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PRELIMINARY INTERPRETATION OF MARINE SPARKER REFLECTION PROFILES OFFSHORE FROM CAPE ANN, MASSACHUSETTS, TO HAMPTON, NEW HAMPSHIRE

by

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Preliminary interpretation of Marine Sparker Reflection Profiles Offshore from Cape Ann, Massachusetts, to Hampton, New Hampshire

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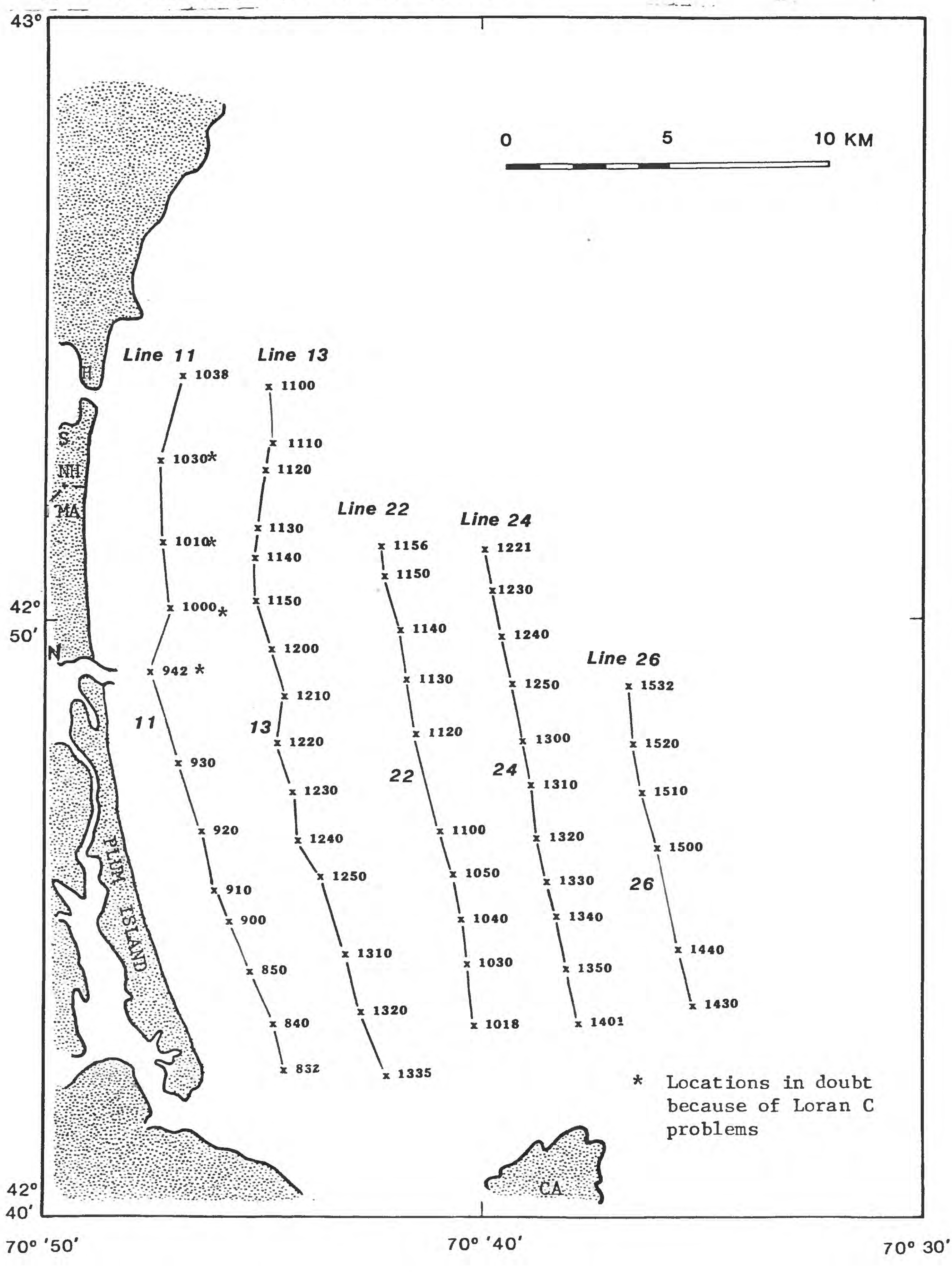
Marine seismic reflection profiling was done off Plum Island, Massachusetts, to examine the relationship between offshore basement topography and onshore lithologic and structural boundaries. In particular, the traces of the Clinton-Newbury, Bloody Bluff, and several smaller faults are known from aeromagnetic anomalies (Harwood and Zietz, 1977; Simpson and Bothner, 1979) and bedrock mapping (Peper, 1978; Barosh and others, 1977; Bell and others, 1977; Shride, 1976) to extend through Plum Island to offshore regions. The seaward extension of the larger faults and the lithologies which they separate are of considerable interest in terms of studying the seismicity and tectonic history of New England (Simpson and Bothner, 1978; Simpson and others, 1980).

Figure 1 shows the positions of five seismic reflection lines obtained on the R/V Asterias (September 9-16, 1978) between Cape Ann, Massachusetts, and Hampton, New Hampshire. Ship tracks are parallel to the Plum Island shoreline at distances of 2.5, 5, 9.5, 12.5, and 16 km offshore and are approximately perpendicular to the major lithologic

FIGURE 1. Location map showing the R/V Asterias seismic reflection lines between Cape Ann (CA), Massachusetts, and Hampton (H), New Hampshire. x's are time marks from original analog records; locations determined from Loran C. S is Seabrook, NH; N is Newburyport, MA.



and structural boundaries onshore. Three additional lines from the U.S. Geological Survey R/V Fay 023 cruise (September 15, 1976) are also incorporated in this report.

Reflection data for both cruises were obtained using the same equipment. A Del Norte[1] 3.5 kHz sparker and streamer served as the energy source. EPC[1] recorders with sweep rates set at 0.5 and 0.25 seconds and the filters at 400-6000 and 280-1600 Hz, respectively, provided the analog records for preliminary interpretation. Ship's radar and Northstar 6000[1] and EPSCO[1] Loran C were used for navigation. Navigational fixes for each profile are indicated by "x" on Figure 1. The original analog records for both the Asterias and Fay cruises may be examined at the USGS Data Library, Quisett Campus, Woods Hole, Massachusetts; interpreted xerox reductions are reproduced in the appendix.

Line drawings of Asterias lines 11, 13, 22, 24, and 26 and Fay Lines 14, 15, and 16 (designated F) shown on Plate 1 were made from digitized scaled copies of the original analog records (Appendix) and show sea surface, sea bottom, and acoustic basement (Plate 2). No reflections suggesting folded late Paleozoic or Mesozoic sedimentary rocks within the basement like those found farther offshore by Ballard (1974) and Ballard and Uchupi (1975) using 5 and 40 in^3 air gun were observed.

[1] The use of brand names in this paper is for descriptive purposes only and does not necessarily constitute endorsement by the U.S. Geological Survey

Scaled profiles on Plate 1 are shifted so that sea floor lies approximately along the ship tracks shown on Figure 1. Emphasis in this study is placed on the character of the basement topography. We suggest that the topographic comlexities of the basement surface reflect the "erodability" of different rock types and that abrupt changes in topographic expression reflect lithic and/or structural contacts. These differences in topographic expression permit tentative correlation of offshore basement reflectors with onshore geology.

Major changes in amplitude and wave length of the basement reflector occur at the north end of Asterias lines 11 and 13. Shallow, exposed (above sea bottom) high amplitude, short wave length reflections change abruptly to deeper, lower amplitude, longer wavelength reflections on strike with the mapped contact between the porphyritic border phase and coarse, equiganular cental phase of the Newburyport quartz diorite (Shride, 1976). A topographic distinction between these phases onshore, however, is not apparent from existing maps. The intrusive contact of the Newburyport quartz diorite into the rocks of the Merrimack Group (Kittery and Eliot formations) is irregular. Quartz diorite occurs as apophyses parallel to layering in the generally east-striking metasedimentary rocks within a wide transition zone both on and offshore (Public Service Company, Final Safety Analysis Report, 1981). Onshore, as mapped in preliminary stages of construction of the Seabrook Nuclear Power Facility (S on Fig. 1), large xenoliths of the Kittery Formation (impure quartzite and intercalated phyllite) in quartz diorite occupy bedrock topographic lows as do apparently more continuous lenses of the Kittery Formation identified in offshore boring and tunneling. The very irregular bedrock topography offshore from Seabrook is mapped as alternating quartz diorite apophyses (highs) in the metasedimentary rocks (lows).

Alternatively, the high grade contact metamorphism (identified petrographically) of the Kittery Formation produced tough, resistent hornfels (relative to quartz diorite) to account for the high amplitude - short wave length reflections. If this is the case, the rock type to topographic character would be the reverse from that hypothesized above. Based on the data from the Seabrook work (FSAR, 1981), the slightly calcareous nature of the Kittery Formation, and the results over the Kittery Formation shown by Birch (1983) in a detailed, slightly overlapping geophysical survey to the north, it appears most likely that the high, rough topography at north ends of lines 11 and 13 reflects a complex interfingered contact zone rather than one specific rock type.

To the south a distinct bedrock valley lies just south of the mouth of the Merrimack River, likely representing a buried river valley cut at a lower sea level stand during the late Pleistocene. It is clearly identified only on line 11 and is on strike with the seaward extension of the Clinton-Newbury fault zone*. That zone occupies a broad topographic low onshore across Interstate 95 (Plate 1). Fault weakened bedrock might have influenced the development of these lows. A ground magnetic traverse on Plum Islands (Simpson and Bothner, 1979) and shipboard magnetic traverses (R/V Gillis, 1979, unpublished data; Birch, 1983) across this zone permits tentative east-northeast extrapolation of this major structure offshore in this vicinity.

* Navigational problems (Loran C) along line 11 between 0930 1038 off Newburyport, MA introduce a possible1.5 km north shift for this bedrock valley (see Appendix, 11 alt) but shore fixes taken in this interval supports the location shown on Plate 1.

South of the Clinton-Newbury fault zone, the Sharpners Pond diorite is separated from the Newbury volcanics by the Parker River fault, and the Newbury volcanics from the Topsfield ganodiorite and associted intrusives by an unnamed fault. Both faults trend towards and appear truncated by the Clinton-Newbury fault zone offshore. The offshore seismic reflectors have a moderate amplitude, short wave length character offshore from the Newbury Volcanics (particularly lines 13, 22, 24 and 15F) in comparison with more gently undulating reflections offshore from the Topsfield granodidorite. Farther south a change to sometimes shallower, slightly more irregular reflections (13, 22 and 24) may represent the trace of the Bloody Bluff fault zone which separates the Topsfield from the Salem gabbro-diorite and Cape Ann granite complexes. Seismic reflection data here do not permit easy distinction between the two complexes. Gravity and magnetic data acquired during the subsequent R/V Gillis (1979) cruise will augment our understanding of the rock units here (work in progress).

These data permit the extrapolation of the Clinton-Newbury and Bloody Bluff fault zones of eastern Massachusetts to the east-northest off the coast as suggested by Simpson and Bothner (1978) and Simpson and others (1980), though the data do not definitely prove that possibility. Work is continuing to establish whether these zones extend eastward to the edge of the continental shelf or change trend to northesterly direction towards the Bay of Fundy (Kane and others, 1972). Either possibility will have important implications to the plate tectonic history of New England.

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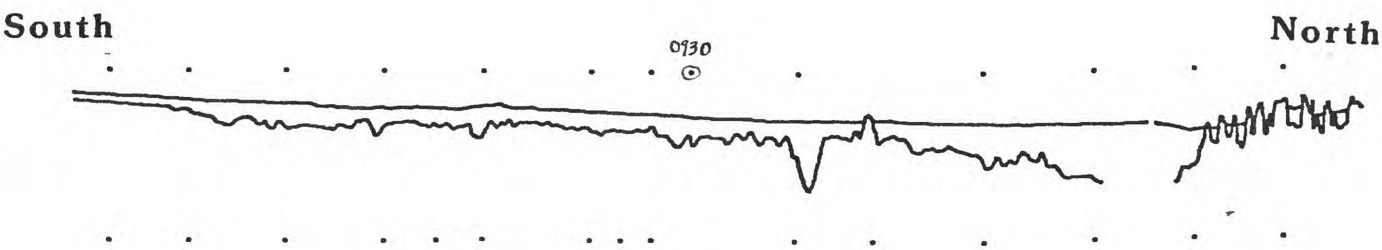
Simpson, R.W., and Bothner, W.A., and Shride, A.F., 1980, Offshore extension of the Clinton-Newbury and Bloody Bluff Fault Systems of Northeastern Masschusetts: in Wones, D.R., ed., Proceedings "The Caledonides in the USA:, I.G.C.P. project 27: Caledonide Orogen, 1979 meeting, Blacksburg, Virginia, p. 229-233.

APPENDIX

The following pages contain xerox-reduced copies of the original analog recordes and the digitized basement topography used in the preparation of Plates 1 and 2.

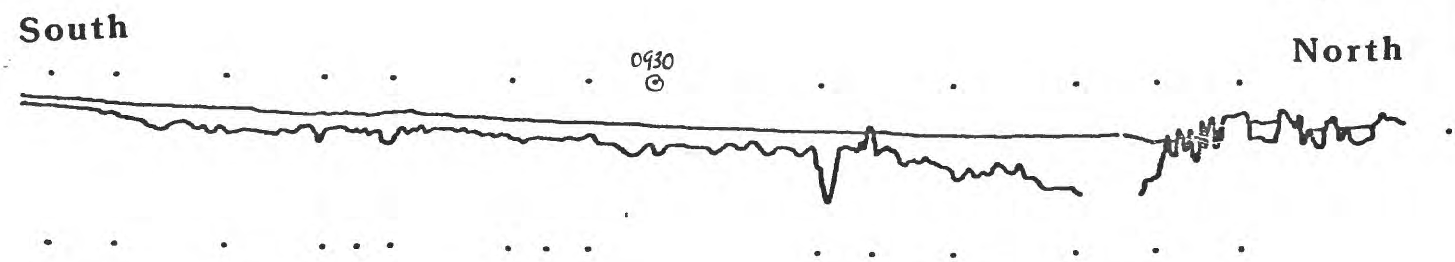
Asterias line 11 - ship speed scaled as one interval between 930 and the north end of the line because of Loran C navigational difficulties noted in text.

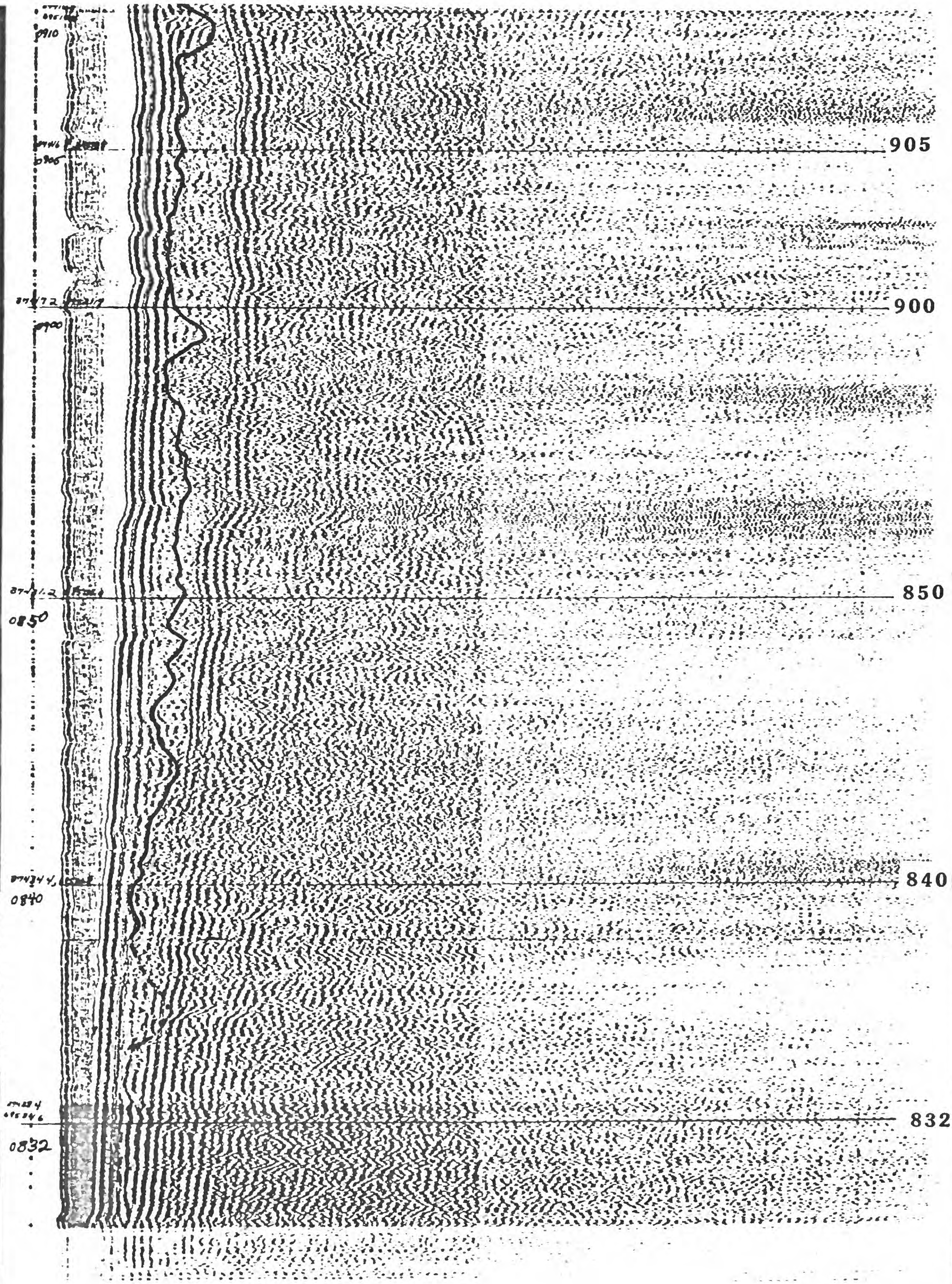
X-scale= 0.2291 Y-scale= 0.2500



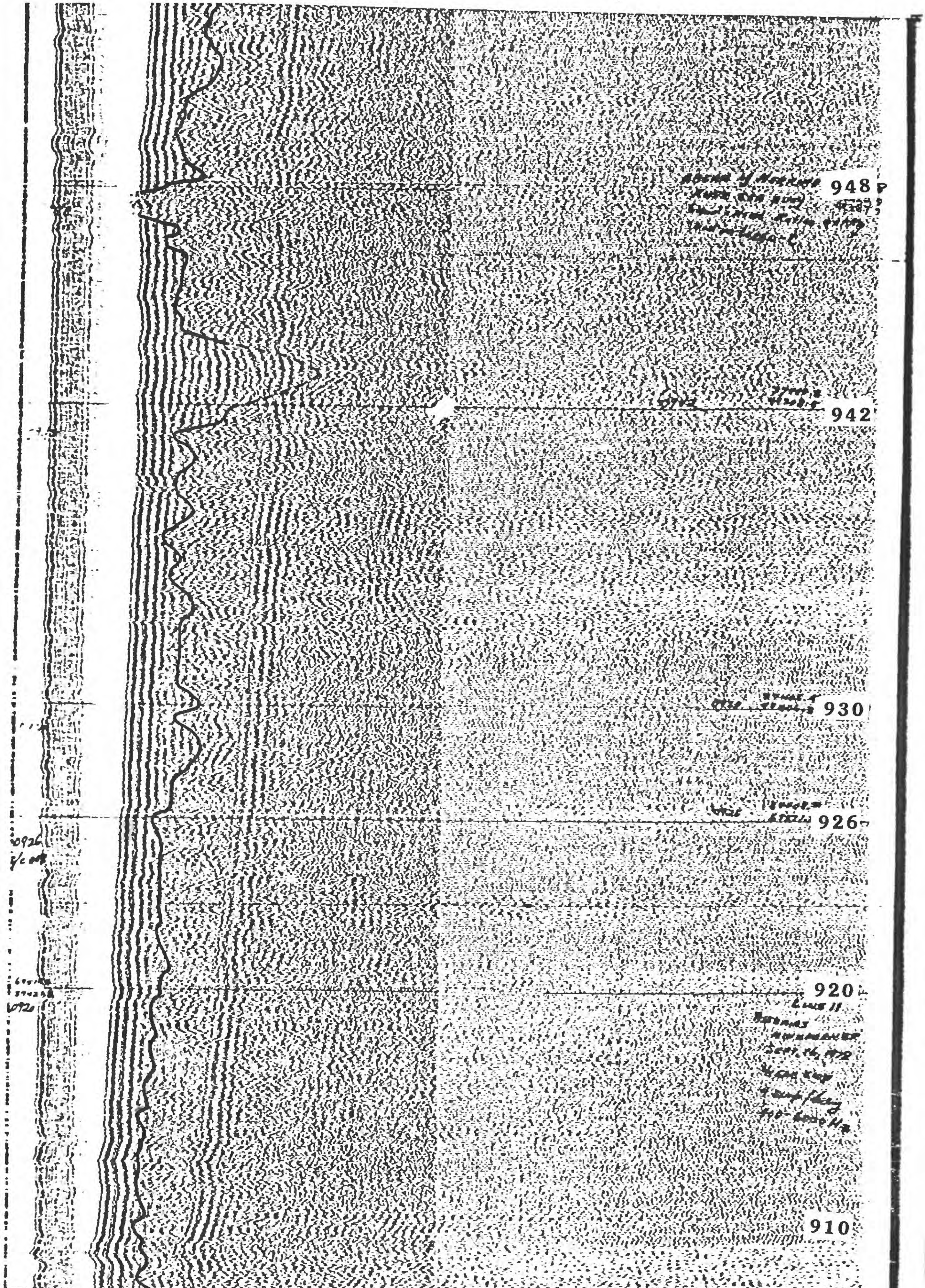
Asterias line 11 (alternative, not used in preparation of Plates 1 and 2) - ship speed scaled for each interval including suspect intervals between 930 and the north end of the line.

Profile 11, Program #1, Plot tape #5
X-scale= 0.5 Y-scale= 0.25

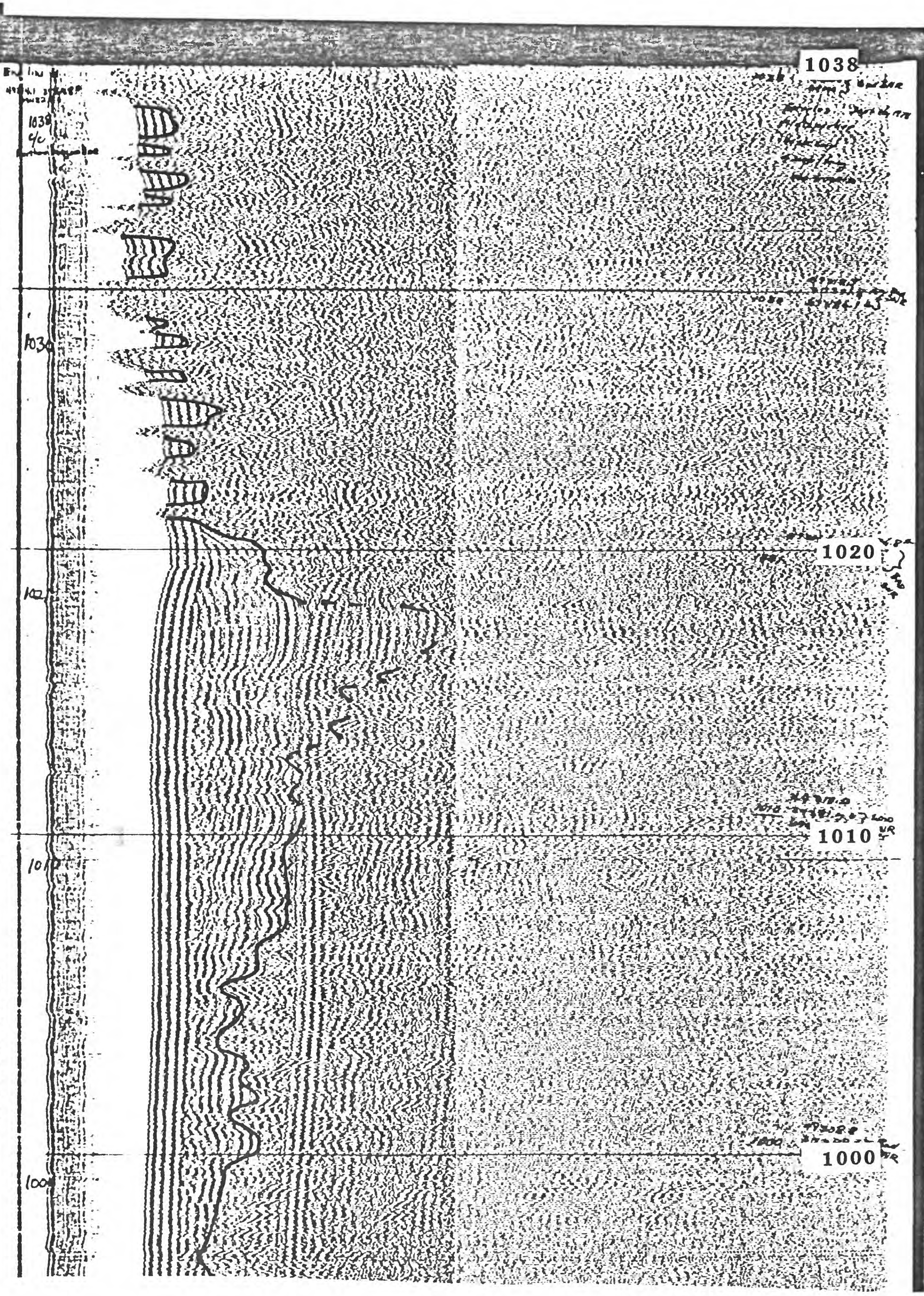




Profile 11-A



Profile 11-B



Profile 11-C

Profile 13, plot tape#2, Program #2
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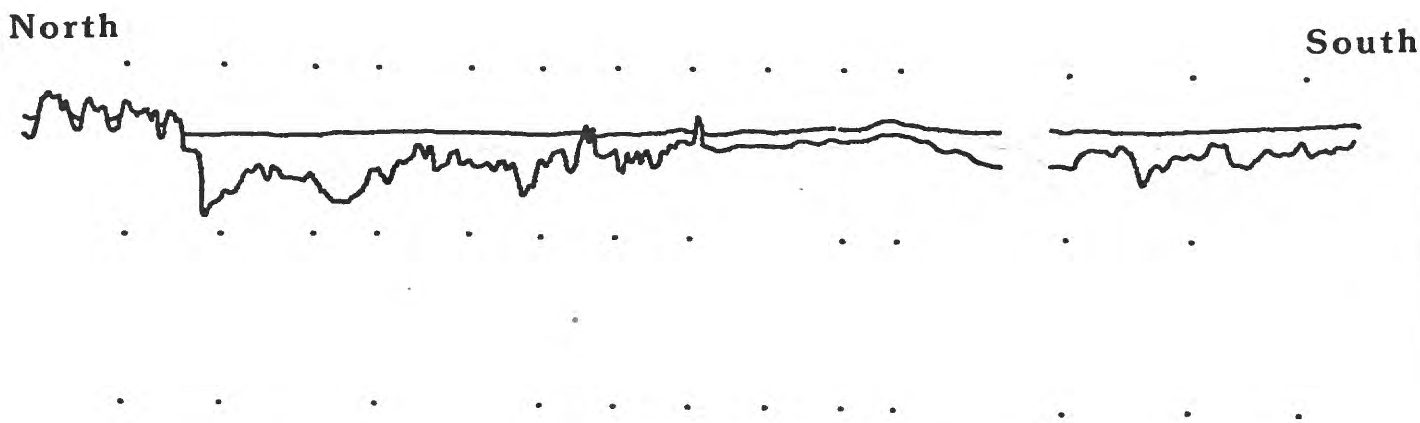
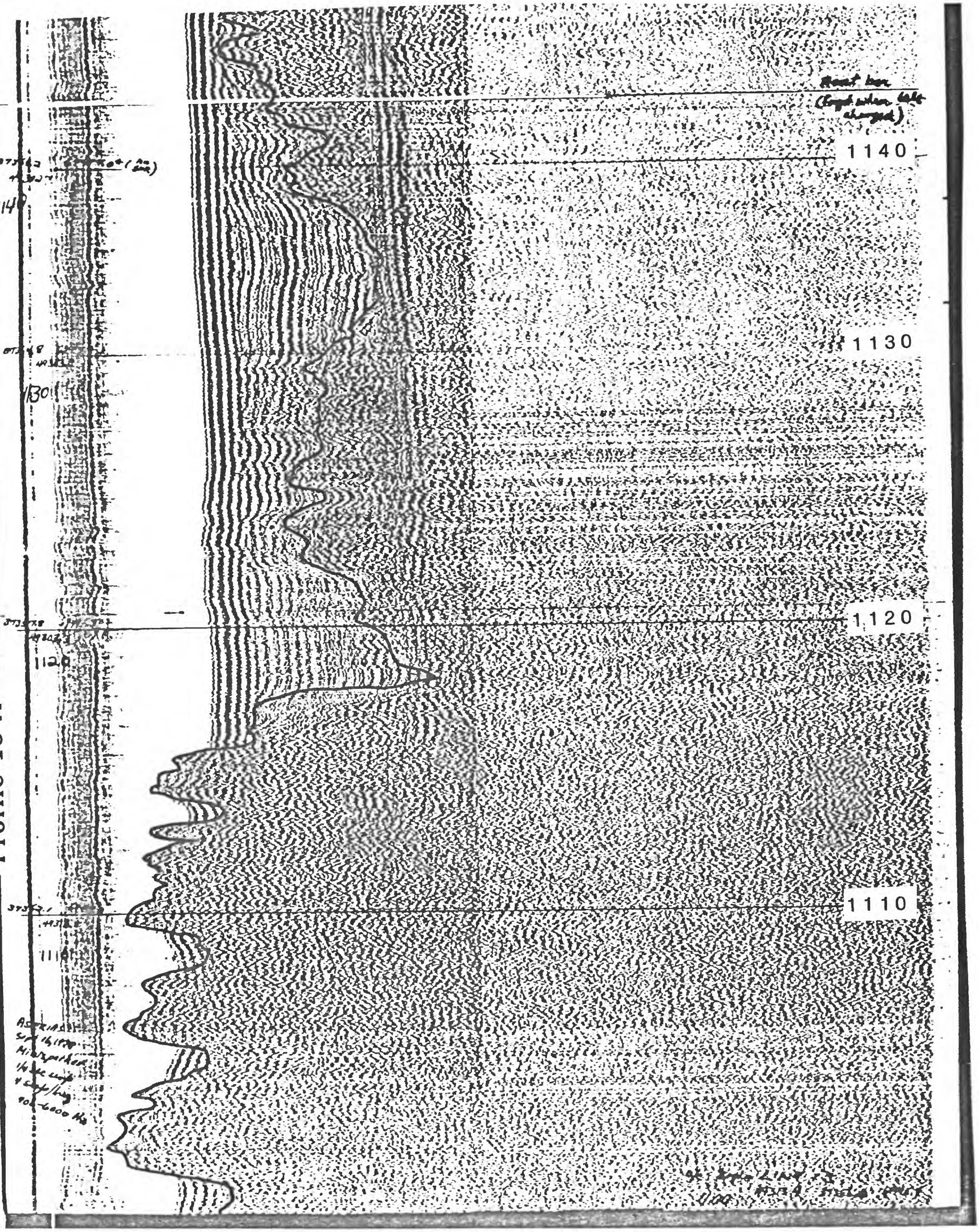
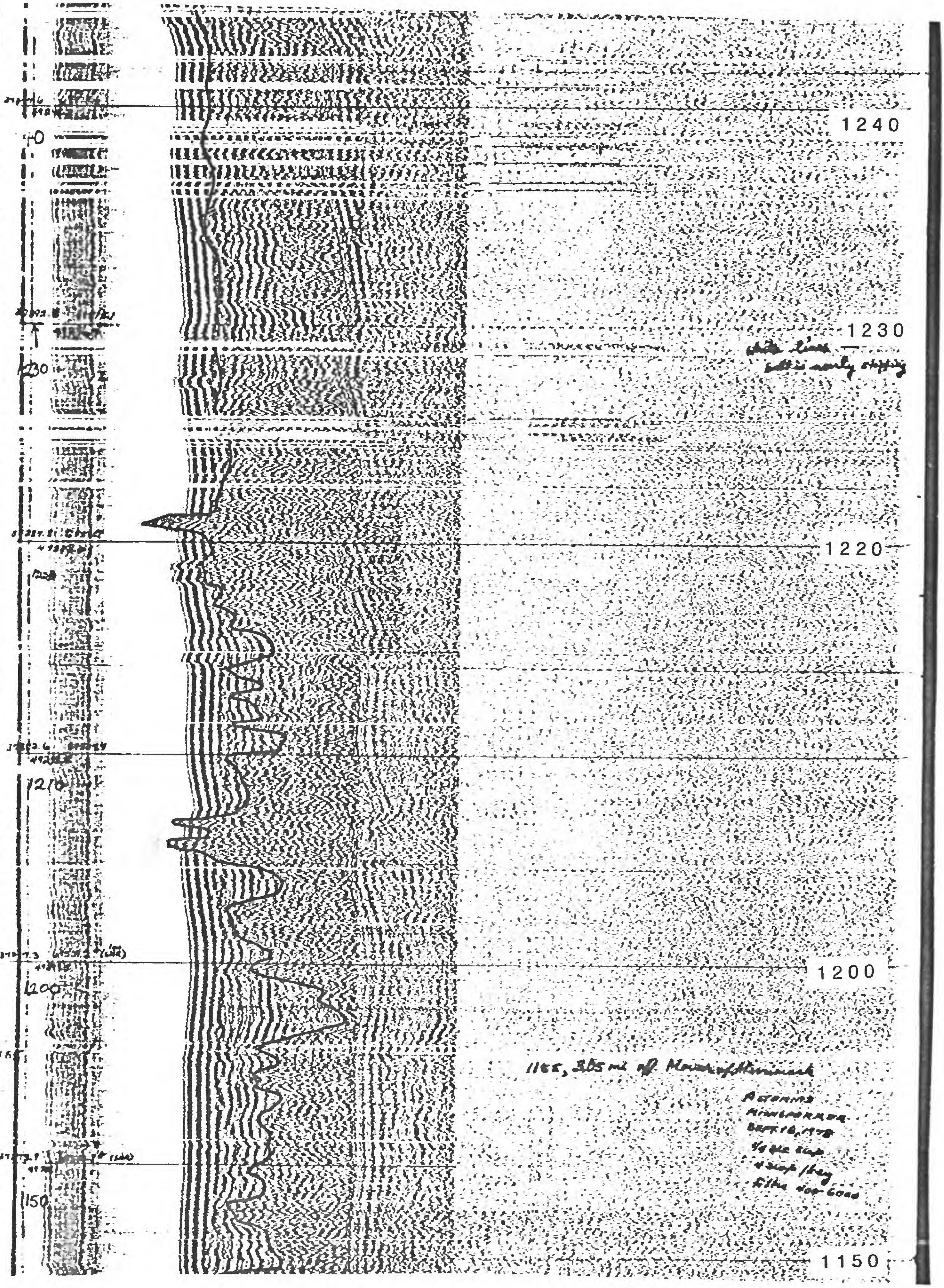
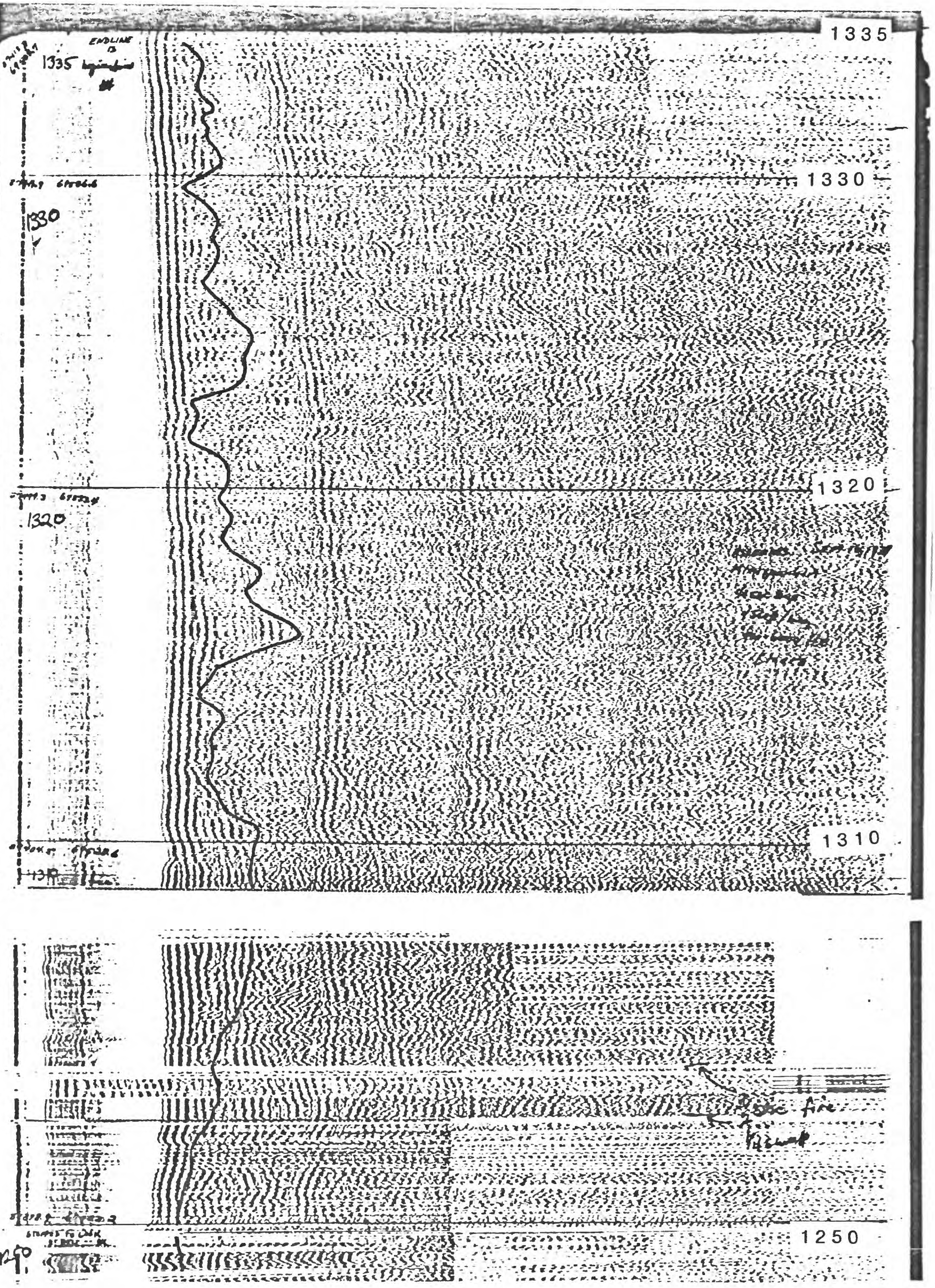




Profile 13-A



Profile 13-B



Profile 13-c

Profile 22, Data tape #1, Program #3
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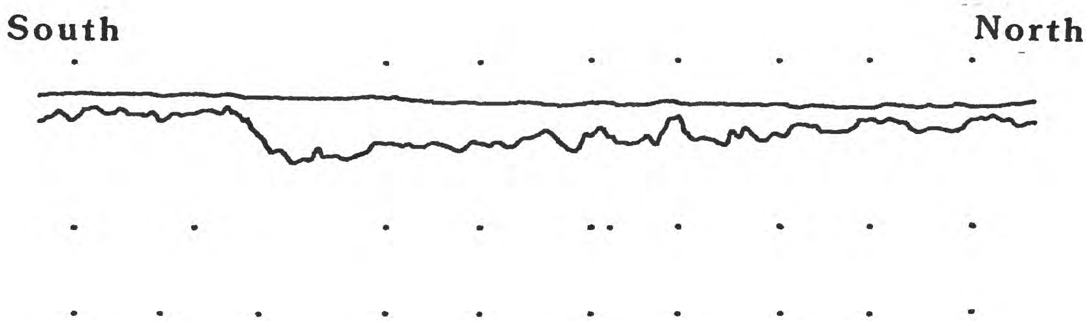
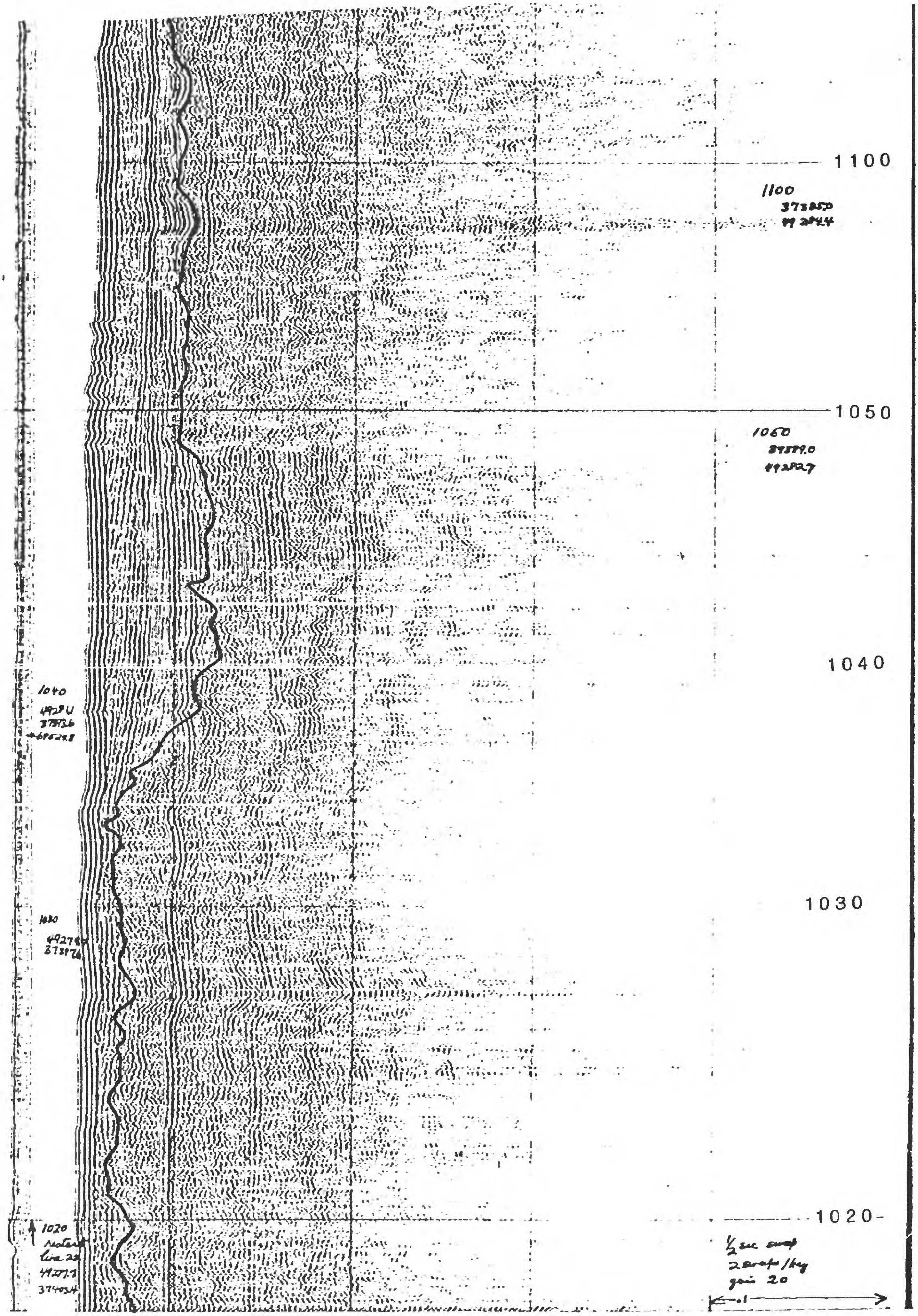
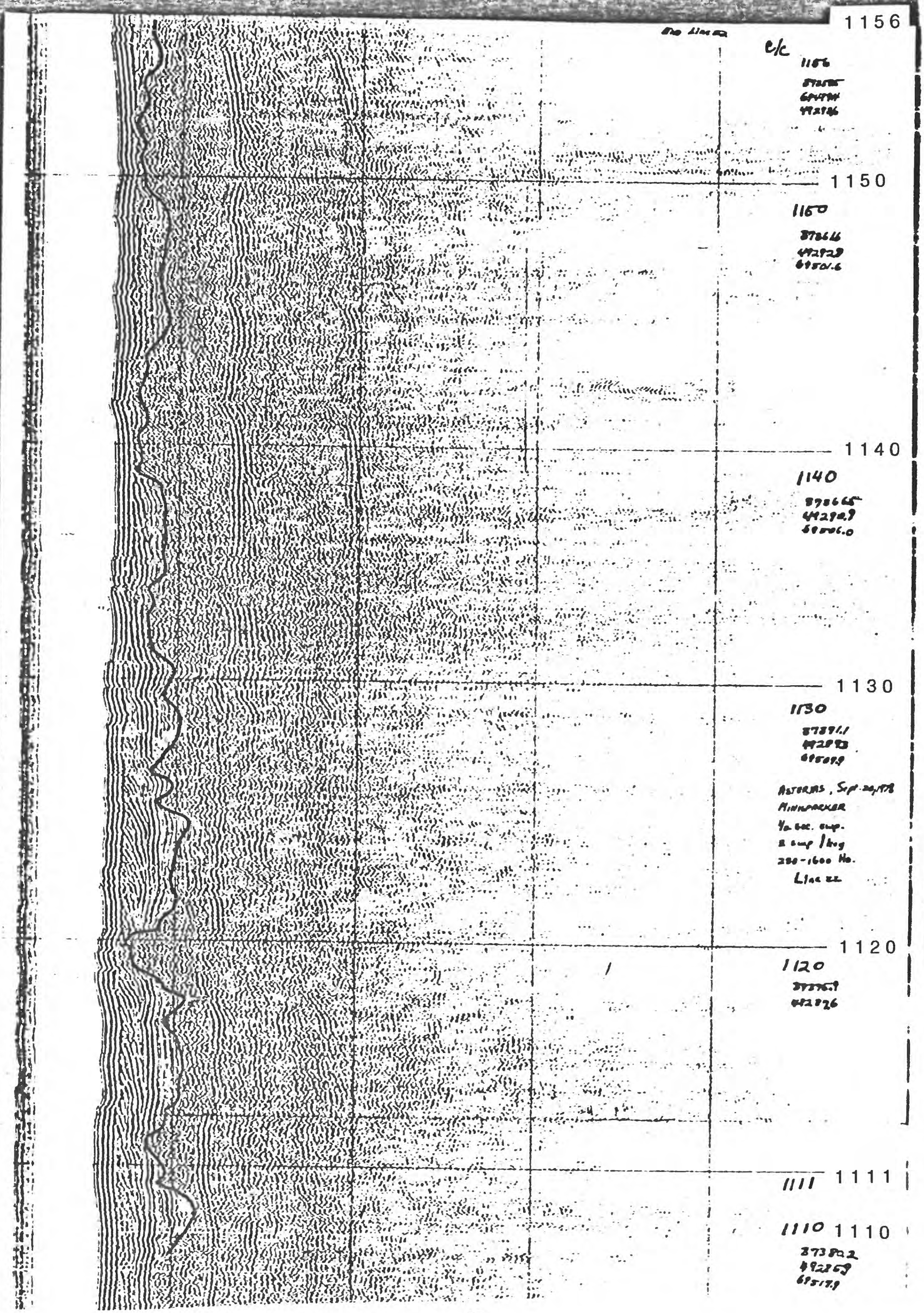




Profile 22-A



Profile-22-B

Profile 24, Data tape #4, Program #4
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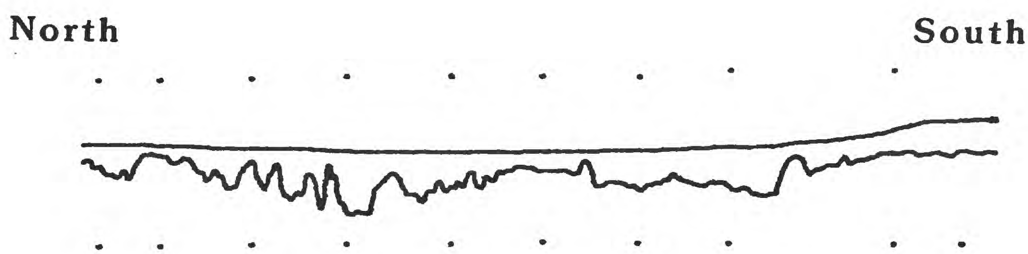
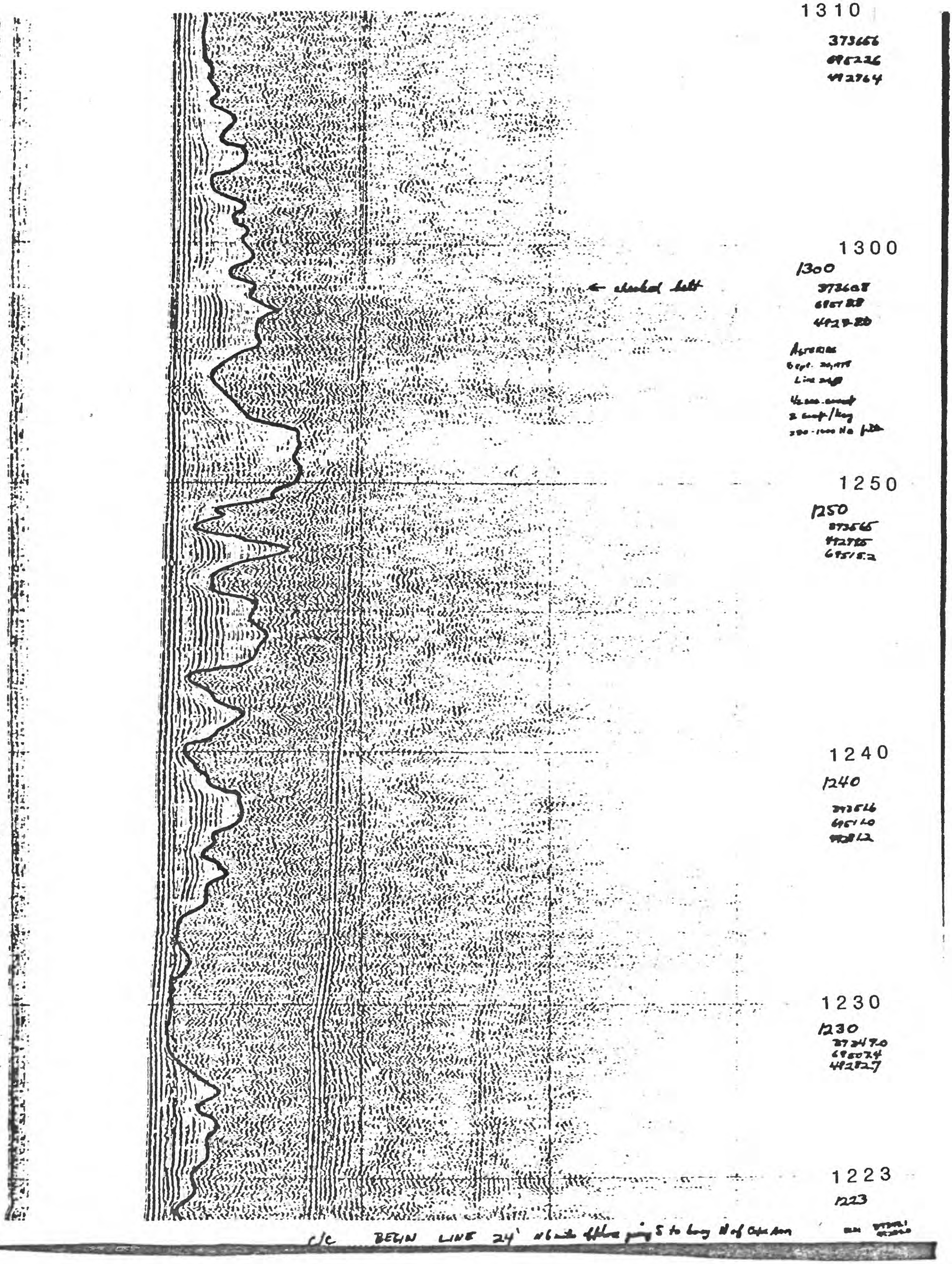
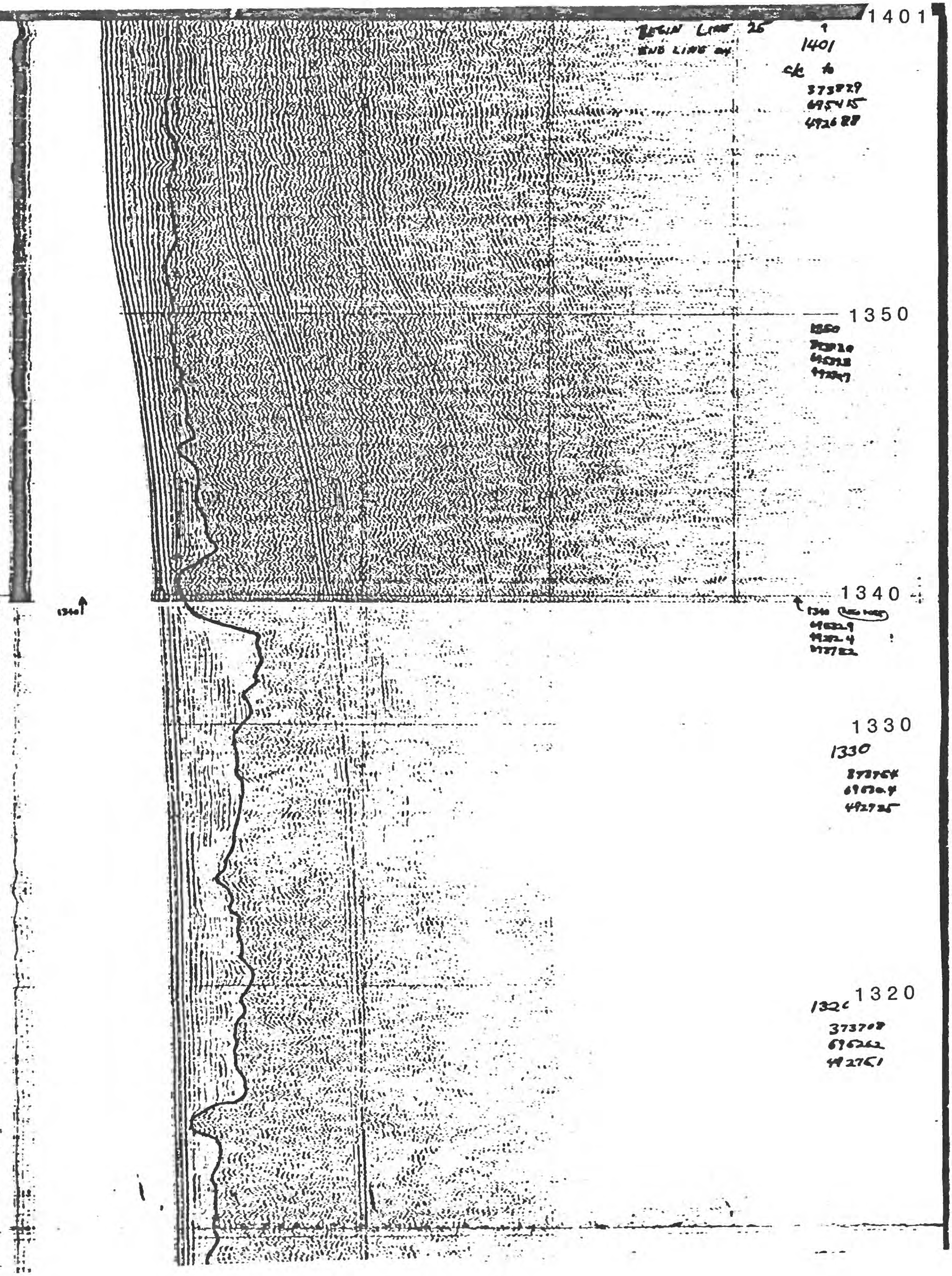



1310
373656
1300
1300
1250
1250
1240
1240
1230
1230
1223
1223
BEGIN LINE 24'

Profile 24-A



Profile 24-B

Profile 26, plot tape #7, Program #5
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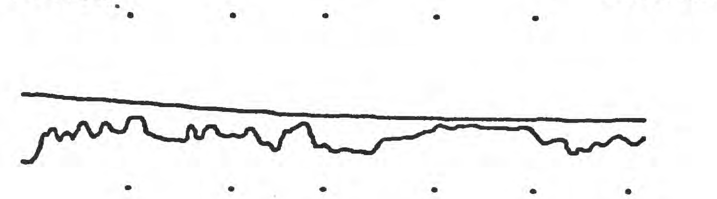
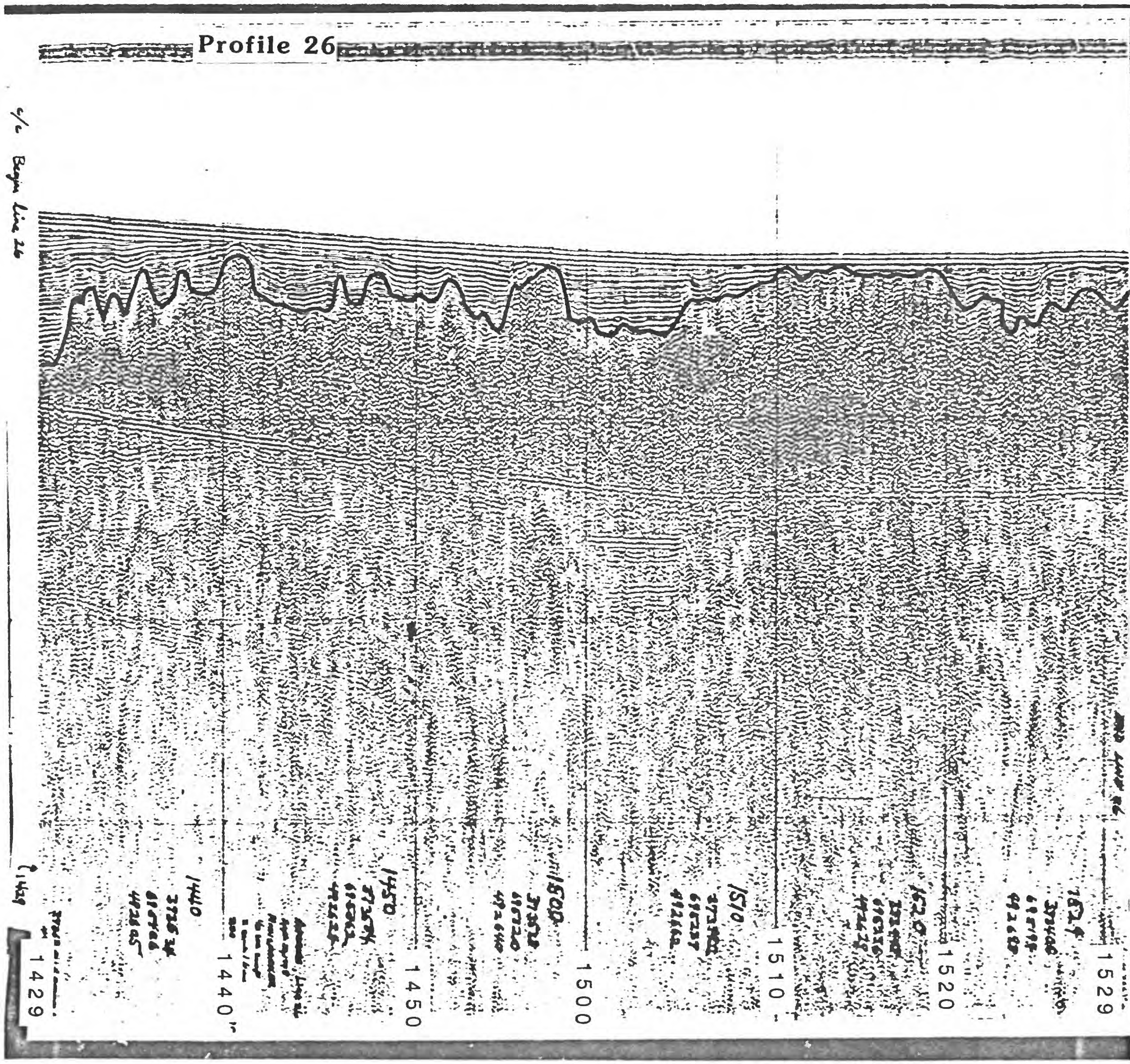
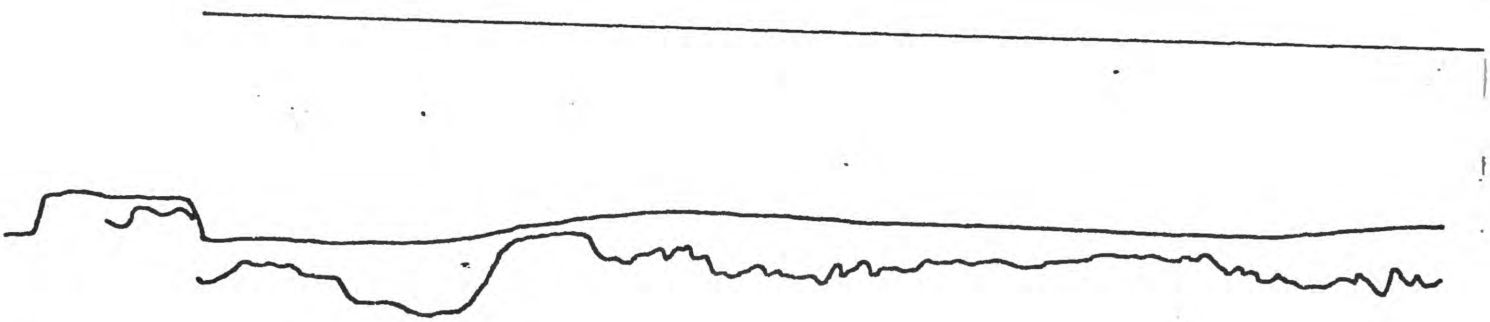




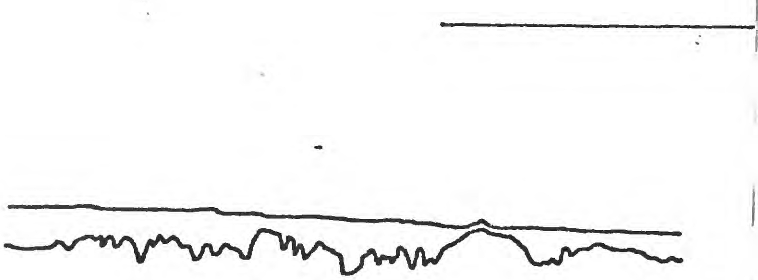
#14F

Fay line, Program #6
X-scale= 0.2994 Y-scale= 0.2375



#15F

Fay line, Program #6
X-scale= 0.2960 Y-scale= 0.2375



Fay line, #16F Program #6
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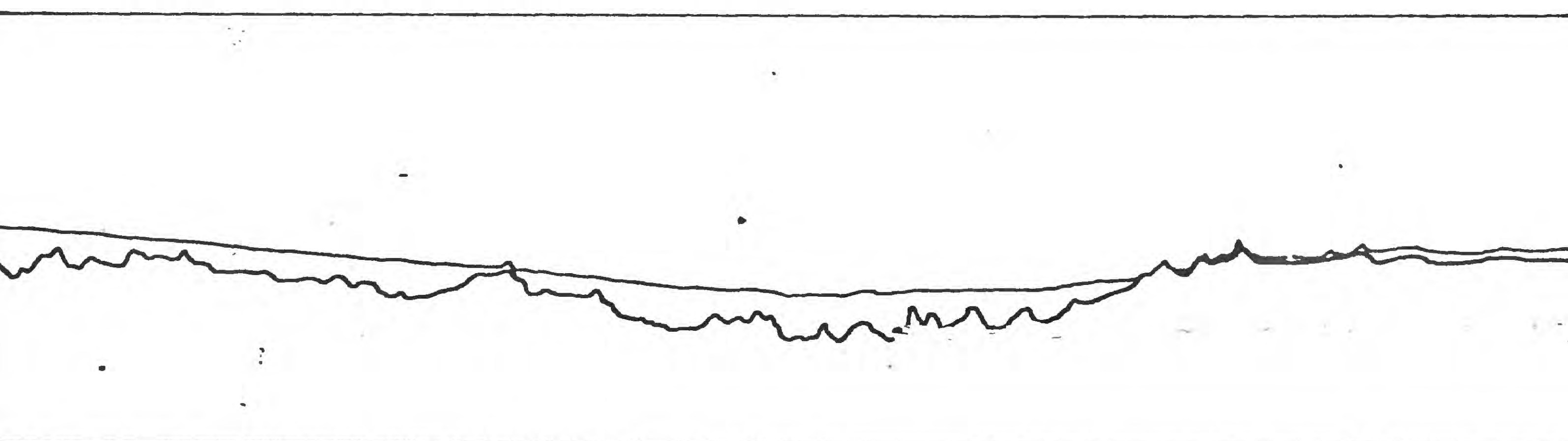
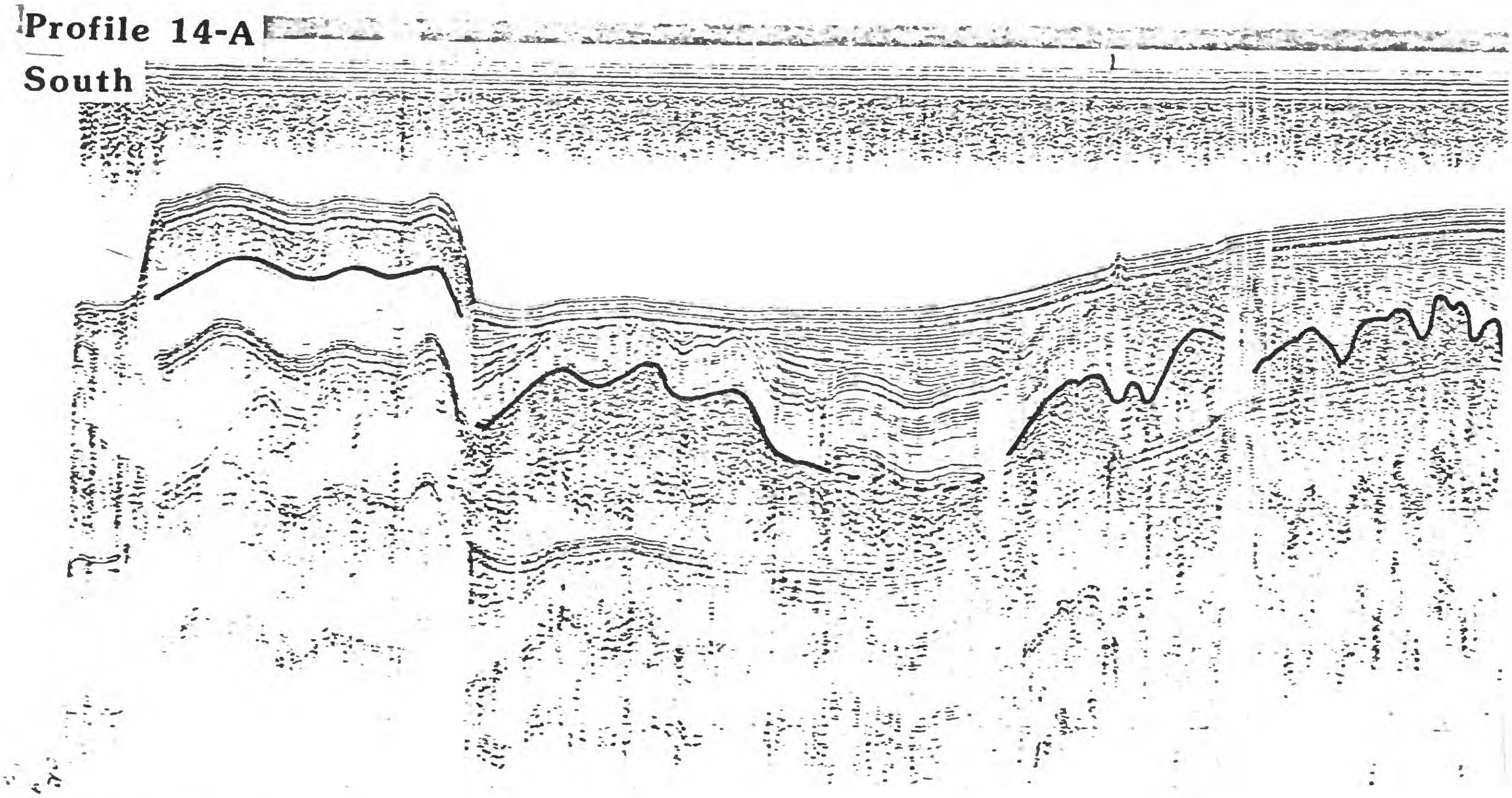


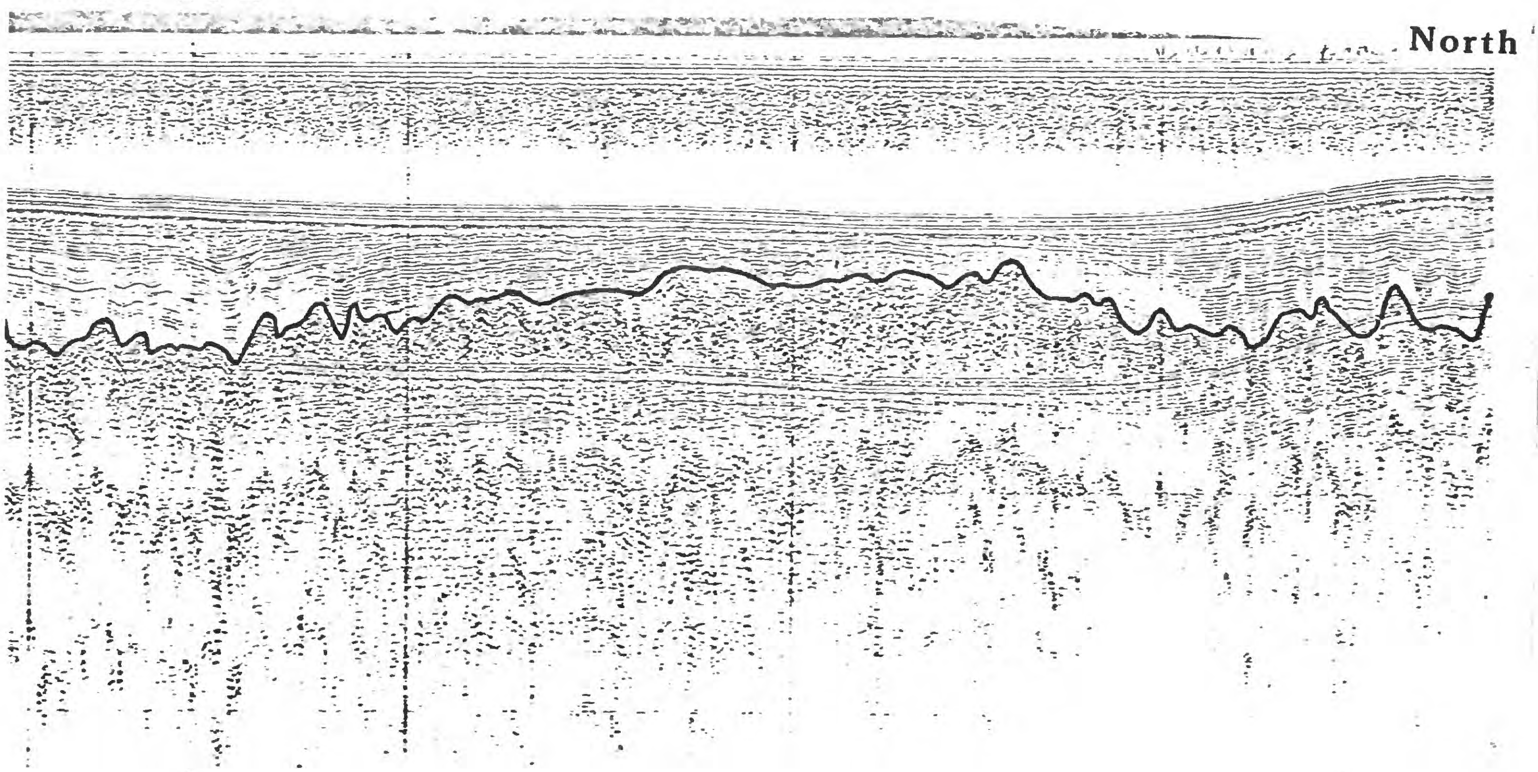
Profile 14-A

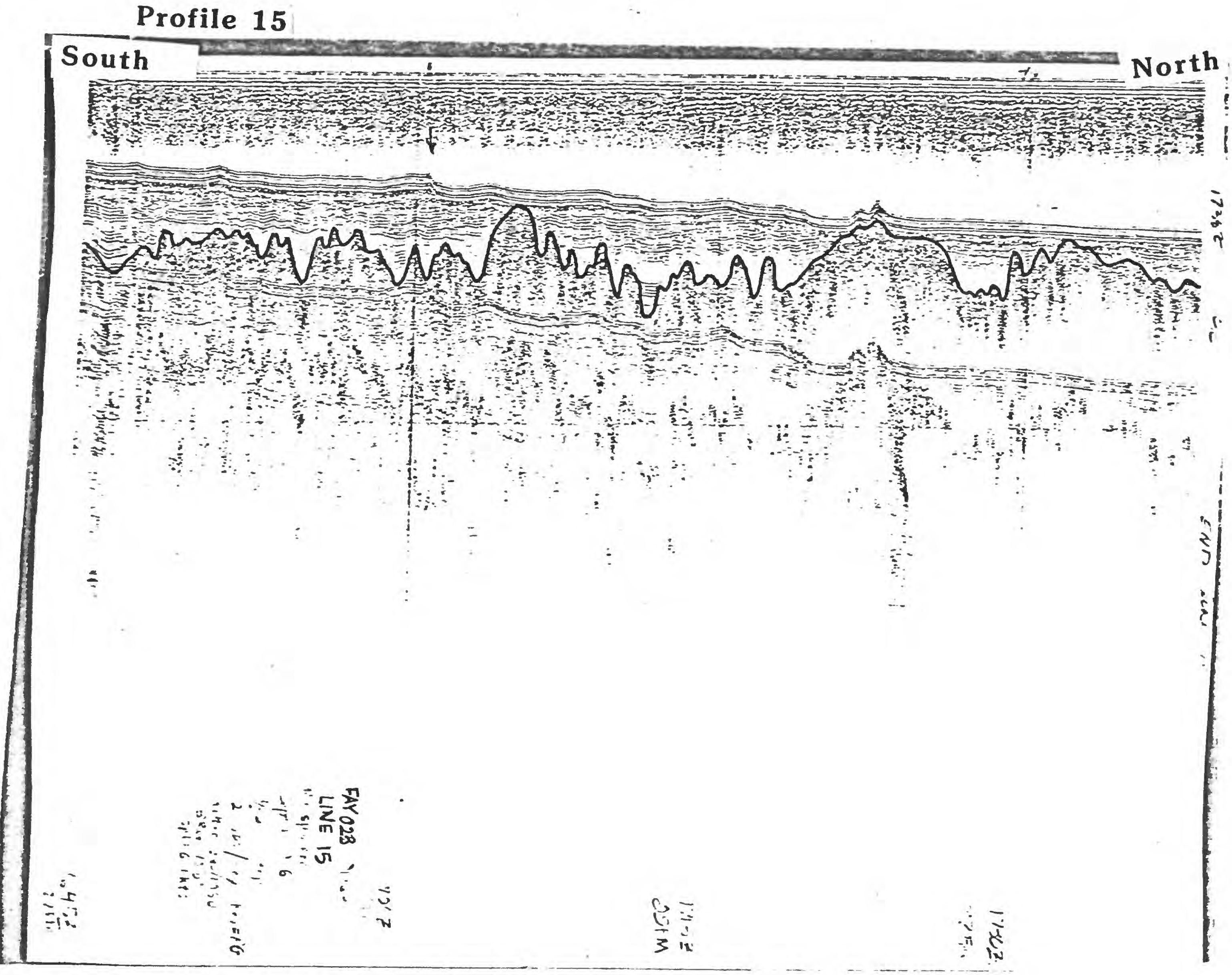
South



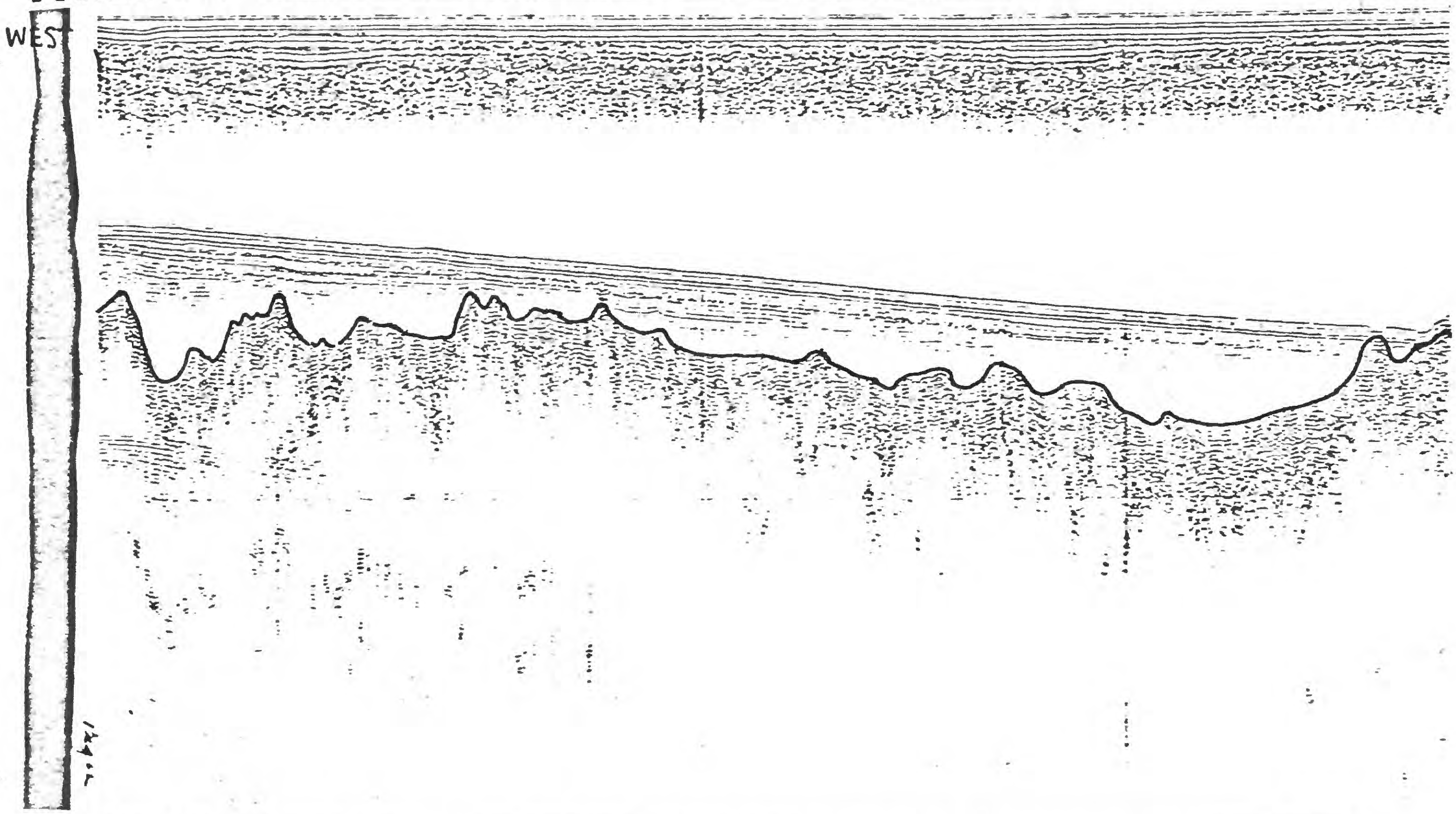
Profile 14-B

North

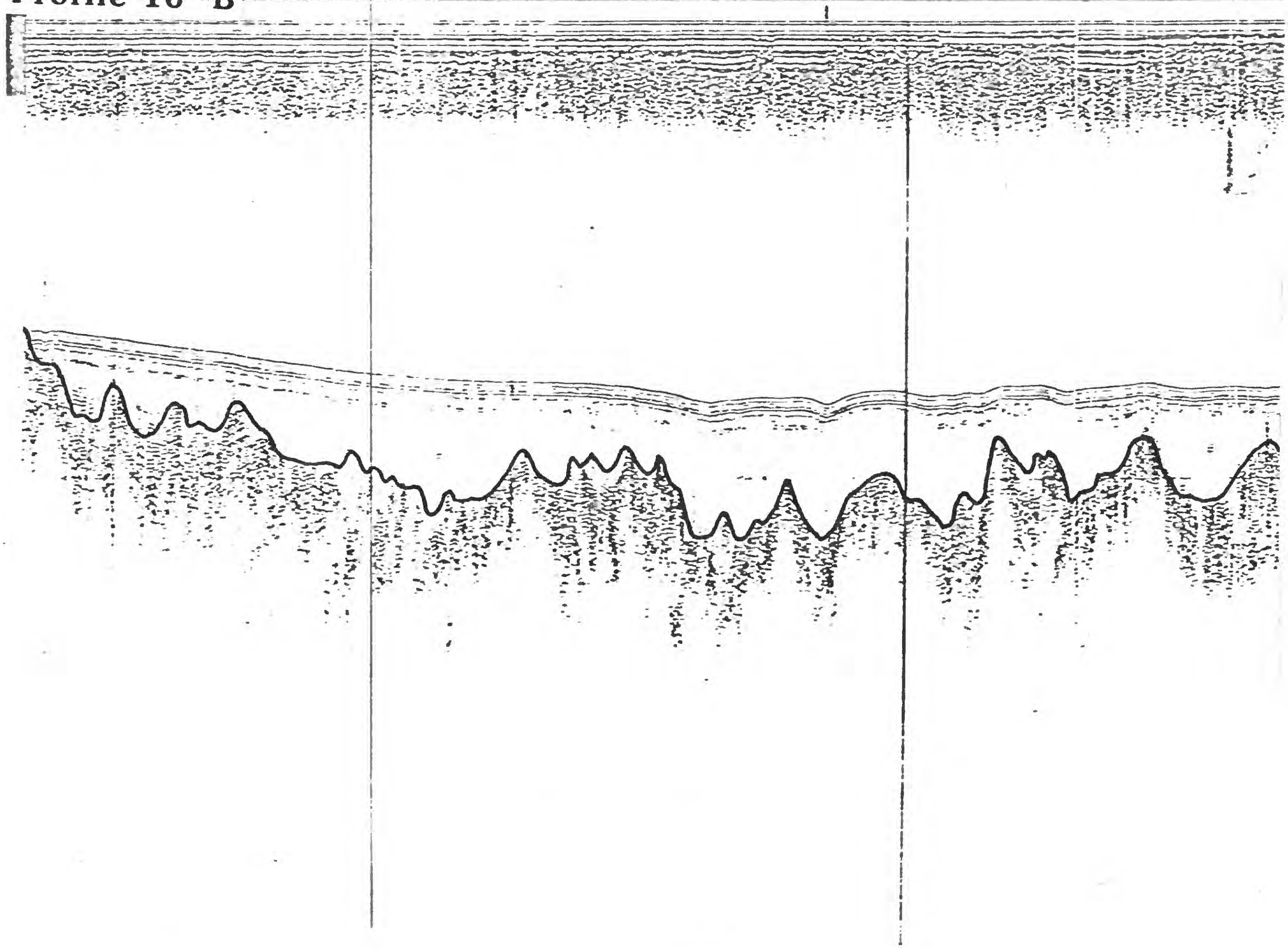



Profile 15
South
North

Profile 16 A



Profile 16 -B



Profile 16-1C