# Seismic Lateral Studies

## Mini-Sosie* Seismic Reflection Surveys

(1) Chalk River Nuclear Laboratory Site, Ontario

(2) Whiteshell Nuclear Research Est., Manitoba

by

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AECL Radioactive Waste Disposal Program

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Earth Physics Branch

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* Trademark Societe Nationale Elf-Aquitaine

## Introduction

The two seismic surveys of this report were conducted by Geoterrex Ltd. of Ottawa/Denver under Contract DSS-15SQ.23233-8-0737. The immediate goal was to determine the utility of a high-resolution seismic reflection technique in mapping the possible boundaries of or the fracture/shear zones within granite batholiths at the two locations.

The technique employed has been dubbed "Mini-Sosie" a trademark of the Societe Nationale Elf-Aquitaine. This technique differs from other reflection seismic methods only in its use of a very low energy source, provided by small earth tampers, and the very high number of additions (stacking) of the seismic energy returned from the earth, provided by the repetitive pulses of this source. The field equipment is adaptable to off-road applications and the depth of penetration, within the earth, of recorded seismic energy, is adequate for qualification of radioactive waste disposal sites.

A previous report (3034240-01/79 by Mair and Lam) describes a seismic survey, using a "weight-drop" device, carried out at Chalk River in October 1977. The description of the "common reflection point stack" concept and a discussion of the resolution capabilities of seismic methods may be found in that report and will not be repeated here. The details of the field procedure, at the two sites of the present report, can be found in the enclosed Geoterrex submissions for each survey.

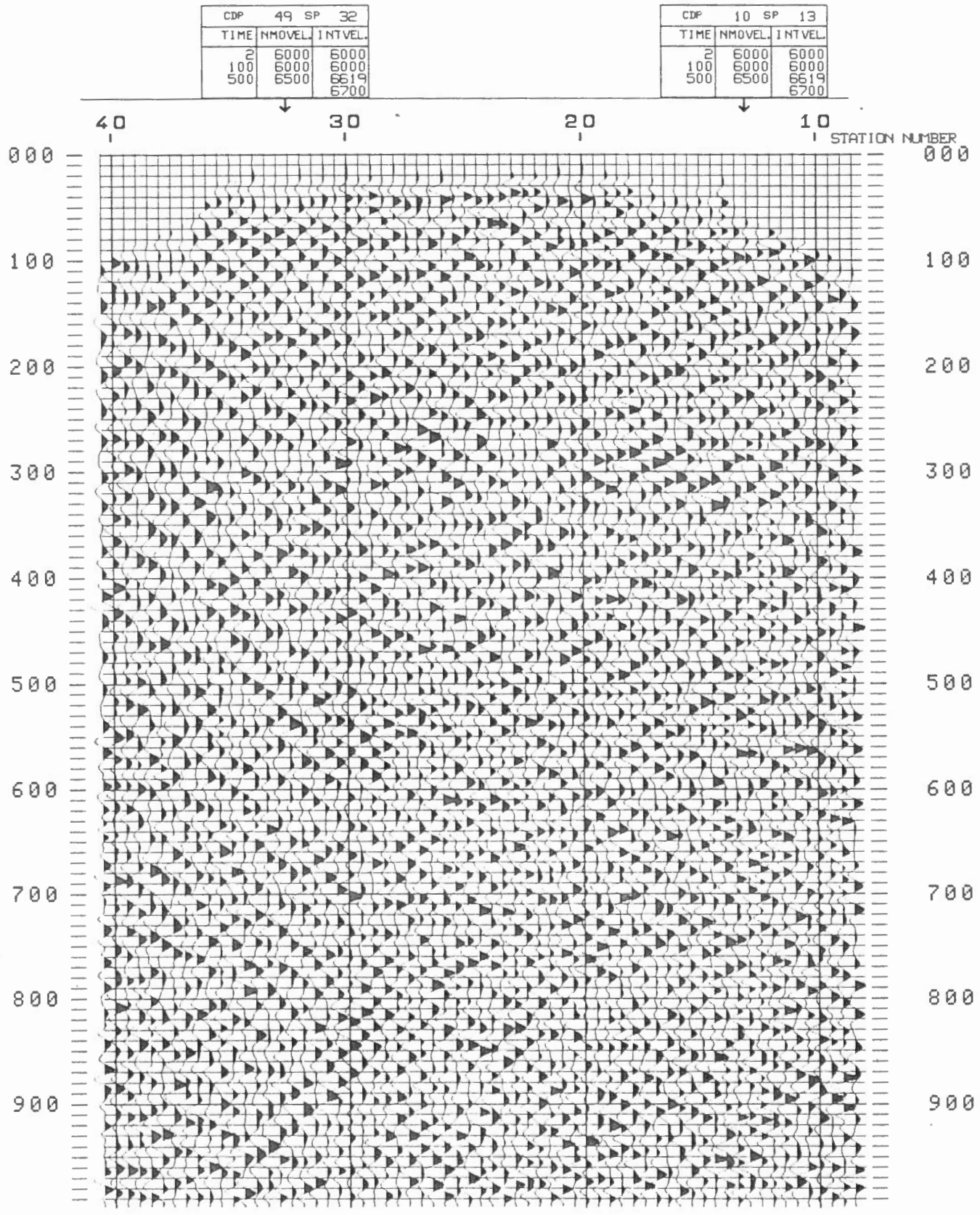
In general Geoterrex has fulfilled all contractual obligations and I find little fault with their field technique or data processing. There were however aggravating delays, by them, in accomplishing the field work and in obtaining their final invoices, completed in a manner satisfactory to our Department of Supply and Services, to the extent that charges for this work could not be paid out of 1978-79 funds.

As I did not fully agree with their interpretation of the Whiteshell sections and believed that there was potential for further enhancement of the data, all of these data have been reprocessed using our in-house routines and the raw field tapes delivered to us as per contract. This reprocessing has been a very useful exercise and in the following, these sections are presented with a brief discussion of the results of each survey.

1. Chalk River Nuclear Laboratory Site, Ontario

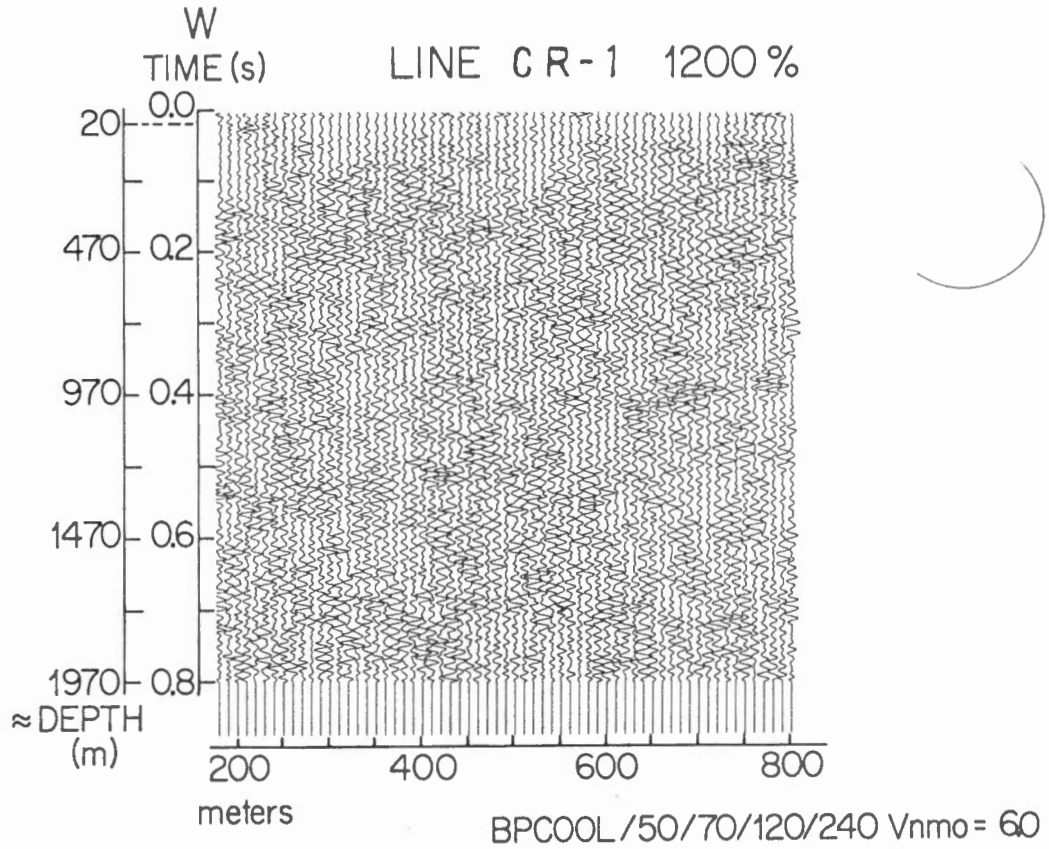
This one day field program (January 17, 1979) was intended to compare the performance of the Mini-Sosie technique with the result of a previous "weight-drop" survey. The previous work had found the batholith at Chalk River, in the area surveyed, virtually homogeneous, insofar as the resolution capabilities of the seismic method used were concerned.

The final Geoterrex section is shown as Figure 1 and our re-processing of these data as Figure 2. No coherent reflected events are evident on these figures and the original conclusion of homogeneity of the batholith or rather heterogeneity at a scale beyond the resolving




LINE CR-I (FINAL STACK WITH AMCOD)

(1)


W
TIME (s)
LINE C R-1 1200 %
0.0
0.2
0.4
0.6
0.8
20
470
970
1470
1970
≈ DEPTH (m)
200
400
600
800
meters
BPCOOL/50/70/120/240 Vnmo = 60

(2)

power of the method, is confirmed. This conclusion is only valid, of course, for the surveyed lines and not necessarily to the total volume of the batholith. While this negative result is what one would wish to obtain for a suitable disposal site, at this point in the program a positive result would have been preferable. Our arguments as to the resolution and the efficacy of the method in general, are highly unconvincing without the positive result obtained in the following experiment.

2. Whiteshell Nuclear Research Est., Manitoba

A four day field program (February 25 - 28, 1979) was conducted at the locations shown in Figure 3. On line WS-1 a drilled hole (WN-1) had encountered a major shear zone of some tens of meters in thickness, at a depth of about 400 m. If no evidence of this zone could be detected by the Mini-sosie method we were prepared to abandon the technique for any further site evaluation work (see report 3034240-1/79).

The final Geoterrex section of this line is not convincing (Figure 4). The shear zone should be evident on this section at times of about 160 ( 0.16 s ) in the general area of station 70. While some correlatable energy is present, it is impossible to relate it, convincingly, to the zone of interest. It could easily be argued that this energy arises from near surface diffraction. Geoterrex were asked to reprocess these data using a higher band pass filter to remove some of the low-frequency energy that dominates the section. They did not do so, possibly because the cost of this additional work would have exceeded the fixed value of their contract.

Figure 5 shows the result of this reprocessing using routines developed at the Earth Physics Branch. Cyclic, coherent events, dipping to the west appear to correlate with and characterize the shear zone beneath WN-1. This signature is consistent over a distance of about 200 m. About 250 m west of WN-1 a very sharp, coherent, reflection wavelet becomes evident for the next 100 m or so, at a depth of about 300 m (times of about 0.13 s ). We have suggested that the petrology producing this reflection be identified by drilling.

Figure 6 is the Geoterrex section of Line WS-2 (Fig. 3) and Figure 7 our reprocessed version. There is no convincing evidence of coherent reflection energy on either of these sections. The suspicion is, that the power line running parallel to this profile has caused poor signal to noise ratio of the recorded seismic energy.

Figure 8 is the Geoterrex section of Line WS-3 indicating an outstanding reflection at a time of 150 to 200 ms on the west end, dipping to a time of about 300 ms at the east end. Our reprocessed version is shown in Figure 9 and emphasizes the high relative amplitude and coherency of this reflector. We suggest that the petrological nature of this event be determined by drilling.

## Conclusions

(1) The utility of high-resolution seismic reflection techniques in mapping the possible boundaries of or the fracture/shear zones within granite batholiths has been conditionally established.

(2) At this stage in the program, the petrology giving rise to recorded reflections should be investigated directly, by drilling.

(3) At a more advanced stage in the program it may be possible to disqualify a proposed disposal site simply by the evidence of a coherent reflection being recorded from, in or near the rock volume. The petrology need not be known, the reflection, being indicative of a major change in the elastic properties of the rock, may be sufficient evidence to disqualify the site.

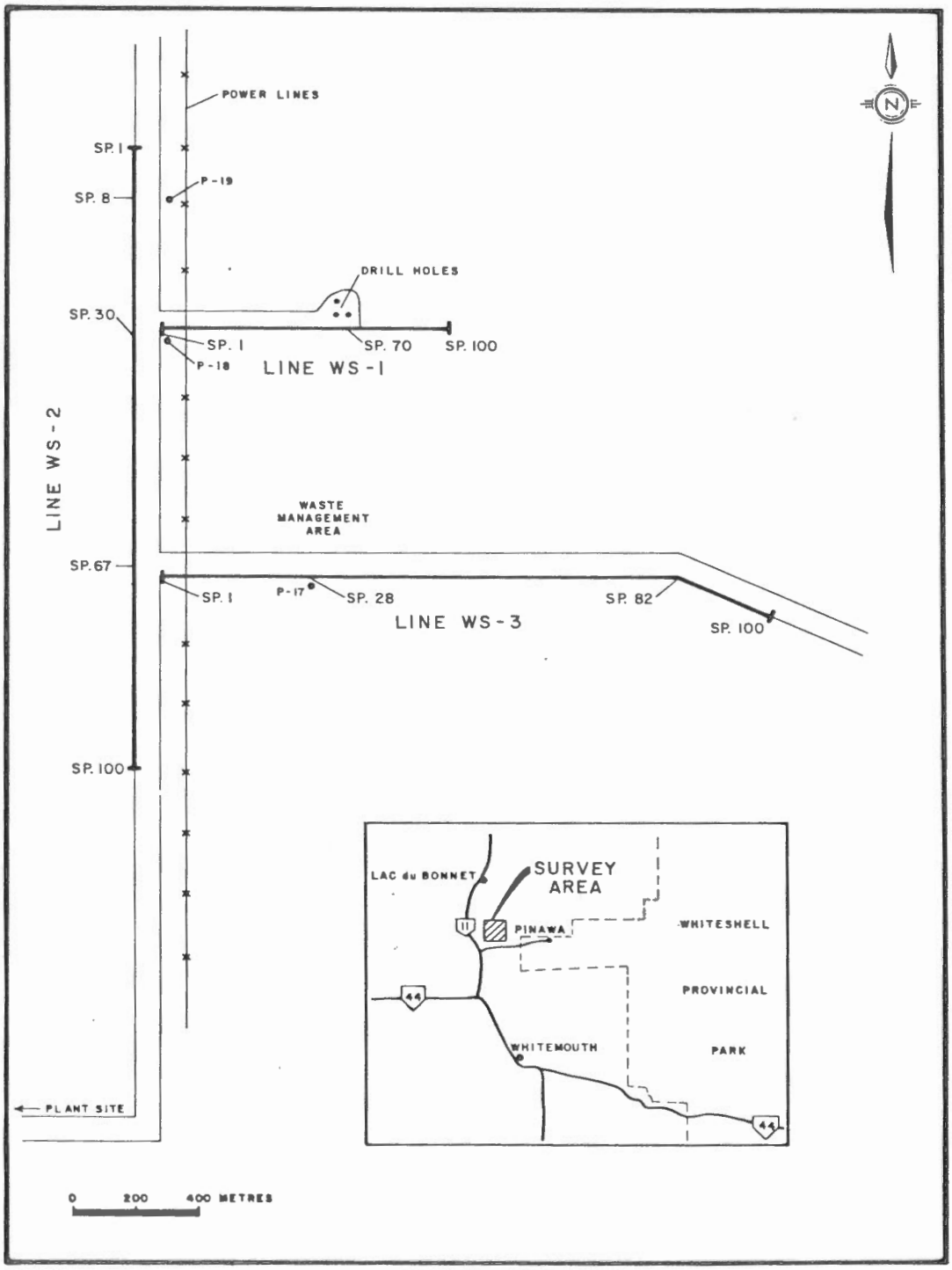
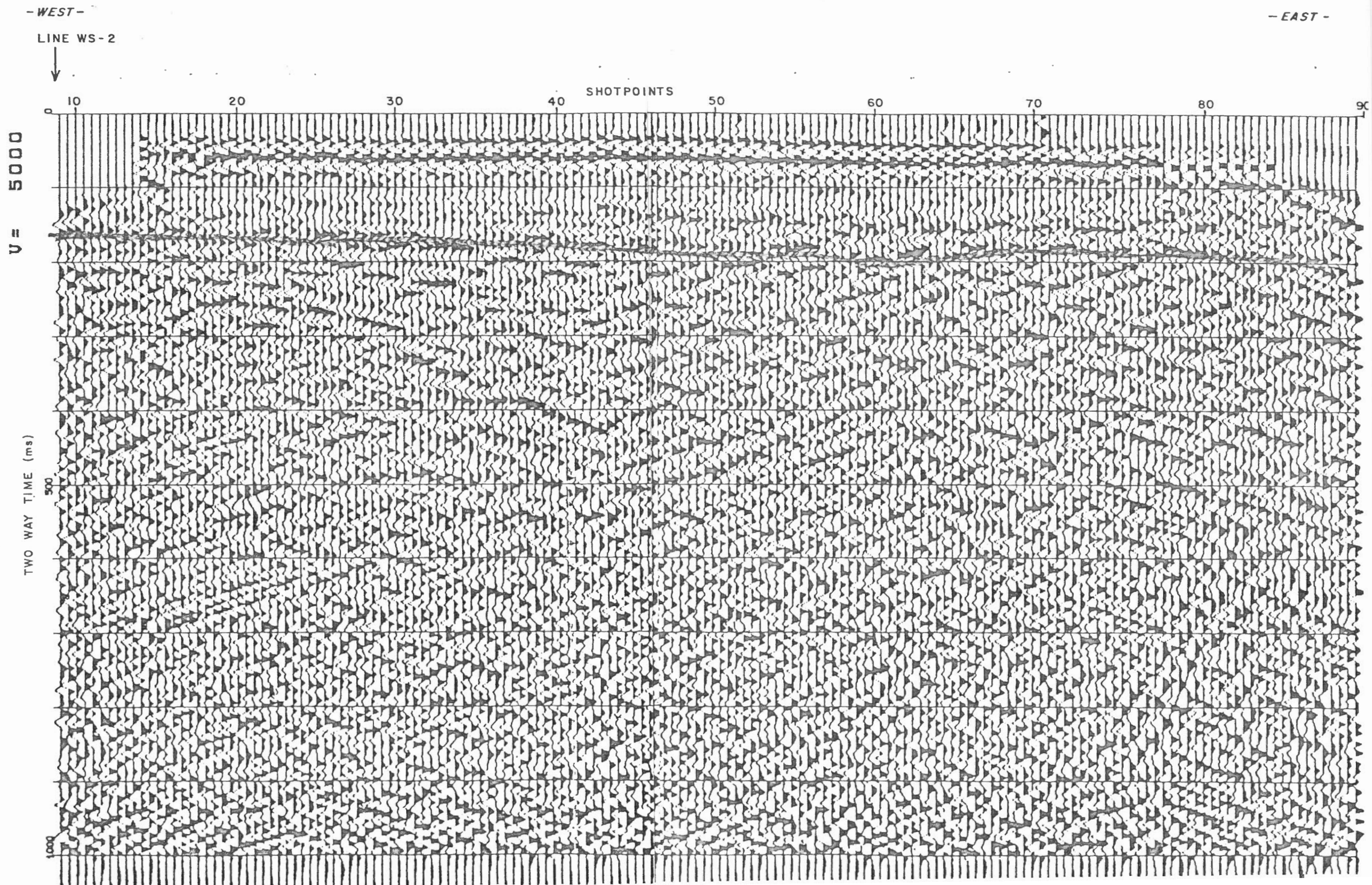

POWER LINES
SP. 1
SP. 8
P-19
DRILL HOLES
SP. 30
SP. 1
SP. 70
SP. 100
P-18
LINE WS-1
LINE WS-2
WASTE MANAGEMENT AREA
SP. 67
SP. 1
P-17
SP. 28
SP. 82
SP. 100
LINE WS-3
SP. 100
PLANT SITE
0 200 400 METRES
LAC du BONNET
SURVEY AREA
PINAWA
WHITESHELL
PROVINCIAL
PARK
WHITEMOUTH
11
44
44

FIGURE 4

LINE WS - 1

VELOCITY SCAN (5000 mps)



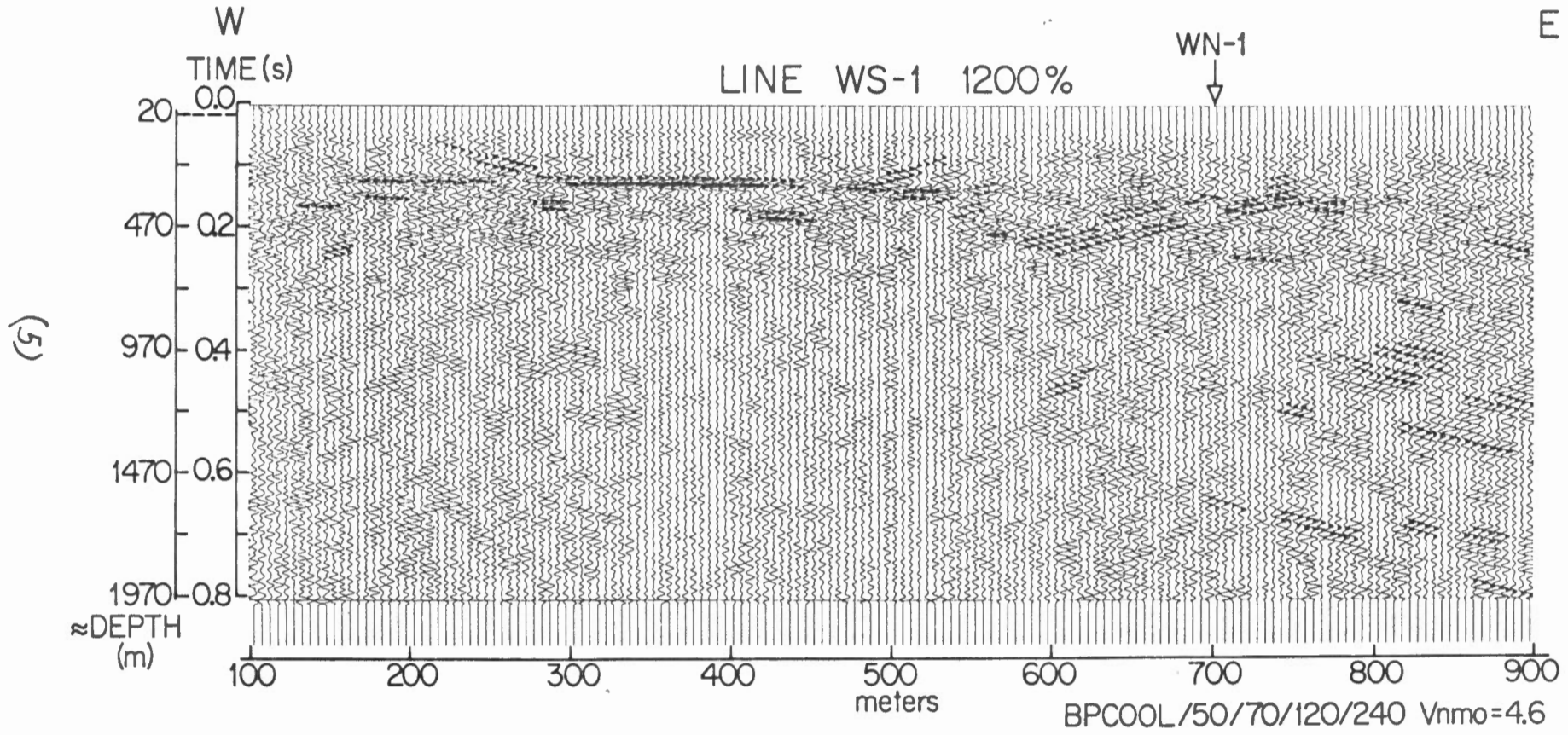
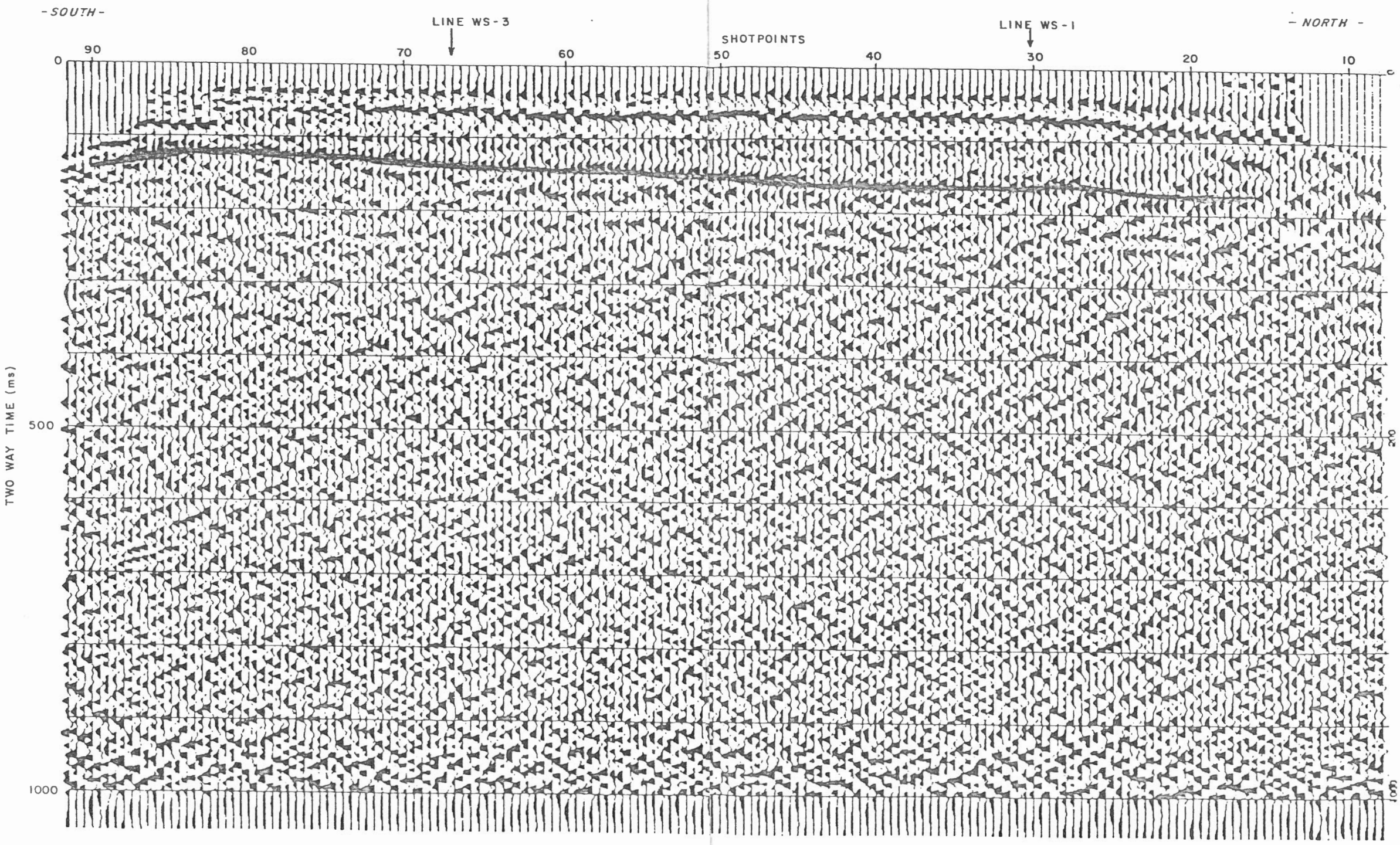

W
E
TIME (s)
LINE WS-1 1200%
WN-1
0.0
0.2
0.4
0.6
0.8
20
470
970
1470
1970
≈DEPTH (m)
(S)
100
200
300
400
500
600
700
800
900
meters
BPCOOL/50/70/120/240 Vnmo=4.6

FIGURE 6

LINE WS-2

VELOCITY SCAN (5000 mps)



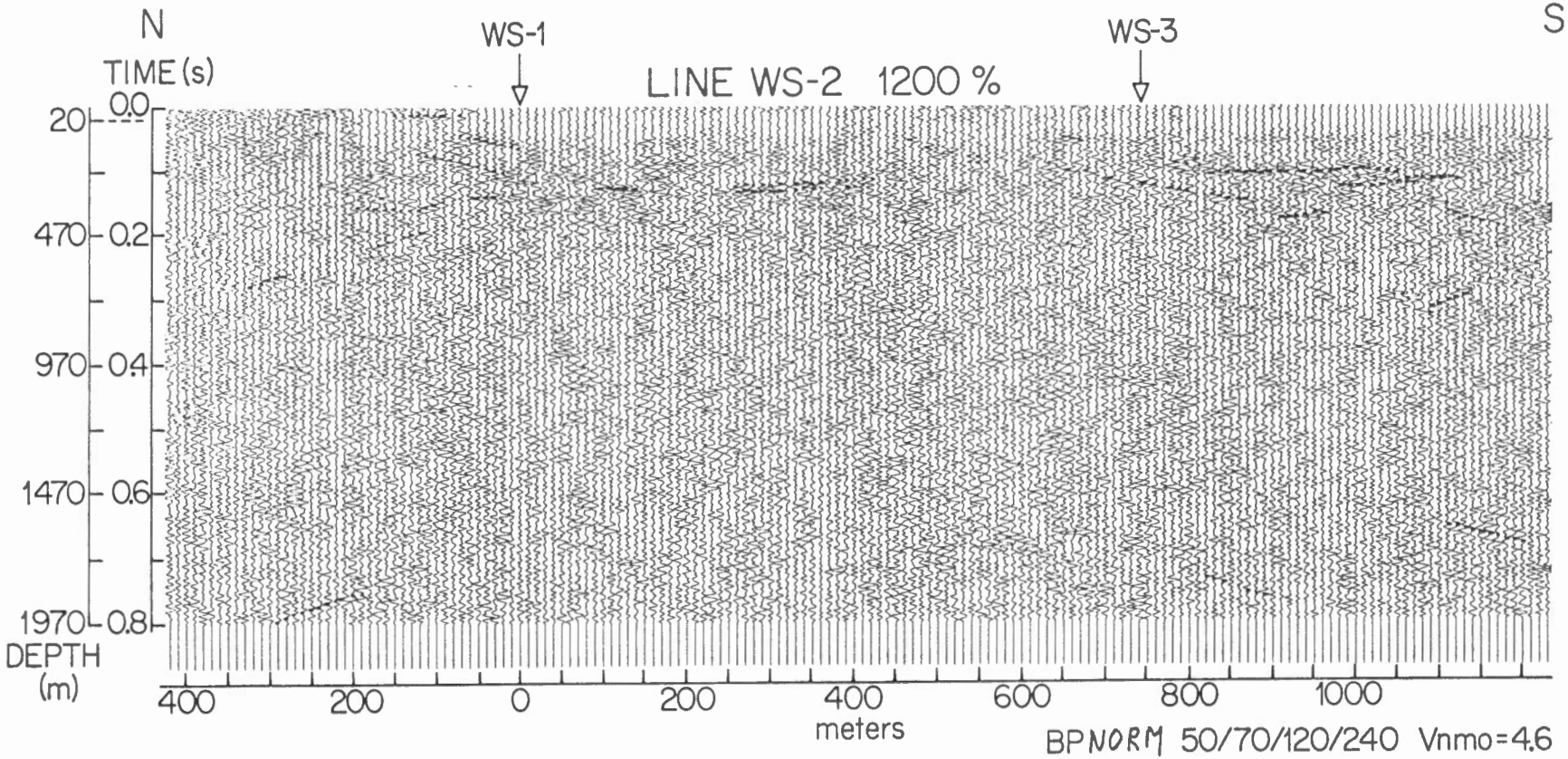
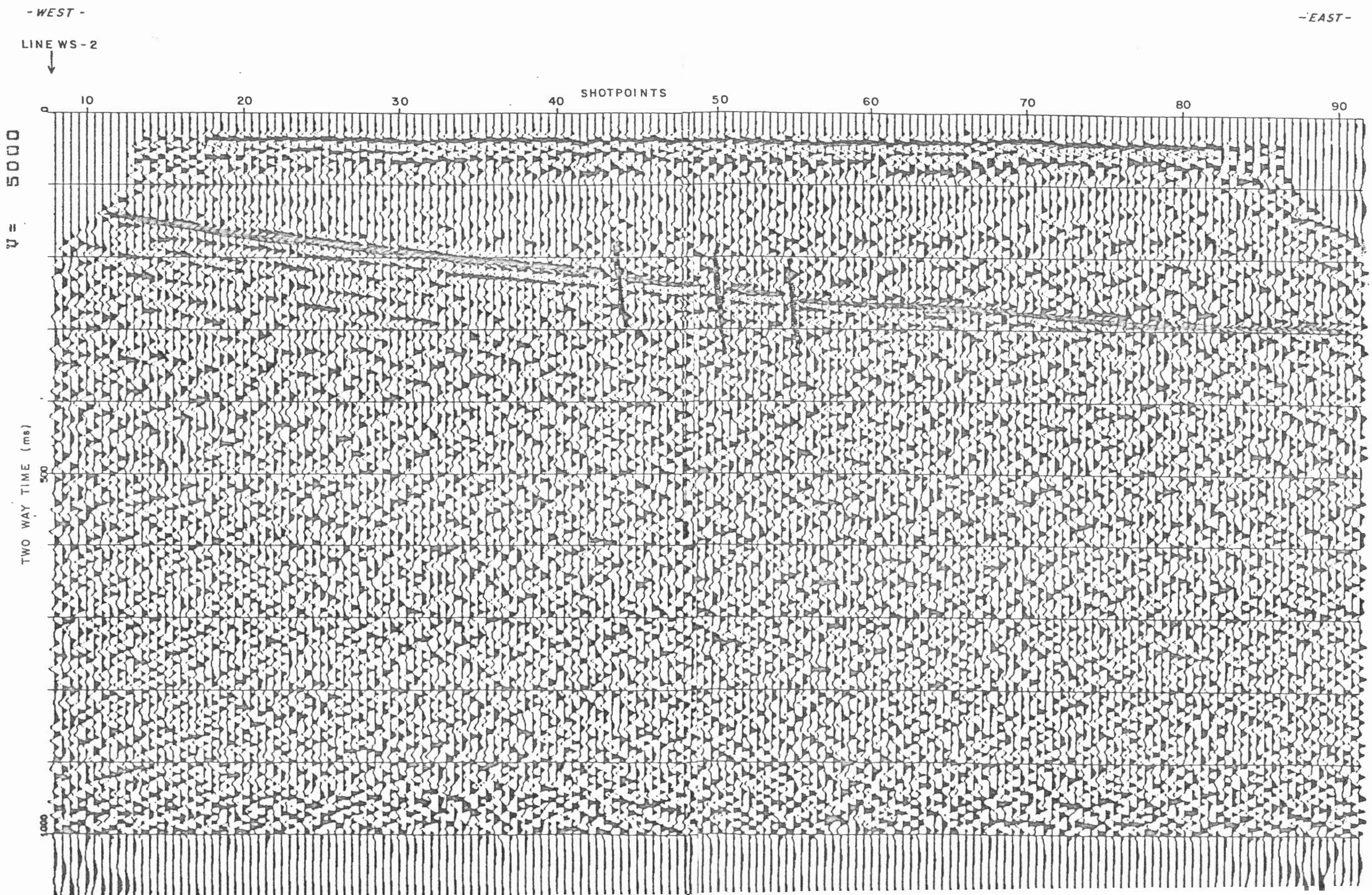
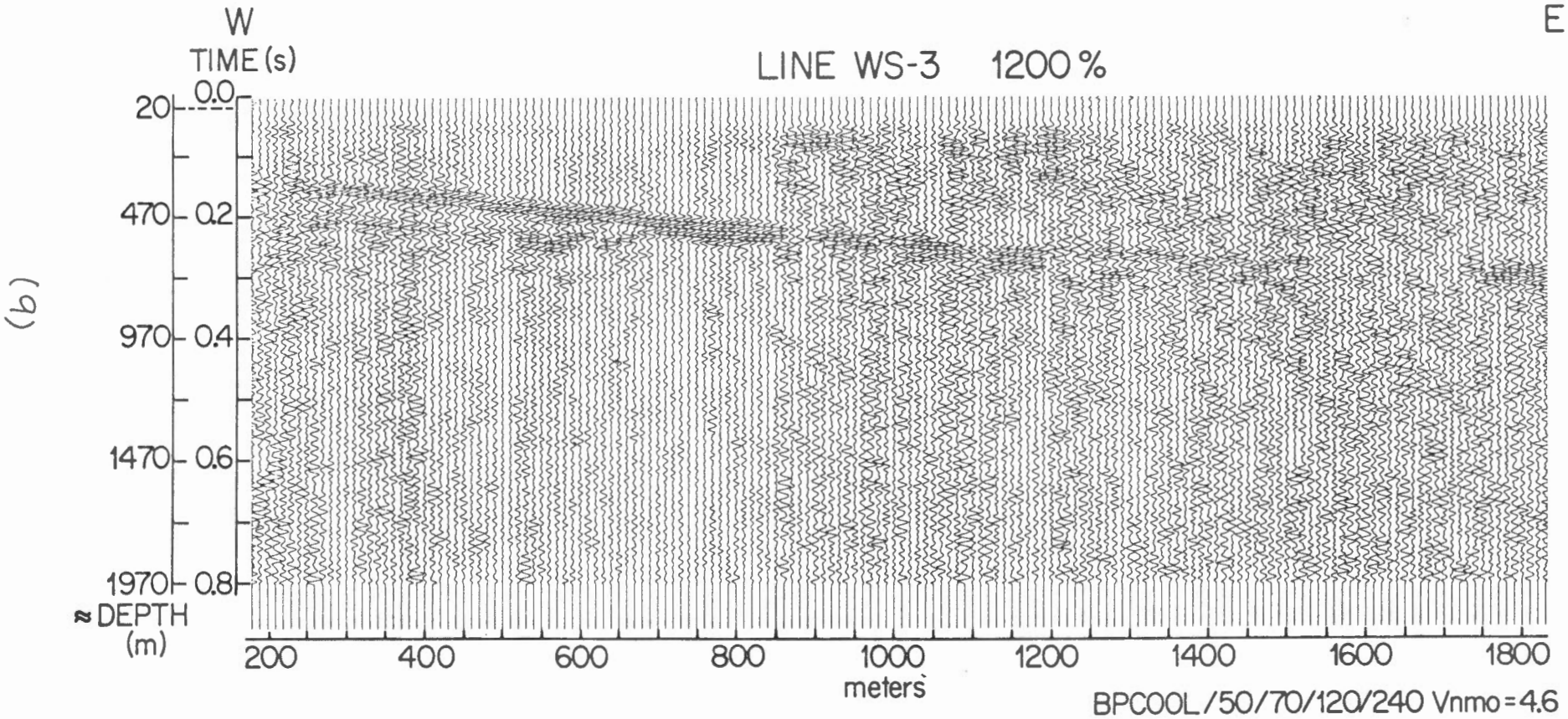

N
S
WS-1
WS-3
LINE WS-2 1200 %
TIME (s)
0.0
0.2
0.4
0.6
0.8
20
470
970
1470
1970
DEPTH (m)
400
200
0
200
400
600
800
1000
meters
BPNORM 50/70/120/240 Vnmo=4.6

FIGURE 8

LINE WS--3

VELOCITY SCAN (5000 mps)




W
E
TIME (s)
LINE WS-3 1200 %
20
0.0
470
0.2
970
0.4
1470
0.6
1970
0.8
≈ DEPTH (m)
200
400
600
800
1000
1200
1400
1600
1800
meters
BPCOOL/50/70/120/240 Vnmo=4.6

(b)

The following are the reports from Geoterrex. I have edited out those parts referring, incorrectly, to the sites as being proposed radio-active waste disposal areas. Their final seismic displays have been shown as Figure 1 (Chalk River) and Figures 4, 6 and 8 (WNRE, Pinawa) in the preceding sections and have been removed from these reports. Their field reports, magnetic tapes, etc. are on file at the Earth Physics Branch.

I disagree with their correlation of reflected events on all three lines at WNRE, Pinawa with the shear-zone evident from drilling on Line 1 (see section XI of the Geoterrex report). I don't believe there is any basis to tie the strong reflector of line WS-3 to any of the various reflecting segments of Line WS-1. Indeed, these segments of Line WS-1 cannot be tied to each other through considerations of phase coherence, dip or seismic signature. It is probable that the reflections arise from different shear zones and possible that these zones may be interconnected to form a permeable layer. Exploration of granite batholiths is a very new game however, and results from drilling are necessary before reasonable conjecture can be presented.