La Malbaie

Experiments to June 1982

by

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TABLE OF CONTENTS

SUMMARY

The La Malbaie P-wave velocity monitoring experiments commenced in 1974. A description of the experiments from then on can be found in the following Internal Reports of the Division.

Period	Report No.
1974 - 1976	77 - 7
1977	78-4
June 1978	78-7
Aug. 1978 - June 1979	79-13

In order to have a complete record of the experiments the period from October 1979 to June 1982 will be described in the present report.

In addition two refereed papers have been published, Buchbinder and Keith (1979) and Buchbinder (1981), and a third paper has been accepted for publication, Buchbinder, Kurtz and Lambert (1983).

The present report will describe shots 14 - 19 set off on the north shore and shots 108 - 112 set off on the south shore. Shot 113 did not go off.

Noteworthy changes during the period occurred in 1980 with shots 15 and 109 and the deployment of new BP's, on 5 June 1981 when station 60 was replaced by station 61, and since June 1981 (shots 110 and 17), when all array high gain channels were recorded on the same head together with the radio signal. Two new stations were also established, one near each shot point, station 40 on the south shore and station 83 on the north shore. For convenience these changes are given in Table 7. Absolute P travel times were obtained for all shots except those of 1981 when the source corrections were not accurately established. Changes in travel time for all shots, with the same proviso as above, were obtained by cross-correlating the wave forms.

Experiments

A complete list of the explosions on the north shore is given in Table 1, and those for the south shore are given in Table 2. The station coordinates and their distances from the shot point are given in Table 3. (Figure 1.)

The shot point on the north shore is a water-filled open air mine and the precise location of the shot point does not change. On the south shore holes are drilled for each shot and corrrections are determined for shot point migration. The locations of the holes are sketched in Fig. 2.

Stations

The station locations are shown in Fig. 2. On 5 June 1981 station 60 was dismantled and moved to Station 61. For the two shots in November 1981 a new station 40 operated on the south shore. This is very near to the ECTN site POC and the shot point. In June 1982 a further new station, 83, was started near the north shore shot point, both serve to provide absolute timing of the shots.

Shot Point Timing

For all the shots described here the delayless shooter box was used. This box has delays of the order of 0.2 ms and thus has no effect on the timing precision. All the 1981 shots are in need of corrections due to mistakes in wiring of the shooter clock box and a bad chip. Before the June 1981 experiments a circuit was installed in the shooter clock box to produce minute marks. Since the device was not powered up it acted like a delay gate and produced a rather uncertain large delay. Different values of the delay were estimated in several ways: one was estimated in the Lab by reading the delay on an oscilloscope giving about 81 ms, a similar value but with a larger

error was estimated in the field by A. Green (pers. comm.). Another estimated value is the average delay of shots 17 with respect to 16 and 111 with respect to 110. This estimate comes to 91 ms and this value has been subtracted from shots 17 and 111.

For shots 18 and 112 the chip was powered up, nevertheless, as determined by cross-correlation with earlier shots, shot 18 was late by 50 ms and shot 112 by 58 ms on the average. These average values were subtracted from the delays for these shots. The estimated delays appear to have been caused by a bad chip in the minute pulse circuit. This only occurred when the shooter clock box was near 0°c, so that it was not detected when testing at room temperature. The correction for shot 112 may be improved upon after the October 1982 shots, when station 40 will have operated for the second time and may provide a better value. The correction for shot 18 cannot be improved upon. All these corrections are listed in Table 4 for reference.

Array Timing

The array timing has been described in previous reports. Suffice it to mention here only the problems that have occurred in the period covered by this report.

For shots 16 and 110 the spare tape recorder unit was used. When the data were analyzed by cross-correlation inconsistencies were noted between array stations and BP that operated at the same station. All stations except 60 were late by 27 ms with respect to the BP (after the BP response had been allowed for). The inconsistencies were finally resolved as follows:

The tape recorder has two write heads, one head writing all the high gain channels except 60 and low gain channel 60; the other head writes the high gain channel 60 with the remainder of the low gain channels and the radio time signal.

This was the spare recorder and for some reason the supposedly fixed spacing of the two write heads had changed at some unknown time by about 6×10^{-3} cm. As a result, since the high gain channel 60 and the radio signal are on one head the timing for this one channel was correct. All the other high gain channels are on the other head and need a correction. By determining the difference in arrival time between the high and low gain channel of station 60 the proper correction of 27 ms was determined. This correction is also listed in Table 4.

New Backpacks

Before the start of the 1980 season the New Backpacks (NBP) arose from the ashes of the old Backpacks (OBP), affording no opportunity to test the NBP and the OBP simultaneously. Thus it was not until much later that arrivals were shown to be about 18 ms earlier on the NBP than on the OBP and the array, owimg to lower order filtering of the NBP. These changes are shown in Table 4 as corrections. The phase response of the instruments and corrections will be discussed in more detail in the next section.

Instrumental Phase Response

Instumental phase response is an important characteristic when different recording systems are used during the same experiment. In the earliest part of the experiment only the array was used and thus no precautions had to be taken to allow for phase delays. When the OBP came into use in 1976 the matter had to be considered. Simultaneous use of an OBP and an array station showed them to agree to a few ms and their instrumental phase responses were assumed to be equal with an uncertainty of $\pm$ 5 ms for the purpose of calculating errors. Furthermore the initial version of the OBP had a timing uncertainty of $\pm$ 8 ms, which was considered much more uncertain than the phase response. In addition, because only six OBP existed, they were not deployed on a routine basis at array sites except for some limited testing. With the

advent of the 11 and then 12 NBP in 1980 the situation changed in that some of the NBP were deployed at array sites, since there were 14 sites and up to 18 recorders with the potential of doubling up at up to 4 sites. Therefore the question of the difference in instrumental response had to be considered in more detail, in particular when it was found that the NBP seemed to be about 20 ms faster than the array.

There are, of course, several ways of going about eliminating or correcting for the instrument phase response.

The phase response of different systems is easy to evaluate algebraically if the appropriate parameters are known, and since OPB no longer exists this is the only way to proceed. The more contentious problem is whether one should use phase ϕ or $d\phi/dw$ as a measure of phase delay? In my opinion ϕ is not the correct value, as it has negative values at higher frequencies and would result in arrivals earlier than zero. Of course ϕ is the value used in correcting surface waves to obtain phase velocities, however here we have P wave arrivals that are more akin to group arrivals. In similar wave analysis one uses $d\phi/dw$ for group velocity determinations and this is the appropriate value for P waves. With fewer words the same can be shown from the principle of stationary phase.

One obvious way of determining the difference between NBP and the array is to cross-correlate the two wave forms recorded from the same shot. Since this includes the clock errors for the NBP and the array, it is not satisfactory as a correction and it cannot be applied to the OBP.

Another method would be to calculate the $d\phi/dw$ for each instrument. Since these values are a function of the frequency of the seismograms the dominant frequency at each station would have to be determined.

In view of the above we have selected the following method, which is independent of the various clocks. A seismogram recorded by an OBP is Fournier transformed, the spectrum is divided by the transfer function for the OBP and then multiplied by the transfer function of the NBP and a new time series is obtained by applying a universe transform. The original wave form and the new waveform are cross-correlated to determine the difference in arrival time, and of course this amount is equal to the difference in the instrumental lag produced by the recording systems. The results of this procedure are listed in Table 5. The precision is about $\pm$ 2 ms or a quarter of the sampling interval. From the Table it can be seen that the differences in response are not particularly frequency dependent and can be approximated as 18 ms for all recording sites.

Similar differences were determined for the change from array to NBP and the results are listed in Table 6. Because of the larger uncertainty in the timing of the analog array with respect to the BP it is not surprising that the delays exhibit more scatter. However the average is not significantly different from 18 ms, with two exceptions. The method breaks down for station 20, for north shore shots, probably because of the relatively long period of the wave form that is usually contaminated by micro seismic noise. Another notable exception is station 60 for shots 112 and 18. For this case it has been determined that the amplifiers of the array at the transmitter site were malfunctioning and this method is no longer applicable because the transfer function of that station is unknown for these shots.

Cross Correlations

For each station changes in travel time were obtained for all the shots on the north shore and separately for all shots on the south shore. The data

are shown in Tables 8 and 9 respectively. The combined data are also plotted in Figure 3.

In Figure 3 the horizontal scale is time in years and cumulative days. At the top are the shot numbers. The vertical scale is in milliseconds, and represents changes in travel time, those above the horizontal line are delays and those below the line are advances with respect to some reference shot. For most stations the reference shot is 14 for the north shore shots and 108 for the south shore shots. The reference shot is arbitrary and was chosen because most stations have data at that time and is recent and therefore afflicated by fewer uncertainties. Note that for station 18 the reference shots were picked at different dates and this gives the impression that the residuals are different from one shot point to the other. The same can be said of station 30.

In addition to the clock corrections the corrections in Table 4 have been applied where necessary. All shot residuals are absolute with respect to the reference shots except the shots in 1982 i.e. 17, 18, 111 and 112. These are floating to the extent that their averages were adjusted to be zero with the averages of shots 16 and 110. As mentioned earlier the reason for this is that these shots were delayed by unknown amounts due to instrumental problems.

The lengths of the wave form used for cross-correlating is 100 samples at 120 samples/second. Generally the results are acceptable as evidenced by the high value of the cross-correlation function cc, with a few exceptions. Station 52 for shot 111 (52 (111)) and 58 for shot 17 (58 (17)) produce anomalous results and will be discussed in a later section.

It is also noted that for 10 out of 14 cases where a BP occupied an array site the agreement between them is from zero to 7 ms. The exceptions

are station 61 where the array is significantly later than the BP. This has now been resolved by recognizing that the array amplifers have been malfunctioning for at least the time including the June and October shots in 1982.

Travel Times

Arrival times and corrected travel times for the new shots are given in Table 10, together with estimates of their accuracy. This accuracy applies to the digitized sample that was estimated to be the first arrival and hence the estimate may be poor if the waveform is emergent. For sharp arrivals the estimate is good to within $\pm$ one half sample or + 4 ms. Inspection of Table 10 shows that 52 (111) is 94 ms earlier and 58 (17) 97 ms later than the average of the proceeding and succeeding shots. These differences are much too large to be accounted for by errors, a more detailed discussion of this discrepancy follows.

Peculiarities of 52 (111), 58 (17).

In earlier sections it was mentioned that the waveforms of 52 (111) and 58(M) do not cross-correlate with the preceeding nor following wave forms which give cc's of over .95 (Fig. 4). The arrival time of 58 (17) is later by 97 ms and that of 52 (111) earlier by 94 ms, however, in the later case we are dealing with a small amplitude arrival and a later large arrival followed by about 100 ms.

Spectra for 58 (17) and 52 (111) were calculated and they are significantly different from the preceeding and following shots. In searching for an explanation one is tempted to blame a malfunctioning seismometer, however it must be noted that for these two shots two vertical seismometers, a Wilmore Mark I and an L-4 were used and both produced identical wave forms.

At this time an explanation for the two anomalous seismograms cannot be provided. For convenience the problem is summarized in Table 11.

Errors

A summary of errors for shots up to 14 and 108 in 1979 is given in Table 12. The errors for the remaining shots is given in Table 13. The upper 4 lines give the instrumental and clock errors. The lower 4 lines give the R.M.S. errors for the various combinations of recording instruments. The last line gives the R.M.S. error when a BP and an array site record the same shot. Of the ten combinations in Tables 8 and 9 when this occurs the differences in delay range from 0 to 5m with one value at 7 ms. However, for the last value the drift of the BP clock is anomalously high. Therefore the R.M.S. errors in Table 13 are reasonable. The errors for the shots in 1981 do not include uncertainties for d-c offset.

Results and Recommendations

With the removal of the uncertainties caused by the hitherto unresolved data at station 60 the remaining data are consistent and show a general increase in velocity, either stepwise with the June 1980 shots or a continuous change. The few data points of June 1982 confirm this. The drift in travel time residual over the last 3-5 years has been up to 12 ms/year. On a percentage change in travel time the largest one occurred at Station 54 and amounts to 1.2% if the whole path is involved.

The continuing gradual but significant changes in travel time that are observed make it imperative to continue the experiment.

References

Buchbinder, G.G.R. Velocity changes in the Charlevoix Region, Quebec, Earthquake Prediction - An International Review. Maurice Ewing Series 4, A.G.U. 367-376, 1981.

Buchbinder, G.G.R. and C.M. Keith. Stability of travel times in the region of La Malbaie, Quebec, Bull. Seism. Soc. Am., 69, 463-481, 1979.

Buchbinder, G.G.R., R.D. Kurtz and A. Lambert. A review of time-dependent geophysical parameters in the Charlevoix Region, Quebec, accepted for publication Earthquake Prediction Research 1983.

Figure Captions

Fig. 1. Triangles represent seismometer stations, stars are shots points.

Fig. 2. Sketch of shot holes for shots including 108 to 112.

Fig. 3. a, b, c, d. Travel time delays for all stations. Solid bars are for shots on the north shore. Open bars are for shots on the south shore. Horizontal scale is time in years and days. Vertical scale is in milli seconds.

Fig. 4. Seismograms for the anomalous recordings for station 52 shot 111 top and station 58 shot 17 bottom. For reference the normal recording for station 52 shot 112 and station 58 shot 18 are also shown. In both cases the cross-correlation function cc is very low.

TABLE 1

St. Jerome Mine

List of Explosions

47.534°N 70.556°W

No.	Date	Hour	Charge Size Lb.	Kg.
1	19 June 74 (170)	17:08:09.305 UT	1000	450
2	13 July 74 (194)	17:11:06.752 UT	1000	450
3	23 July 74 (204)	17:26:08.925 UT	5000	2300
4	24 Sept 75 (267)	17:53:00.036 UT	5000	2300
5	15 Dec. 76 (350)	20:25:59.989 UT	500	230
6	31 Aug. 77 (243)	22:30:00.000 UT	2000	900
7	31 May 78 (151)	21:30:00.000 UT	1500	680
8	01 June 78 (152)	21:30:00.000 UT	500	230
9	24 Aug. 78 (236)	21:30:00.000 UT	2000	900
10	02 Nov. 78 (306)	05:00:00.000 UT	1500	680
11	02 Nov. 78 (306)	22:00:00.000 UT	1500	680
12	27 June 79 (178)	22:00:00.000 UT	1500	680
13	28 June 79 (179)	22:00:00.000 UT	500	230
14	06 Sept 79 (249)	22:00:00.000 UT	1500	680
15	04 June 80 (156)	21:50:00.000 UT	1500	680
16	16 Oct. 80 (290)	21:00:00.000 UT	1500	680
17	11 June 81 (162)	21:30:00.000 UT	1500	680
18	05 Nov. 81 (309)	21:30:00.000 UT	1500	680
19	10 June 82 (161)	21:30:00.000 UT	1500	680

TABLE 2

List of Explosions
La Pocatière Shot Hole

47.3500°N 70.0112°W

No.	Date	Hour	Charge Size Lb.	Kg.
101	06 Oct. 75 (280)	15:16:00.000 UT	1000	450
102	28 Oct. 76 (302)	16:26:00.000 UT	1000	450
103	16 Dec. 76 (351)	17:26:00.000 UT	2000	900
104	30 Aug. 77 (242)	23:30:00.000 UT	1500	680
105	30 May 78 (150)	21:30:00.000 UT	1000	450
106	23 Aug. 78 (235)	21:30:00.000 UT	1000	450
107	26 June 79 (177)	23:00:00.000 UT	700	320
108	05 Sept 79 (248)	22:00:00.000 UT	1000	450
109	05 June 80 (157)	22:00:00.000 UT	1000	450
110	15 Oct. 80 (289)	21:00:00.000 UT	1000	450
111	10 June 81 (161)	22:00:00.000 UT	1000	450
112	04 Nov. 81 (308)	22:00:00.000 UT	1000	450

TABLE 3

Station Coordinates

Station	Latitude N	Longitude W	Distances N-Shore Km	Distances S-Shore Km
10	47.2460	-70.1930	42.18	17.98
11	47.2430	-70.1970	42.24	18.42
16	47.4680	-70.0100	41.82	13.13
18	47.5190	-69.8640	52.18	21.84
20	47.7060	-69.6900	67.90	46.42
21	47.7040	-69.6900	67.84	46.23
30	47.3360	-69.9410	51.39	5.53
40	47.3408	-70.0094	46.52	1.03
50	47.7860	-70.7410	31.30	73.30
52	47.4270	-70.5200	12.21	39.39
54	47.4570	-70.4130	13.77	32.60
56	47.5500	-70.3270	17.34	32.61
58	47.5250	-70.2130	25.87	24.72
60	47.6920	-70.0930	39.02	38.55
61	47.6937	-70.0912	39.22	38.71
62	47.7520	-70.0090	47.75	44.73
64	47.8270	-69.8910	59.66	53.84
74	47.6330	-70.4610	13.11	46.28
76	47.6430	-70.2410	26.63	36.92
83	47.5217	-70.5540	1.38	45.21

TABLE 4

CORRECTIONS IN MS
(other than clock corrections)

Shot Nos.	BP	Array	Shot Point
14	-	-	-
108	-	-	-
15	+18	-	-
109	+18	-	-
16	+18	-27 except stn 60	-
110	+18	-27 except stn 60	-
17	+18	-	-91
111	+18	-	-91
18	+18	-	-50
112	+18	-	-58+
19	+18		

+May be improved upon in October 1982

TABLE 5

Instrumental Phase Delays
OBP to NBP in ms.

STN	SHOT NO. 18	17	16
52	18	18	
56	18	19	
58	19	18	
60	18	18	
62	18	18	
74	19	19	
76	18	19	
10	17	18	
18	18	18	
30	17	19	
40	17	--	
16			18
54			18

STN	SHOT NO. 112	111	110	109
52	18	19		
56	19	20	19	
58	19	19		
60	19	19		
62	18	19		
74	18	18	18	
76	19	19		
10	19	19		
18	18	19		
30	19	20		
40	18	--		
54			19	19
16			19	

TABLE 6

Instrumental Phase Delays
Array to NBP in ms

	SHOT NO.			
STN	112	111	110	109
54	14	12	20	13
60	45	18	18	--
64	14	17	18	17
10	17	22	19	17
16	17	16	14	13
20	14	17	16	12

	SHOT NO.			
STN	18	17	16	15
54	16	18	16	15
60	57	14	16	--
64	14	19	15	14
10	21	15	--	--
16	12	17	16	18
20	162	162	166	169

TABLE 7

Significant Changes

Type of change	Date	Starting with Shot No.
New BP	June 1980	15, 109
Station 60 becomes 61	05 June 1981	17, 111
Array high gain channels on one head	June 1981	17, 111
Station 40	Nov. 1981	112
Station 83	June 1982	19

TABLE 8

VALUES FROM CROSS-CORRELATION IN MILLISECONDS

SHOT JUL.D CUM.D	3 204 1	4 267 429	5 350 877	6 243 1136	7 151 1409	8 152 1410	9 236 1494	10 306 1564	11 306 1564	12 178 1801	13 179 1802	14 249 1872	15 156 2143	16 290 2278	17 162 2516	18 309 2663	19 161 2880
DATE / STN	23 7 74	24 9 75	15 12 76	31 8 77	31 5 78	1 6 78	24 8 78	2 11 78	2 11 78	27 6 79	28 6 79	6 9 79	4 6 80	16 10 80	11 6 81	5 11 81	10 5 82
60	A -13	A 9	BP 14	A 33	A -2	A -4	A -2	A -1	A -2	A -2	A 13	A 0	BP -3	A BP 0 -3	BP -10	BP -14	A -6
54	A -29	A -15	BP -6	A 2	A -12	A -1	A -6	A 5	A 2	A 2	A 13	A 0	A -23	BP A -30 -30	A -25	A -23	
64				A 3	A -9	A -1	A -3	A 5	A 5	A 3	A 13	A 0	A -19	A -29	A -22	A -21	A -36
11				A 8	A 1	A 8	A -3	A 9	A 7	A 6	A 17	A 0					
16					A -11	A 1	A -2	A 6	A 4	A 4	A 15	A 0	A -14	A BP -31 -34	A -26	A -23	A BP -38 -31
21				A 3	A -14		A -6	A 6	A 2	A 2	A 10	A 0	A -16	A -30	A -27	A -22	A -38
56			BP 4	BP 15	BP 0		A -2	A -3	A -4	A -1	A 16	A -2	BP -6	BP -8	BP -13	BP -21	
52					BP 2		BP 0	BP 2	BP 3	BP -2	BP 10	BP 0	BP -9	BP -9	BP -14	BP -16	
58	A -15	A 7		BP 19				BP 1		BP -4	BP 7	BP 0	BP -11	BP -15		BP -21	BP -11
74			BP 8	BP 19	BP -2		BP -2	BP -2				BP 0	BP -8	BP -12	BP -12	BP -13	BP -14
76				BP 20			BP -1	BP -2	BP -1	BP -5	BP 5	BP 0	BP -8	BP -9	BP -21	BP -22	
62					BP 1		BP 1	BP 1	BP 2	BP -2		BP 0	BP -6	BP -9	BP -15	BP -13	
18	A 0	A 15		BP 26									BP 26	BP 25	BP 22	BP 16	
30	A 0	A 15		BP 27	BP 6		BP 6			BP 4		BP -2	BP 7		BP -4	BP -2	BP 3
50								BP 0	BP 1								

Corrections

Shot No.	Ms
17	-91
18	-50

VALUES FROM CROSS-CORRELATION IN MILLISECONDS

SHOT JUL.D CUM.D	101 280 442	102 302 829	103 351 878	104 242 1135	105 150 1408	106 235 1493	107 177 1800	108 248 1871	109 157 2145	110 289 2277	111 161 2515	112 308 2662
DATE SIN	7 10 75	28 10 76	16 12 76	30 8 77	30 5 78	23 8 78	26 6 79	5 9 79	5 6 80	15 10 80	31 5 81	4 11 81
60	A 4	BP 25	BP 20	A 34	A -1	A 6	A -2	A 0	BP -3	A BP -2 -6	BP -7	BP -13
54	A -30		BP -13	A -9	A -17		A 0		A BP -36 -37	A BP -34 -37	A -35	A -33
64				A 5	A -9	A 7	A 5	A 0	A -24	A -28	A -27	A -22
11				A 5	A -5	A 5	A 0	A 0	A -16	A -29	A BP -31 -36	A BP -28 -33
16			BP -14		A -12	A 6	A -2	A 0	A -22	A BP -33 -34	A -30	A -30
21				A 5	A -11	A 5	A 1	A 0	A -23	A -30	A -32	A -28
56		BP 40	BP 37	BP 11	BP 1	A 3	A -6	BP 0	BP -12	BP -15	BP -17	BP -17
52					BP -1	BP 6		BP 0	BP -6	BP -15		BP -15
58	A -3	BP 20	BP 8	BP 11			BP -3	BP 0	BP -14	BP -14	BP -13	BP -17
74		BP 12		BP 19		BP 3		BP 0	BP -7	BP -13	BP -20	BP -16
76				BP 7	BP -2	BP 7	BP -3	BP 0	BP -11	BP -18	BP -23	BP -22
62				BP 9		BP 9	BP -4	BP 0	BP -6	BP -11	BP -17	BP -18
18	A 0			BP 5				BP -16	BP -12	BP -10	BP -21	BP -15
30	A 0				BP 1	BP 7	BP -6			BP -17	BP -22	BP -16
50												

Corrections

Shot No.	Ms
111	-91
112	-58

TABLE 10

TRAVEL TIMES FOR LA MALBAIE AREA SHOTS

SHOT	DAY	DATE	ORIGIN TIME	ERRORS	CORRECTIONS ALL IN MS
14	249	[illegible]	22 0 0.000	2 0	0 34 0 0

ST	INST	ARR.TIME	ERRORS	CORRECTIONS			TRAVEL TIME	+/- ERRORS
52	BP	[illegible]	4 5	2	-4	2 0	2.139	.007
56	BP	[illegible]	4 5	2	-2	2 0	2.977	.007
58	BP	[illegible]	4 5	2	-13	2 0	4.305	.007
62	BP	[illegible]	4 5	2	7	2 0	7.801	.007
76	BP	[illegible]	4 5	2	-14	2 0	4.479	.007
74	BP	[illegible]	4 5	2	-17	2 0	2.157	.007
60	A	[illegible]	4 5	2	[illegible]	0 0	6.496	.007
54	A	[illegible]	4 5	2	[illegible]	0 0	2.424	.007
64	A	[illegible]	4 5	2	[illegible]	0 0	9.682	.010
56	A	[illegible]	4 5	2	[illegible]	0 0	2.972	.007
21	A	11.31[illegible]	4 5	2	[illegible]	0 0	11.354	.010
16	A	[illegible]	4 5	2	[illegible]	0 0	7.220	.007
11	A	[illegible]	4 5	2	[illegible]	0 0	7.271	.007

SHOT	DAY	DATE	ORIGIN TIME	ERRORS	CORRECTIONS ALL IN MS
15	156	[illegible]	21 50 0.000	2 0	0 26 0 0

ST	INST	ARR.TIME	ERRORS	CORRECTIONS			TRAVEL TIME	+/- ERRORS
16	A	[illegible]	4 5	2	-17	0 0	7.199	.007
54	A	[illegible]	4 5	2	-17	0 0	2.408	.007
64	A	[illegible]	4 5	2	-17	0 0	9.660	.007
21	A	11.32[illegible]	4 5	2	-17	0 0	11.338	.007
56	BP	[illegible]	4 5	2	-12	3 0	2.962	.007
76	BP	[illegible]	4 5	2	-7	3 0	4.482	.007
74	BP	[illegible]	4 5	2	-14	3 0	2.138	.007
58	BP	[illegible]	4 5	2	0	3 0	4.358	.007
60	BP	[illegible]	4 5	2	-2	3 0	6.482	.007
52	BP	[illegible]	2 4	2	-13	3 0	2.129	.005
30	BP	[illegible]	4 5	2	-18	3 0	8.991	.007
18	BP	[illegible]	4 5	2	-24	3 0	8.865	.007

SHOT	DAY	DATE	ORIGIN TIME	ERRORS	CORRECTIONS ALL IN MS
16	290	[illegible]	21 0 0.000	2 0	0 13 0 0

ST	INST	ARR.TIME	ERRORS	CORRECTIONS			TRAVEL TIME	+/- ERRORS
54	A	[illegible]	4 5	2	31	0 0	2.420	.007
60	A	[illegible]	4 5	2	31	0 0	6.497	.007
64	A	[illegible]	4 5	2	31	0 0	9.679	.007
16	A	[illegible]	4 5	2	31	0 0	7.197	.007
21	A	11.[illegible]	4 5	2	31	0 0	11.300	.007
52	BP	[illegible]	4 5	2	52	3 0	2.127	.007
54	BP	[illegible]	4 5	2	29	3 0	2.305	.007
56	BP	[illegible]	4 5	2	-15	3 0	2.961	.007
58	BP	[illegible]	4 5	2	-41	3 0	4.366	.007
60	BP	[illegible]	4 5	2	-42	3 0	6.484	.007
62	BP	[illegible]	4 5	2	-35	3 0	7.793	.007
74	BP	[illegible]	4 5	2	-30	3 0	2.138	.007
76	BP	[illegible]	4 5	2	-26	3 0	4.461	.007
16	BP	[illegible]	4 5	2	-12	3 0	7.170	.007

SHOT	DAY	DATE	ORIGIN TIME	ERRORS	CORRECTIONS ALL IN MS
17	162	11. [illegible]	21 30 0.000	2 [illegible]	[illegible] 14 -91 0

ST	INST	ARR.TIME	ERRORS	CORRECTIONS			TRAVEL TIME	+/- ERRORS
54	A	[illegible]	4 5	2	22	[illegible] 0	2.378	.007
61	A	[illegible]	4 5	2	22	0 0	6.512	.007
64	A	[illegible]	4 5	2	22	0 0	9.644	.007
52	BP	[illegible]	4 5	2	-24	3 0	2.125	.007
56	BP	[illegible]	4 5	2	-18	3 [illegible]	[illegible]	.007
58	BP	[illegible]	4 5	2	-22	3 0	4.453	.007
60	BP	[illegible]	4 5	2	-21	3 0	[illegible]	.007
61	BP	[illegible]	4 5	2	-17	3 0	[illegible]	.007
74	BP	[illegible]	4 5	2	-21	3 0	[illegible]	.007
76	BP	[illegible]	4 5	2	-14	3 0	4.460	.007

SHOT DAY	DATE	ORIGIN TIME	ERRORS		CORRECTIONS ALL IN MS			
18 309	5.11.1981	21 30 0.000	2	0	0	6	-50	0

ST	INST	ARR.TIME	ERRORS		CORRECTIONS			TRAVEL TIME +/- ERRORS	
52	BP	2.173	4	5	2	-14	3	0	2.120	.007
56	BP	2.99?	4	5	2	-5	3	0	2.955	.007
58	BP	4.41?	4	5	2	-17	3	0	4.359	.007
61	BP	6.5?5	4	5	2	-17	3	0	6.512	.007
62	BP	7.82?	4	5	2	-6	3	0	7.783	.007
74	BP	2.172	4	5	2	0	3	0	2.133	.007
76	BP	4.50?	4	5	2	-26	3	0	4.439	.007

SHOT DAY	DATE	ORIGIN TIME	ERRORS		CORRECTIONS ALL IN MS			
108 248	5. 4.1979	22 0 0.000	2	0	0	35	0	0

ST	INST	ARR.TIME	ERRORS		CORRECTIONS			TRAVEL TIME +/- ERRORS	
52	BP	6.911	4	5	2	-4	2	-5	6.938	.007
56	BP	5.81?	4	5	2	-4	2	-5	5.840	.007
58	BP	4.58?	4	5	2	-6	2	-4	4.607	.007
76	BP	6.52?		5	2	-7	2	-3	6.552	.010
74	BP	7.953	4	5	2	-7	2	-5	7.988	.007
62	BP	7.71?	4	5	2	-3	2	0	7.744	.007
11	A	3.54?	4	5	2	-6	-5	0	3.562	.007
16	A	2.67?	4	5	2	-5	0	0	2.697	.007
21	A	8.32?	4	5	2	-6	3	0	8.352	.007
64	A	9.1??	4	5	2	-6	1	0	9.159	.006
60	A	6.80?	4	5	2	-6	-1	0	6.826	.007

SHOT DAY	DATE	ORIGIN TIME	ERRORS		CORRECTIONS ALL IN MS			
109 156	5. 6.1980	22 0 0.000	2	0	0	24	0	0

ST	INST	ARR.TIME	ERRORS		CORRECTIONS			TRAVEL TIME +/- ERRORS	
56	BP	5.80?	4	5	2	-1	3	-1	5.825	.007
76	BP	6.50?	4	5	2	2	3	-2	6.536	.007
74	BP	7.9??	4	5	2	0	3	-1	7.961	.007
58	BP	4.559	4	5	2	3	3	-1	4.590	.007
60	BP	6.79?	4	5	2	3	3	-2	6.821	.007
52	BP	6.89?	4	5	2	-2	3	0	6.917	.007
64	A	9.177	4	5	2	-10	3	0	9.191	.007
54	A	5.80?	4	5	2	-10	3	0	5.815	.007
11	A	3.454	4	5	2	-10	1	0	3.468	.007
16	A	2.743	4	5	2	-10	0	0	2.757	.007
21	A	8.32?	4	5	2	-10	0	0	8.340	.007
54	BP	5.51?	4	5	2	2	3	-1	5.543	.007
62	BP	7.71?	4	5	2	-3	3	-2	7.732	.007

SHOT DAY	DATE	ORIGIN TIME	ERRORS		CORRECTIONS ALL IN MS			
110 289	15.10.1980	21 0 0.000	2	0	0	16	0	0

ST	INST	ARR.TIME	ERRORS		CORRECTIONS			TRAVEL TIME +/- ERRORS	
60	A	6.80?	4	5	2	11	-4	0	6.828	.007
64	A	9.1??	4	5	2	11	-3	0	9.186	.007
11	A	3.53?	4	5	2	11	1	0	3.560	.007
21	A	8.37?	4	5	2	11	-3	0	8.396	.007
52	BP	6.91?	4	5	2	-14	3	-2	6.918	.007
56	BP	5.83?	4	5	2	-29	4	-5	5.824	.007
58	BP	4.60?	4	5	2	-33	4	-4	4.586	.007
60	BP	6.82?	4	5	2	-23	3	-4	6.820	.007
62	BP	7.75?	4	5	2	-27	3	-4	7.750	.007
74	BP	7.97?	4	5	2	-34	3	-3	7.961	.007
76	BP	6.58?	4	5	2	-32	3	-4	6.567	.007
16	BP	2.67?	4	5	2	-13	3	-4	2.676	.007
18	BP	3.97?	4	5	2	-16	3	-3	3.968	.007
30	BP	1.1??	4	5	2	-11	3	2	1.208	.007

SHOT DAY	DATE	ORIGIN TIME	ERRORS		CORRECTIONS ALL IN MS			
111 161	10. 6.1981	22 0 0.000	2	0	0	20	-91	0

ST	INST	ARR.TIME	ERRORS		CORRECTIONS			TRAVEL TIME +/- ERRORS	
61	A	6.90?	4	5	2	11	-2	0	6.843	.007
64	A	9.1??	4	5	2	11	-2	0	9.167	.007
11	A	3.5??	4	5	2	11	1	0	3.531	.007

16	A	[illegible]	4	[illegible]	2	11	-2	0	[illegible] .007
21	A	5.431	4	[illegible]	2	11	-2	0	5.369 .007
52	BP	[illegible]	4	[illegible]	2	-13	3	0	6.819 .007
56	BP	5.904	4	[illegible]	2	-11	3	-1	5.824 .007
58	BP	4.668	4	[illegible]	2	-12	3	-1	4.587 .007
60	BP	[illegible]	4	[illegible]	2	-13	3	-2	6.813 .007
61	BP	[illegible]	4	[illegible]	2	-12	3	-2	6.827 .007
62	BP	7.721	4	[illegible]	2	-9	3	-2	7.712 .007
11	BP	[illegible]	4	[illegible]	2	-5	3	1	3.518 .007
18	BP	[illegible]	4	[illegible]	2	-9	3	-2	3.991 .007
30	BP	1.273	4	[illegible]	2	-12	3	1	1.194 .007

SHOT DAY	DATE	INIT. TIME	ERRORS	CORRECTIONS ALL IN MS
112 305	4.11.1981	[illegible] 0 0.000	2 0	0 12 -58 0

ST	INST	ARR.TIME	ERRORS	CORRECTIONS			TRAVEL TIME +/- ERRORS
52	BP	[illegible]	4 [illegible]	2	-8	3 2	[illegible] .007
56	BP	[illegible]	4 [illegible]	2	0	1 1	[illegible] .007
58	BP	[illegible]	4 [illegible]	2	-7	3 [illegible]	[illegible] .007
61	BP	[illegible]	4 [illegible]	[illegible]	-6	[illegible] -1	[illegible] .007
62	BP	7.751	4 [illegible]	2	-9	3 -2	7.727 .007
74	BP	[illegible]	4 [illegible]	2	-3	3 1	7.957 .007
76	BP	[illegible]	4 [illegible]	2	-4	3 0	6.527 .007
11	BP	[illegible]	4 [illegible]	[illegible]	-35	3 3	3.527 .007
18	BP	[illegible]	4 [illegible]	[illegible]	-34	3 -3	3.987 .007
30	BP	[illegible]	4 [illegible]	2	-26	3 -2	1.207 .007
40	BP	[illegible]	4 [illegible]	2	-1[illegible]	3 1	.251 .007

TABLE 11

Station 58

	Shot No.		
	16	17	18
Travel times in sec.	4.366	4.463	4.367
difference		+.097	

Station 52

	Shot No.		
	110	111	112
Travel times in sec.	6.918	6.829	6.928
difference		-.094	

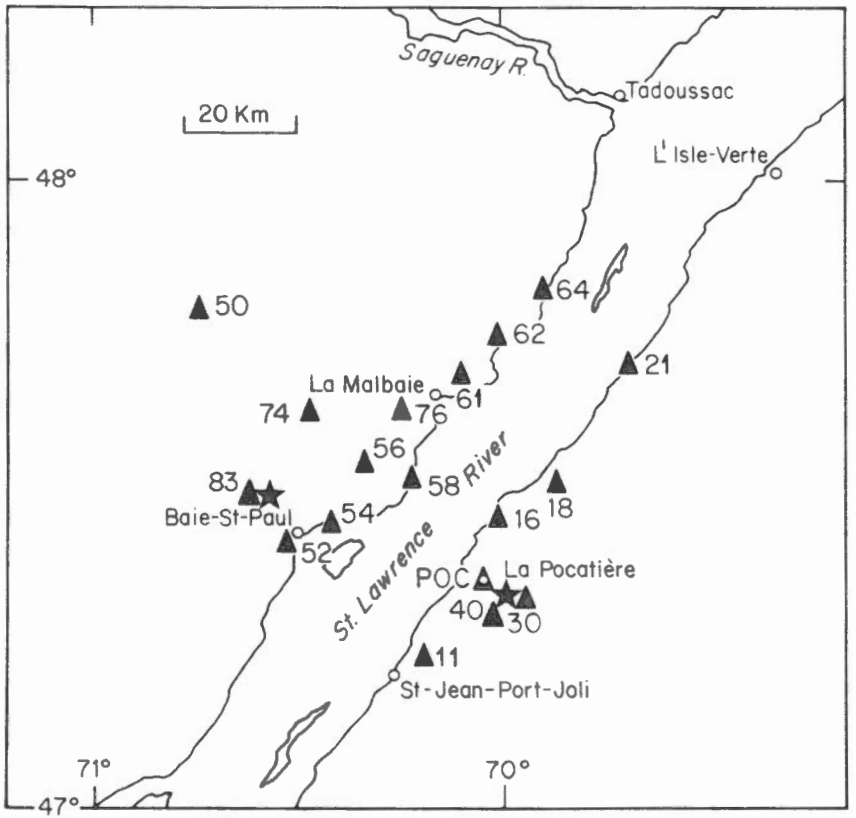
	Cross-Correlation Function cc	
58	16 x 17	15 x 18
	.432	.950
52	110 x 111	109 x 112
	.261	.981

TABLE 12 SUMMARY OF ERRORS

3	4	5	6	7	8	9	10	11	12	13	14	SHOT
	101	102 103	104		105	106			107		108	NUMBERS
1974	1975	1976	1977	1978					1979			YEAR
4	4	4	4	4	4	4	4	4	4	4	4	Array digit.
	2	2	2	2	2	2	2	2				Blaster box
	2	2	2	2	2	2	2	2	2	2	2	Shooter clock
2	2	2	2	2	2	2	2	2	2	2	2	Recorder clock
7												Commerc. blaster
		8	8									BP Micropr.
5	5	5	5	5	5	5	5	5	5	5	5	BP-A
		9	9	5	5	5	5	5	4	4		BPxBP
10	7	7	7	7	7	7	7	7	7	7		A x A
		11	11	8	8	8	8	8	8	8		BPXA

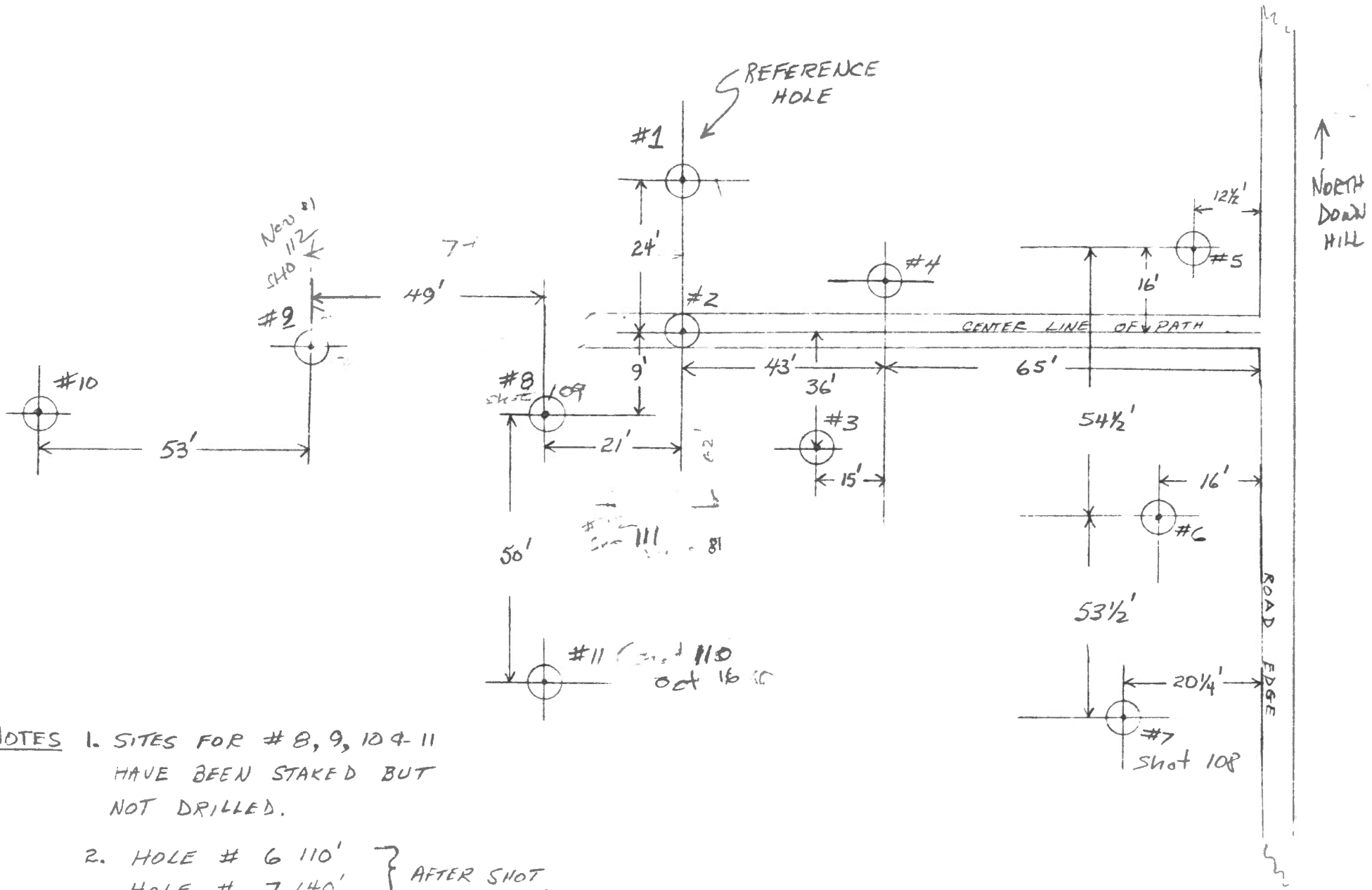
TABLE 13
SUMMARY OF ERRORS

	CHOT NUMBERS	14 108	15 109	16 110	17 111	18 112	19
	YEAR	1979	1980		1981		1982
ARRAY	Array Digit	4	4	4	4	4	4
BP	Shooter Clock	2	2	2	2	2	2
	Recorder Clock	2	2	2	2	2	2
	BP - A	5	5	5	5	5	5
RMS	BP x BP	4	4	4	4	4	4
	A x A	7	7	7	7	7	7
	BP x A	8	8	8	8	8	8
	BP x A Same Shot	7	7	7	7	7	7


Saguenay R.
Tadoussac
20 Km
L'Isle-Verte
48°
50
64
62
21
La Malbaie
61
74
76
56
58
River
83
Baie-St-Paul
54
16
18
52
St. Lawrence
POC
La Pocatière
40
30
11
St-Jean-Port-Joli
71°
70°
47°

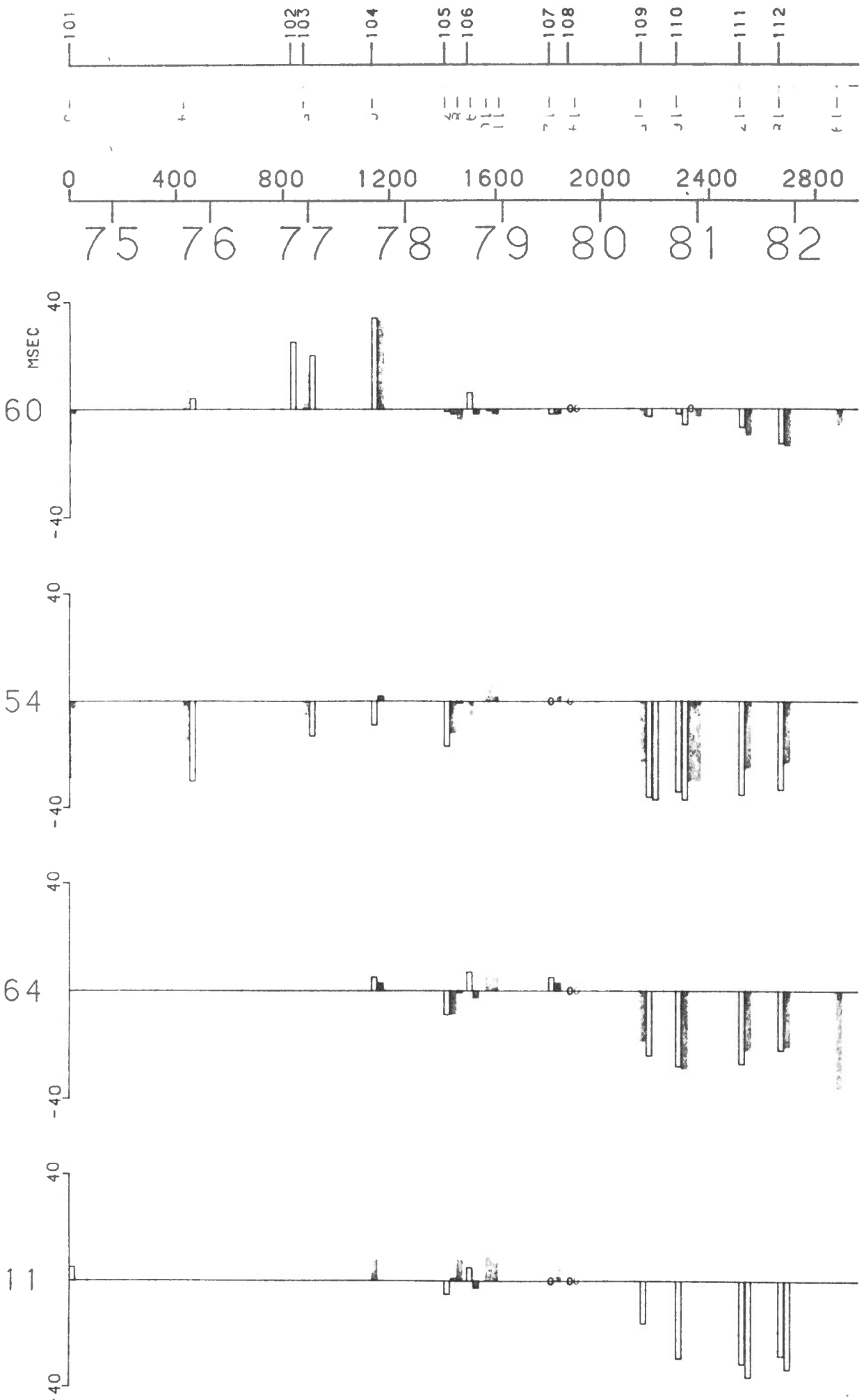
LAPOCATIERE SHOT POINT

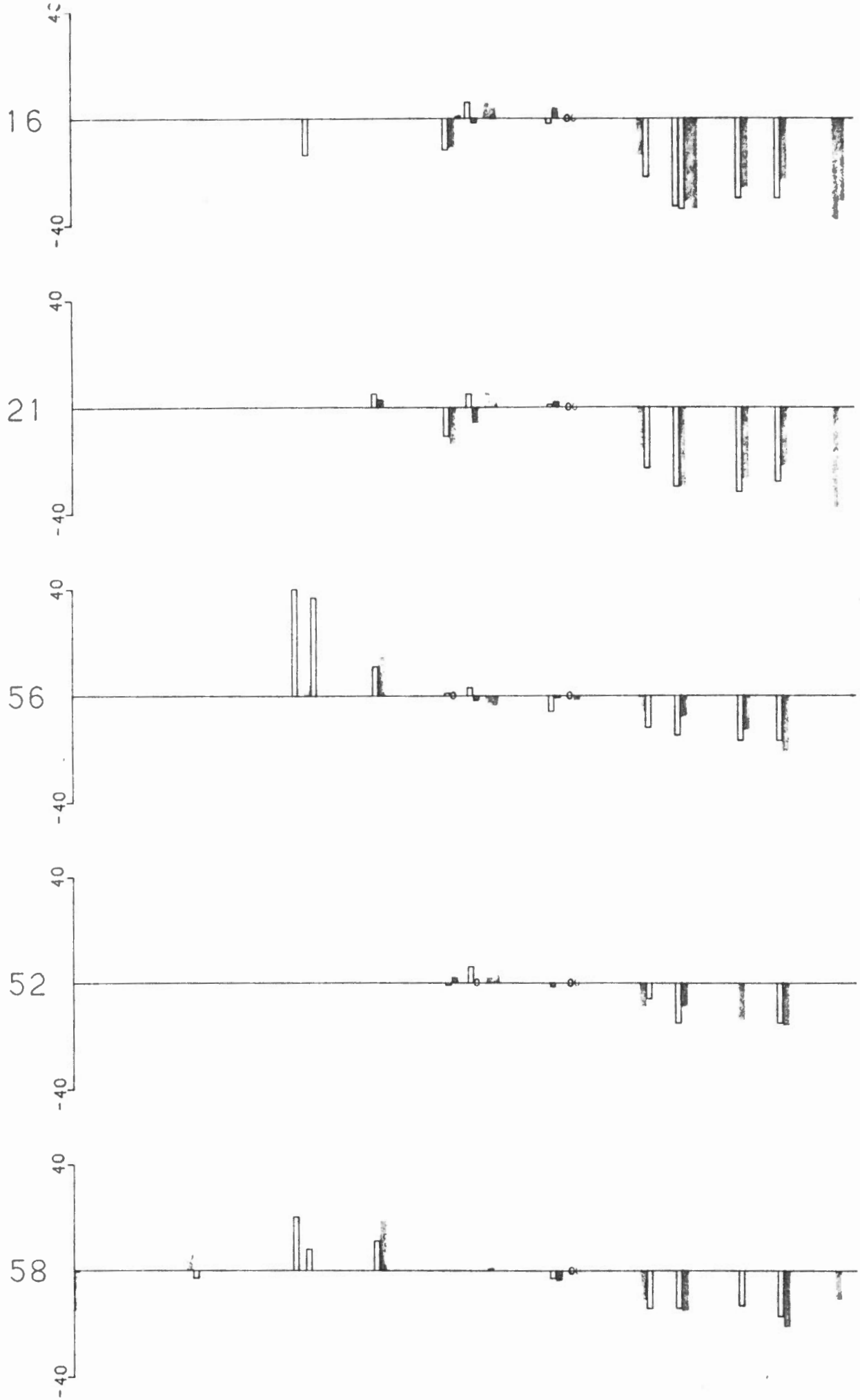
17 SEPT 1979
J.T.



NOTES 1. SITES FOR #8, 9, 10 & 11 HAVE BEEN STAKED BUT NOT DRILLED.

2. HOLE # 6 110' } AFTER SHOT
HOLE # 7 140' } 5 SEPT 79


101
102
103
104
105
106
107
108
109
110
111
112
0
400
800
1200
1600
2000
2400
2800
75
76
77
78
79
80
81
82
MSEC
40
-40
60
54
64
11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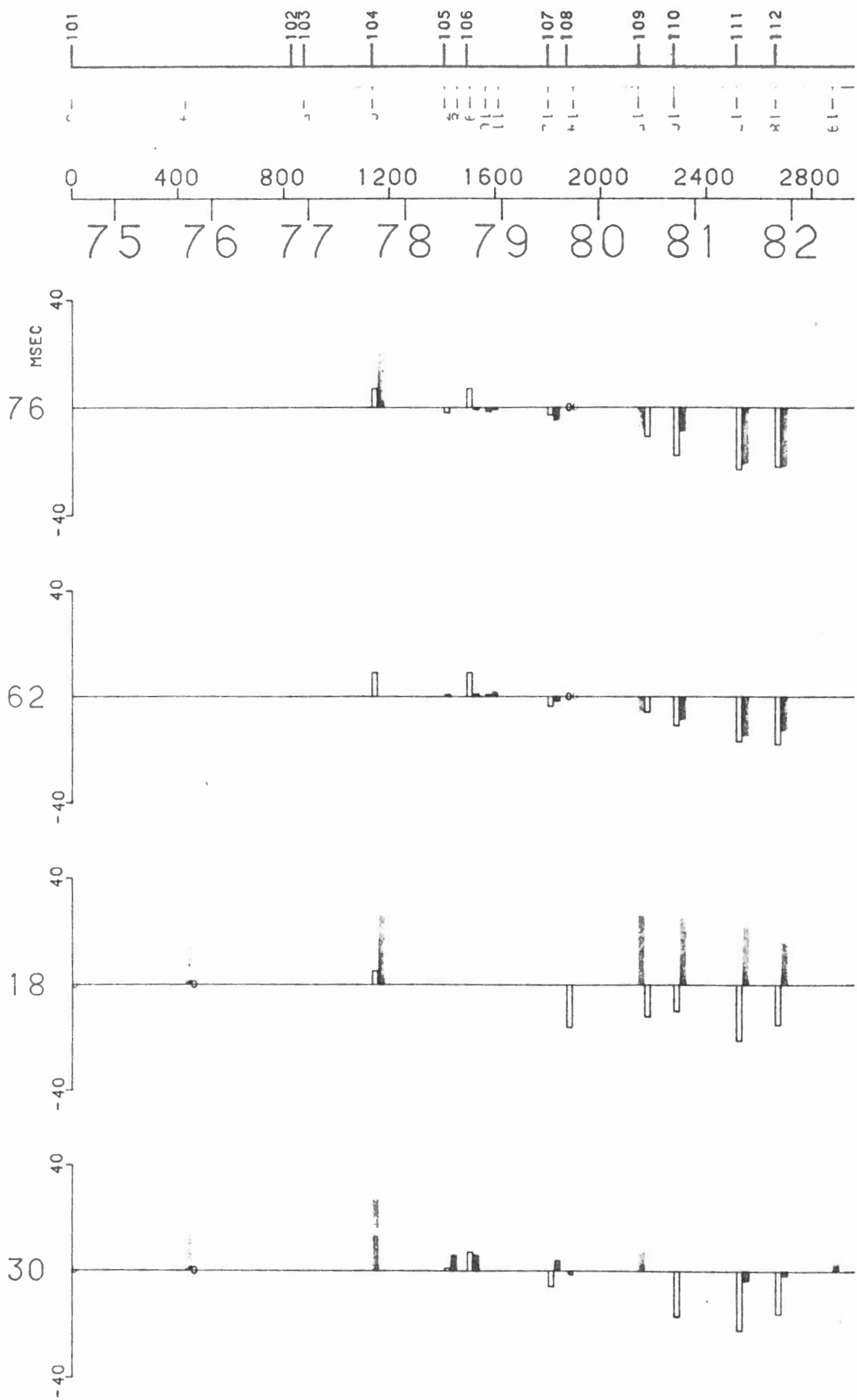
40
-40
21
40
-40
56
40
-40
52
40
-40
58
40
-40


101
102
103
104
105
106
107
108
109
110
111
112
0
400
800
1200
1600
2000
2400
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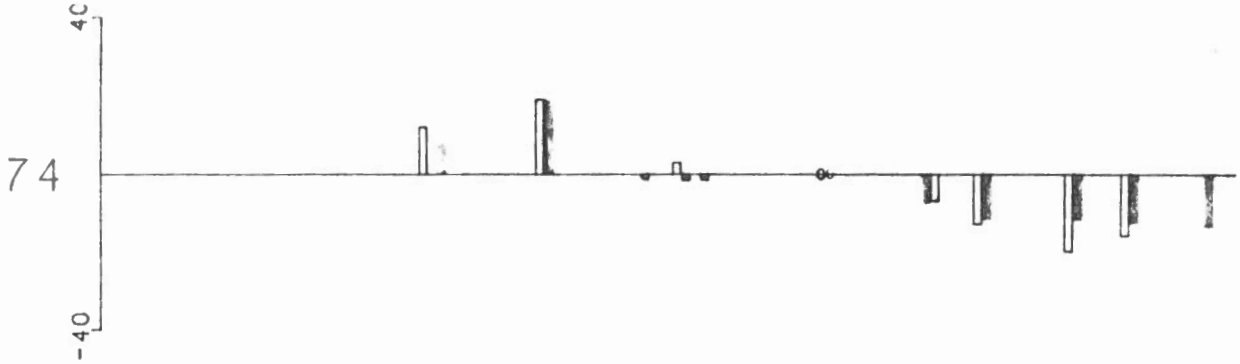
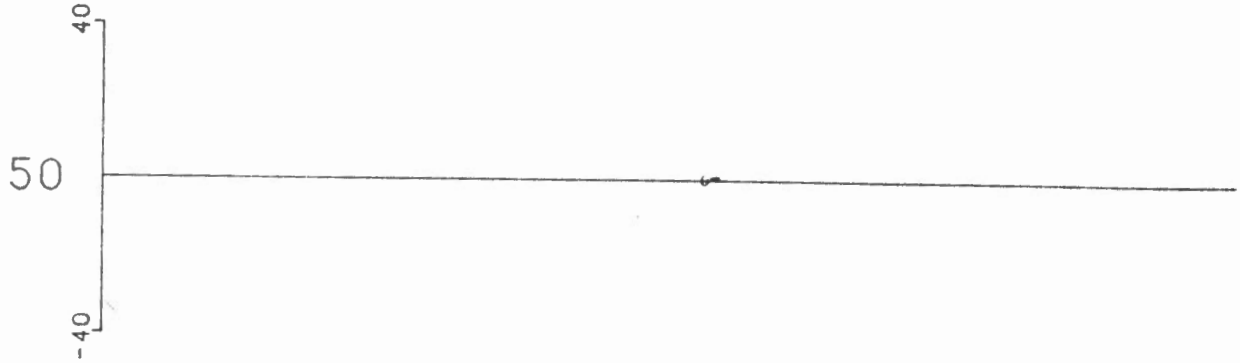
81
82
MSEC
40
-40
76
62
18
30


74
40
-40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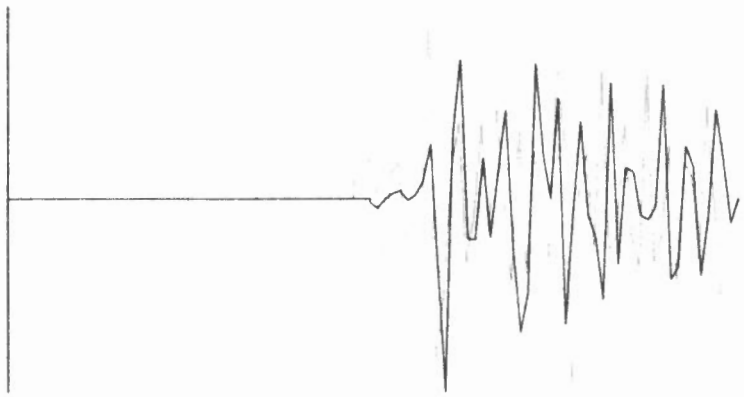
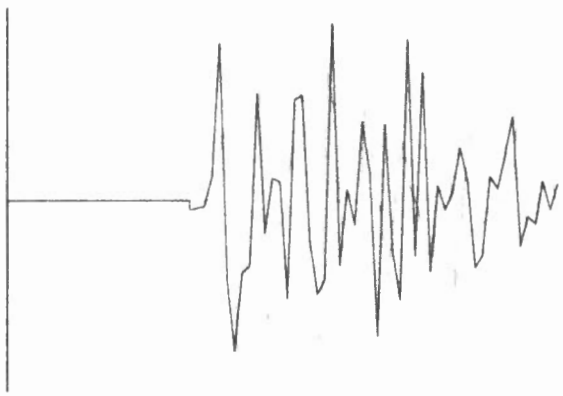


BP52 112 4 NOV 81 22 0 0 6



BP58 18 5 NOV 81 21 30 0 4