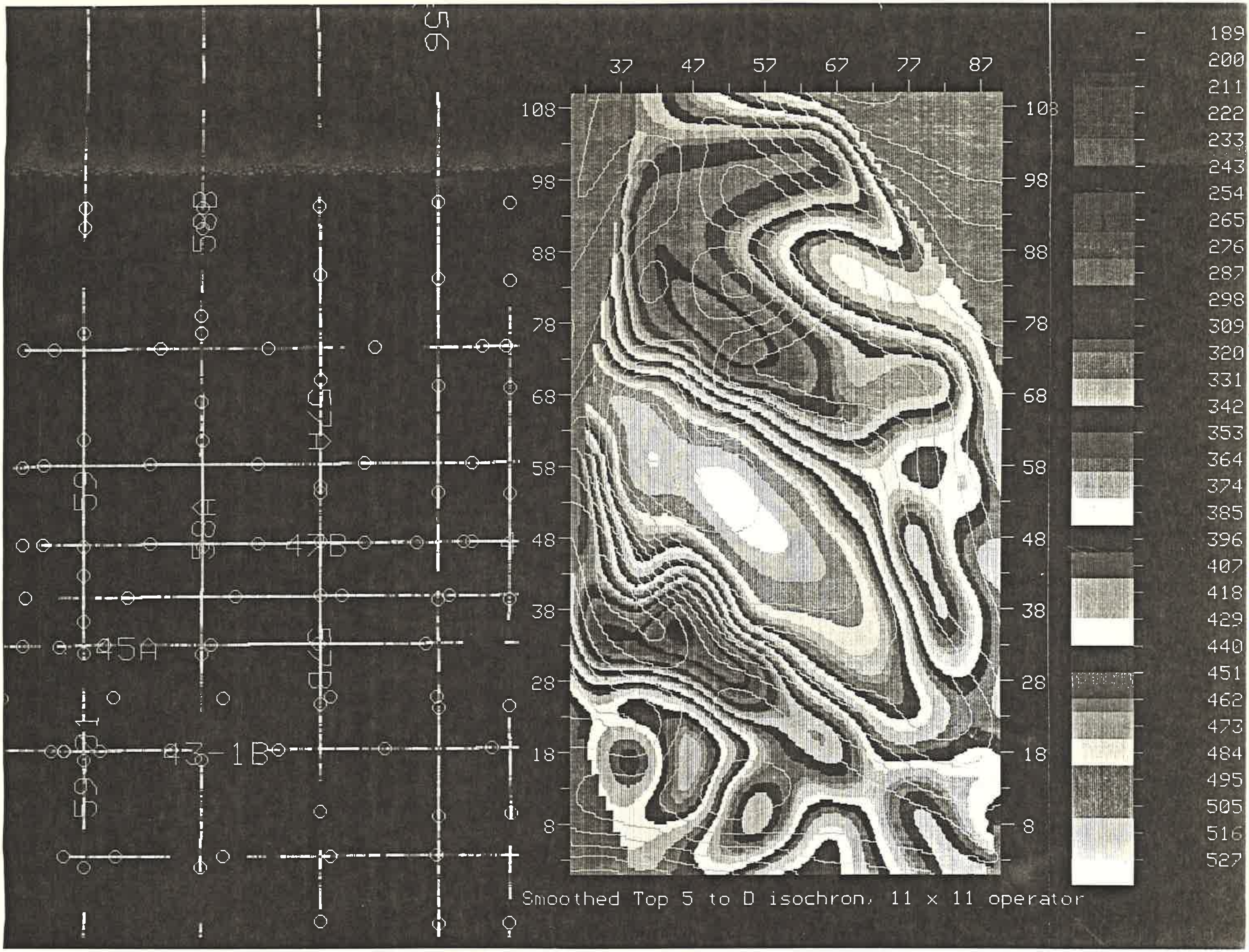

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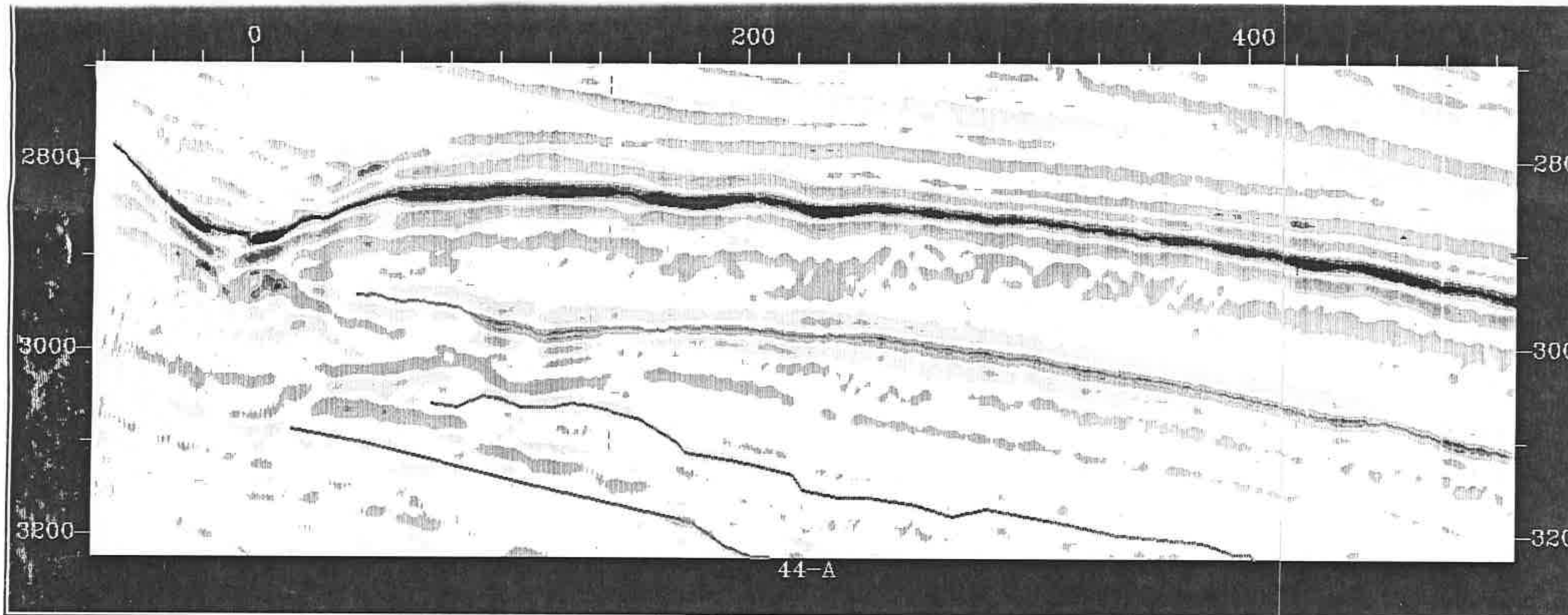
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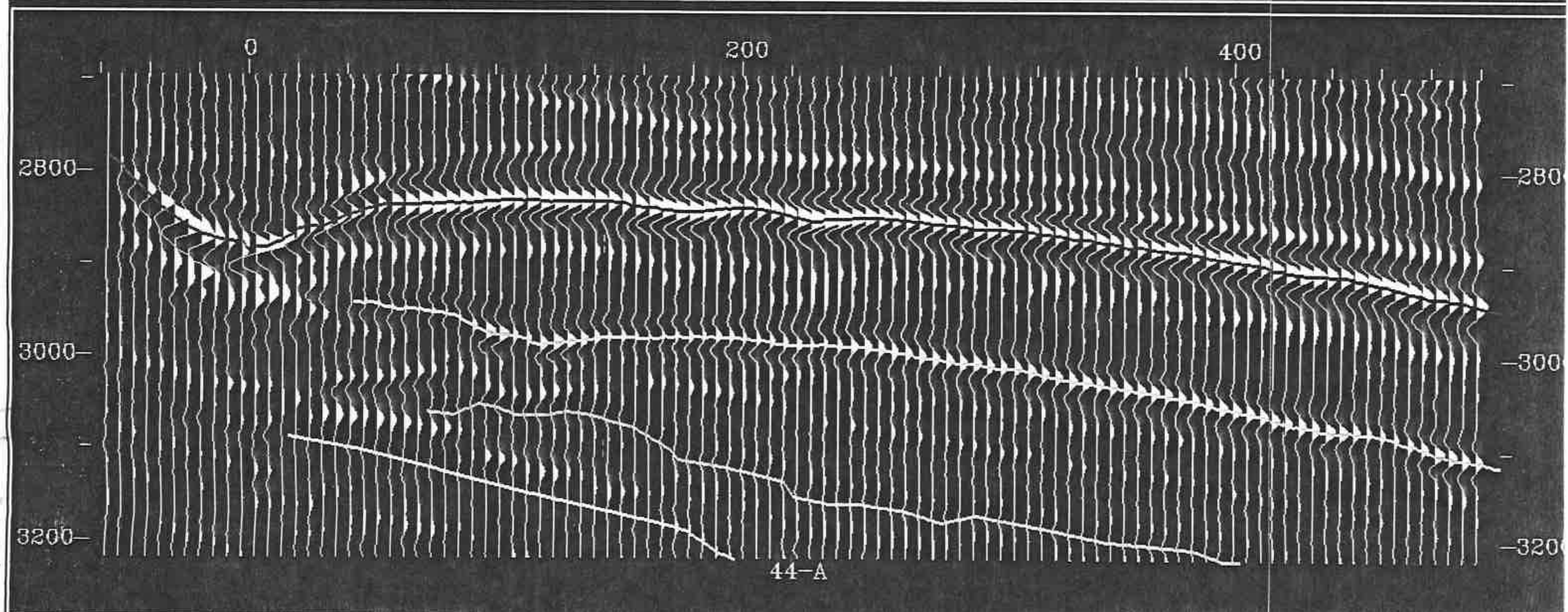
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