La Malbaie
Experiments to June 1979

by

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APPENDICES

SUMMARY

As a continuation of the La Malbaie experiment two shots Nos. 106 and 107, have been set off at the Experimental Farm in La Pocatière. Five further shots No. 9, 10, 11, 12 and 13 have been detonated in the mine at St. Jerôme. The details for all of these are given in Table 1.

Shots 10 and 11 were set off in November 1978 and are referred to as the Tide Test Shots. As the name implies, these were intended to test the hypothesis that the solid earth tide induces changes in velocity. The experiment showed that no travel time changes of more than ± 2 ms occurred, thus effectively refuting the hypothesis.

Shots 106 and 9 (August, 1978), and 107 and 12 (June, 1979) served to monitor travel times. The result of these experiments is that stations outside the crater show no changes. Some stations inside the crater continue to show significant changes in travel time. Finally, Shot 13 was also exploded in June. It was intended to provide and did near-source wave data, and for that purpose two new temporary stations were established at 2 and 5 km from the mine. This shot also produced an average shot residual of about 10ms that poses an interesting problem for its interpretation.

The six element portable array was still operating for all these shots. In addition, station 56 was recorded on the array tape for all shots. Thus there are fortunately, seven array records. Only five of the six Mark I Backpacks that were deployed operated.

Absolute P travel times were determined and the data were also analyzed by cross-correlation, with, if possible, two previous shots, one the earliest shot recorded at each station and then the most noise-free record in the series. As mentioned above some stations continue to show significant changes in travel time. All travel time and cross-correlation data will be presented here again for completeness and convenience. The most notable change in the experiment is that Shots 107, 12 and 13 were set off with the new delayless shooter box. Thus the -35 ms correction that applied to the previous shots no longer occurs.

Experiments

The stations and shot points are shown in Figure 1. Table 1 contains all the parameters for the shots; date, hour and size. Shot No. 106 was set off in hole number 5 on the Experimental Farm on 23 August 1978. Four hundred and fifty kg of Geogel were used. A diagram of relative hole numbers is given in Figure 2.

On 26 June 1979, Shot No. 107 was first loaded in holes 5 and 4 which had been used previously. The holes however, could not be properly loaded and 320 kg was loaded and detonated in shot hole number 6 instead. Only hole number 7 now remains unused.

In the mine at St. Jerôme, Shot No. 9 was set off on 24 August 1978. The Tide Test shots No. 10 and 11 were set off on 2 November 1978. On 27 June 1979 Shot No. 12 was set off. All of these were 680 kg except for No. 9 which was 900 kg.

Finally, on 27 June 1979 a 230 kg shot was set off. This was primarily intended to supply near source data. It was not anticipated that it be recorded on the south shore and therefore stations 30 and 62 were not occupied by Backpacks. The instruments from these stations were placed near the mine instead.

Stations

The station sites are shown in Figure 1, those labelled with an A are array sites. For the shots described here station 56 was also recorded on the array tape. Because of transmission problems this had previously not always been possible. The other sites in Figure 1 were occupied by Backpacks. The details for each shot are in tables further on in this report. Station 18 was not occupied for any of these shots.

For the Tide Test Shots station 30 was not occupied. Instead a new site 50, well out of the crater, 31 km north of the mine was occupied. For Shot No.13, the source investigation, stations 30 and 62 were not occupied. Instead, two near source stations 80 and 82 at 2 and 5 km respectively from the mine were established. The coordinates of the new stations are given in Appendix A and the epicentral distances for all stations from La Pocatière in Appendix B. Appendix C shows similar data for the St. Jerôme mine shot point.

Improvements and Changes

Shots 106, 9, 10 and 11 are still corrected for the blaster box delay of 35 ms. For Shots 107, 12 and 13 the new, essentially delayless, blaster box was used. The delay of this box is microseconds rather than milliseconds and this means that the 35 ms correction to the origin time no longer occurs.

For Shots 106, 9, 10 and 11, all clocks were kept running continuously and not advanced nor delayed between each shot. For Shots 107, 12 and 13 the north shore Backpacks and for Shots 12 and 13 the shooter clock was reset to the master clock before each shot, so that no continuous clock drift rate was obtained and this could be a factor in the change in arrival times for Shot No. 13.

Site 60 has now been surveyed and the time correction to be applied to the old site 60 is now known to be -9 ms for the mine shot point and + 8 ms for the Experimental Farm shot point. This correction was discussed in the same section, paragraph d, of the last Internal Report #78-7.

Travel Times

Arrival times and corrected travel times for all shots are given in Tables 2 and 3. The line containing information on each shot gives the Shot Number, the day number, the date and origin time. Following this are three spaces for errors concerning the shot time, these are followed by up to three corrections concerning the shot time. The sign of the corrections is such that they will be applied to the arrival time. For the latest shots 107, 12 and 13, fired with the delayless blaster, there is only one correction and one error, that due to the shooter clock. Somewhat earlier shots have one additional error and correction, that due to the blaster box. Shots 104 - 105 and 6 - 8 have a third error, that due to the instruments. Shots earlier than this were set off without time pulses and one combined error for origin time of ± 8 ms is given.

The lines giving information on recording stations contain the following data: station number, recording instrument type and arrival time, which is followed by up to three errors concerning arrival time. This is followed by up to three corrections, finally the travel time and R.M.S. error is given. The three errors are the uncertainty in reading the phase, the recording instrument error and the clock correction error. The three corrections are the (1) recording clock correction, (2) for Backpacks the program correction and for the south shore shots (3) the shot point migration correction. For earlier shots where the recording instrument error was not given with the origin time, it is found with the station data.

Cross-correlations

The cross-correlation results for the last three sets of shots are given below. However, it is no longer economic to give all combinations for a station. Therefore, here we present the newer data with only one or two older shots. The cross-correlation results for the August 1978 shots, 9 and 106, are given in Tables 4 and 5 respectively, each was correlated with one older shot.

Table 6 contains the Tide Test data of Shots 10 and 11 that were cross-correlated with each other and with Shots 6 and 9. Here it is noteworthy that Shots 10 and 11 agreed with one another within 0 to ± 2 ms, except station 21 where the difference was -4 ms. For these Tide Test shots the error is smaller than for the other travel time shots for two reasons: cross-correlations are only Backpack-to-Backpack and array-to-array so that the 5 ms instrumental error is no longer applied and no older shots are involved. Therefore the BP-to-BP error is as follows. For each BP the errors consist of shooter clock error, recorder clock error and shooter relay error of 2 ms each, therefore the total error is $\{2(3 \times 2^2)\}^{\frac{1}{2}} = \pm 5$ ms. For each array seismogram the errors consist of the same errors as above plus the digitizing error of 4 ms so that we have $\{2(4^2 + 3 \times 2^2)\}^{\frac{1}{2}} = \pm 7$ ms. Thus the 11 data points from the Tide Test shots are in good agreement with each other and considerably below the level of the combined error, at worst half the admitted errors.

Tables 7 and 8 contain the cross-correlation data of the most recent shots of June 1979, that is 12, 13 and 107. They were cross-correlated with each other and each with the oldest shot at each station and the one with the best signal to noise ratio. As mentioned before, Shot 13 was mainly intended to give near source information, and only 230 kg instead of the usual 680 kg of explosive were used. However the wave-forms of the two shots are identical, at least to the naked eye. We will demonstrate this in diagrams later.

Discussion of the Data

(a) Tide Test Shots

In order to test the hypothesis that the solid Earth tide causes changes in velocity, the Tide Test shots were undertaken. Essentially there were two reasons for this. First, there had been reports in the literature of very near surface changes in velocity due to the Earth's tide. Secondly, statistical analysis of travel time changes and changes in tide for 7 data points, giving 5 degrees of freedom, of mine shots recorded at stations 54 and 60 gave significant correlations. For station 54 the probability against correlation was .1% and for station 60 it was 10%. This is shown in Figure 3. Data points and least squares lines labelled 'r' refer to station 54, those labelled 'g' refer to station 60. The changes in travel time extended over about 50 ms while the changes in gravity extended over about 65 μ gals. Thus if these changes in travel time were due to tide, then undertaking an experiment when the tide differences are about 200 μ gals. should produce changes in travel time of 150 ms.

Since in early November 1978 tidal differences of 220 μ gals. were expected, the experiment was planned for 2 November 1979 at 05 and 22 hours U.T. The observed difference in travel time at station 54 was -2 ms and at station 60 0 ms. Seven other stations recorded similar changes. Station 21 had a difference of -4 ms. In addition a new temporary station, 50, had been installed 31 km NNW of the mine, well removed from the crater, here also no change in travel time was observed. The large circles in Figure 3 are the data points for the Tide Test shot. Admitting errors of ± 5 ms for BP-to-BP cross-correlation and ± 8 ms for array-to-array cross-correlation, no significant change in travel time was observed for changes of 220 μ gals in the vertical component of the earth's tide. The Tide Test shots are also an indication of the accuracy and precision of our experimental method and analysis.

(b) Calibration Shots of 1978 and 1979

The calibration shots of August 1978 and June 1979 together with the Tide Test shots on the north shore extend the time of this series by another 400 days. Thus from the mine shot point we now cover 1800 days and for the south shore 1359 days. The north shore data are summarized in Figure 4 and the south shore data in Figure 5. In these Figures there is one column for each shot, with the shot number, the shot day, the cumulative shot day and date being given at the top. The rows are the station data. The first zero on the left indicates the first shot at a station. The numbers on the right are the changes in ms from the first shot. The letters BP and A refer to Backpack or array observations respectively, and blanks indicate no observations. Finally Station 10 changes to station 11 with Shot 6.

The changes in travel time from cross-correlation are also shown graphically in in Figures 6 and 7 for the north shore shot point in the mine. Similarly, Figures 8 and 9 show the summary of the cross-correlation results for the south shore shot point at La Pocatière.

Interpretation

(a) General

Significant changes in travel time do occur but there is no simple, obvious pattern or trend. Later in section (b) we will argue that Shot 13 is anomalous and would better fit a trend at many stations if it were reduced by about 10 ms. Considering this correction, we can see the following trends in the data. Station 54 from both shores shows a steady increase in anomaly to 30 ms. Stations 58 and 60 from the north shore show an increase to 1977 of 34 and 46 ms respectively, then a drop of 30 ms occurred with no change since then. From the south shore station 60 shows the same behaviour but the 1977 maximum is only 30 ms. For station 58 the changes are even smaller than for the north shore and the maximum may have occurred one year earlier. Station 76 from the north shore started only in 1977 but shows a decrease of 26 ms since then. Station 56 from the south shore started only in 1976 but shows a steady decrease to 46 ms since then.

Of the south shore stations, No. 30 shows an increase to 1977 of 26 ms then a decrease of 20 ms and no change since then. This is quite similar to station 60. Thus, if we regard the data from station 60 as defining a trend, an increase to 1977 and then a drop followed by no change; then stations 58 and 30 follow this. Station 54 deviates from the trend by continuing to increase after 1977, but Station 76 decreases since 1977 and station 56, from the south shore, decreases since 1976.

It may be interesting to determine the change in anomaly with time. For station 60, the rate from start to maximum is + 4 ms/100 days (ms/cd) and for station 54 about half this. On the other hand the changes for stations 56 and 76 are -4.7 ms/cd and -3.8 ms/cd.

In an attempt to extract more information than that given above we will start our more detailed discussion with the latest data because the errors are smaller than with the earlier data.

(b) Shots 12 and 13

Shots 12 and 13 were set off at 2200 U.T. on 27 and 28 June 1979 respectively, thus separated by 24 hours. For each shot, each station was occupied by the same instruments. Ten stations recorded both shots and the cross-correlation data from Table 7 show that shot 13 was systematically later than Shot 12. For station 56 the difference is 18 ms. For the other 9 stations the difference varies from 8 to 12 ms with an average of 10.6 ms. This difference is larger than the experimental errors and we have to accept that the difference is significant and real. It is difficult to argue that the experimental errors for Shot 13 are larger than for Shot 12. We may conclude that this results from a near source anomaly that affects the path to station 56 more than to the other stations.

In order to demonstrate that the difference in shot size did not produce different wave trains, we show in the top of Figure 10 the wave forms of the two shots recorded at station 56. The cross-correlation analysis gives an 18 ms difference between the two shots. Here the waveforms are aligned to give maximum cross-correlation coefficient. The frequency of the first cycle is 20 Hz or has a period of 50 ms, therefore 18 ms is a very large fraction of one cycle. In order to demonstrate that 13 ms for these frequencies is indeed a large fraction of a cycle, we also plotted the two wave trains but offset by 18 ms with respect to one another. This is shown in the bottom of Figure 10. It is obvious that a shift of 18 ms is readily detectable with the naked eye.

In Figure 11 we show similar data for station 58, here the shift from cross-correlation is 12 ms and the first cycle has a frequency of 10 Hz, or has a period 100 ms so that the shift is 10% of the first cycle. The bottom of Figure 11 shows that this is detectable when the wave trains are off set by 12 m. Thus we will assume that the observed difference is real. An interpretation of this is given below. These examples also demonstrate that there is no obvious difference in the waveforms from Shots 12 and 13, inspite of their difference in charge size.

To interpret the observation in terms of the dilatancy hypothesis we can argue that on 27 June 1979 at 2200 hours the state of stress around the shot point was regional. By 28 June at 2200 hours, that is 24 hours later, dilatancy had started near, and east of the shot point and produced an anomaly that manifested itself by changes in travel time of between 11 to 18 ms.

On 5 July 1979 at 12:25 a magnitude 2.9 earthquake occurred at 47° 22.3'N and 70° 24.2'W, which is under the southern end of the Isle aux Coudres.

The event occurred thus 8.5 days after Shot 12. According to the dilatancy hypothesis there is a relation between length of the anomalous period and magnitude. From the empirical data of Whitcombe et al. for a magnitude 3 event, the duration of the anomaly is 8.5 days. From Anderson et al. the length of the dilatant zone is Log (L dil.) = 2.6 M + .46, which gives L = 17 km for M = 3. Therefore the beginning of the anomaly to the time of earthquake interval is in agreement with the magnitude of the earthquake.

Even if we assume that the ray path from the source to station 56 traversed the entire dilatant zone of 17 km, a change in velocity of .04 km/sec or .7% would produce a change in travel time of 18 ms. Thus for that path length the size of the velocity change is smaller than the 4% of 15% reported in the literature. If the path length is only 2 Km the velocity change would be about 7.0%.

If the above is correct, we can combine it with the interpretation presented in the previous section and suggest that the variations that we are observing have two components, a long term trend of 2 - 5 ms/cd on which are superimposed short term anomalies of 10,000 to 18,000 ms/cd.

(c) Analysis of the Earlier Data

In light of the apparent interesting correlation of Shot 13 with a magnitude 3 earthquake, one is tempted to search for similar correlations in the earlier data. Thus we could attempt to separate anomalies at a station due to small earthquakes from the long term trends that may be due to a future large event.

In consideration of the above we have determined the average shot residual (ASR) for each shot. However, before determining the ASR all the data had to be adjusted to some common arbitrary datum, since the residuals in Figures 6 - 9 are always with respect to the earliest shot, which is not the same for all stations. Thus all residuals for a station were corrected by a constant (= residual for Shot 12) so that the residual for Shot 12 is zero. Shot 12 was chosen because it was recorded by the largest number of stations. After all stations were corrected the ASR was calculated for each shot, then they were subtracted from each shot. This results in a reduced residual, (RR) and these are shown for the St. Jerôme mine shots in Figures 12 and 13. At the bottom of Figure 13 are also shown the ASR. Similar data for the La Pocatière shot point are given in Figures 14 and 15. Here we took shot 107 as base with the ASR at the bottom on Figure 15.

If the shot residuals are zero, it not only means that there was no long nor short term average change between Shot 12 and the other shot, but there was no significant error in the shot time, unless fortuitously one cancels the other. If the ASR are not zero, at least three interpretations are possible: (1) it is due to small earthquakes in the region of the shot point, (2) it is due to timing errors of the shot instant, (3) it is due to the long term trend. Unfortunately any combination of the above is possible and any interpretation based thereon has to be considered critically.

Of the 11 mine shots, 8 are very nearly zero and we can have some confidence in the data, that is the ASR and RR. The ASR for Shots 3, 6 and 13 are not zero. For Shot 13 an explanation has already been given; it falls under (1). Shots 3 to 12 were not followed by earthquakes of sufficient size to affect their residuals, thus the ASR for shots 3 and 6 cannot be accounted for by (1). Both may be due to (2), but for shot 6 there may be another explanation. Assuming that the shot residual falls under (3) we can reduce it to zero by putting it back into the station residuals. The height of the residuals is then indicated by an open circle in Figures 12 and 13. The first notable effect of this change is that the residuals for Shot 6 at stations 64, 10 and 20 become zero. Since all other residuals at these stations are already near zero, we can then conclude that these stations have no long term drift.

The second effect of putting the average shot residual of Shot 6 back with the station residuals is that it gives a peak in residuals at 56, 58 and 60.

For Shot 3 there are no ready answers nor indirect arguments as to whether the ASR is due to error or long term drift. If it is due to an error it should be removed, if due to the long term trend it should remain with the residuals. If we want to be most pessimistic about the residual we could remove the shot from further discussion. This would affect 6 stations and not change any of the principal arguments.

In summary, we can say that the ASR of Shot 13 is likely due to an earthquake following the shot. That of Shot 6 is likely part of the long term residual at some stations. The ASR of Shot 3 is uncertain. Finally it must be pointed out that the ASR may not always be a meaningful average. If the anomalous zone is near the shot point, allpaths will be effected, and the average will be meaningful. If the anomalous zone is not near the shot point, some paths may miss it and the residuals will be near zero and contribute only their errors to the average and thereby bias it.

In Figure 14 and 15 are shown the reduced residuals (RR) and the average shot residual (ASR) for the south shore shots at La Pocatière. The ASR are mainly non-zero. Since there is no reason to believe that the shot timing on the south shore was worse than on the north shore, we cannot readily attribute the ASR to errors. The large residual of Shot 102 may be due to an M2.3 earthquake that occurred 2.5 days after the shot. However the catalogue location for the event is likely not such as to give the observed residuals, but this is a pre-array location and may be in error.

The ASR may thus be part of the long term drift and should be recombined with the RR so that we should sue the original residuals without corrections.

An overview of the residuals of Figures 6 – 9 gives the following results. For the north shore shots the peripheral stations 52, 62, 64 and 10 show zero change. Stations 56, 58, 60 and 30 had a maximum in 1977. Station 54 has not dropped off after the maximum of 1977. Station 76 only started in 1977, but has decreased since then. Some of the other stations exhibit changes but only just beyond the level of significance.

For the south shore shots the largest change is shown by station 56, it decreases since 1976. Stations 58 and 60 show a maximum in 1976 and 1977 respectively. Station 54 is increasing since 1975. For the rest of the stations it may be too early to talk of a trend. Most of them have a few zeros but also one or two large residuals.

In summary there seems to have been a maximum in 1977 from the north shore data and a maximum one year earlier from the south shore data.

Recommendations

We conclude that the data in this report demonstrate that velocity changes do occur, both in the long and short term at Charlevoix. Whether these changes are due to dilatancy however remains to be demonstrated. In view of the long term changes observed at some of the stations, we recommend that the experiment be continued in May and October 1980 when twelve Backpacks will be available to occupy all stations, including station 18 that has not been occupied since 1977. The aim of this part of the experiment remains unchanged, that is the detection of changes in velocity before a significant earthquake of magnitude 5.5 or larger.

To substantiate the short term changes in velocity and relate them to dilatancy it is tempting to propose an experiment with frequent shots to define the changes of velocity due to an M_L 3 or larger earthquake. Unfortunately there are only three or four such events per year on average, so that such an experiment would be expensive under our present experimental setup, with the Division paying for explosives and assuming the costs for a field project of several months. Therefore we will investigate the suitability of using mine blasts from Thetford Mines, Schefferville or other areas, as sources for calibration experiments.

Figures

1. Station distribution for calibration shot experiment. Station 18 was not occupied in 1978 and 1979. Near shot point stations 80 and 82 are not shown, neither is control station 50. "A" are array stations, others Backpack stations, stars are shot points.

2. Map of the distribution of shot points at La Pocatière.

3. Distribution of change in cross-correlation in milliseconds against vertical component of solid Earth tide. Lines are least squares fits. Large dots are from the Tide Test shots, small dots are for earlier shots.

4. Change in cross-correlation in milliseconds for St. Jerôme shots, always with respect to first P wave recorded at the station. A stands for array and BP for Backpack.

5. Same as Table 4 for La Pocatière shot point.

6. Changes in travel time from the St. Jerôme mine from cross-correlating one second of P wave forms. Horizontal scale is in days. Vertical scale is in milliseconds. Heavy dot on left on base line indicates start of data for each station. Vertical bars indicate change in travel time with respect to start. Above base line corresponds to increase in travel time, below base line means decrease in travel time.

7. Continuation of St. Jerôme data from Figure 6.

8. Data from La Pocatière shots similar to Figure 6.

9. Continuation of La Pocatière data from Figure 8.

10. Top of the Figure shows wave forms from Shots 12 and 13 recorded at station 56 superimposed for maximum correlation for which Shot 13 had to be advanced by 18 ms. Bottom of the Figure shows the same wave forms as above without the 18 ms advance to show the effect of a shift of this size.

11. Wave forms for station 58 treated similarly to those of Figure 10. Here the advance is 12 ms.

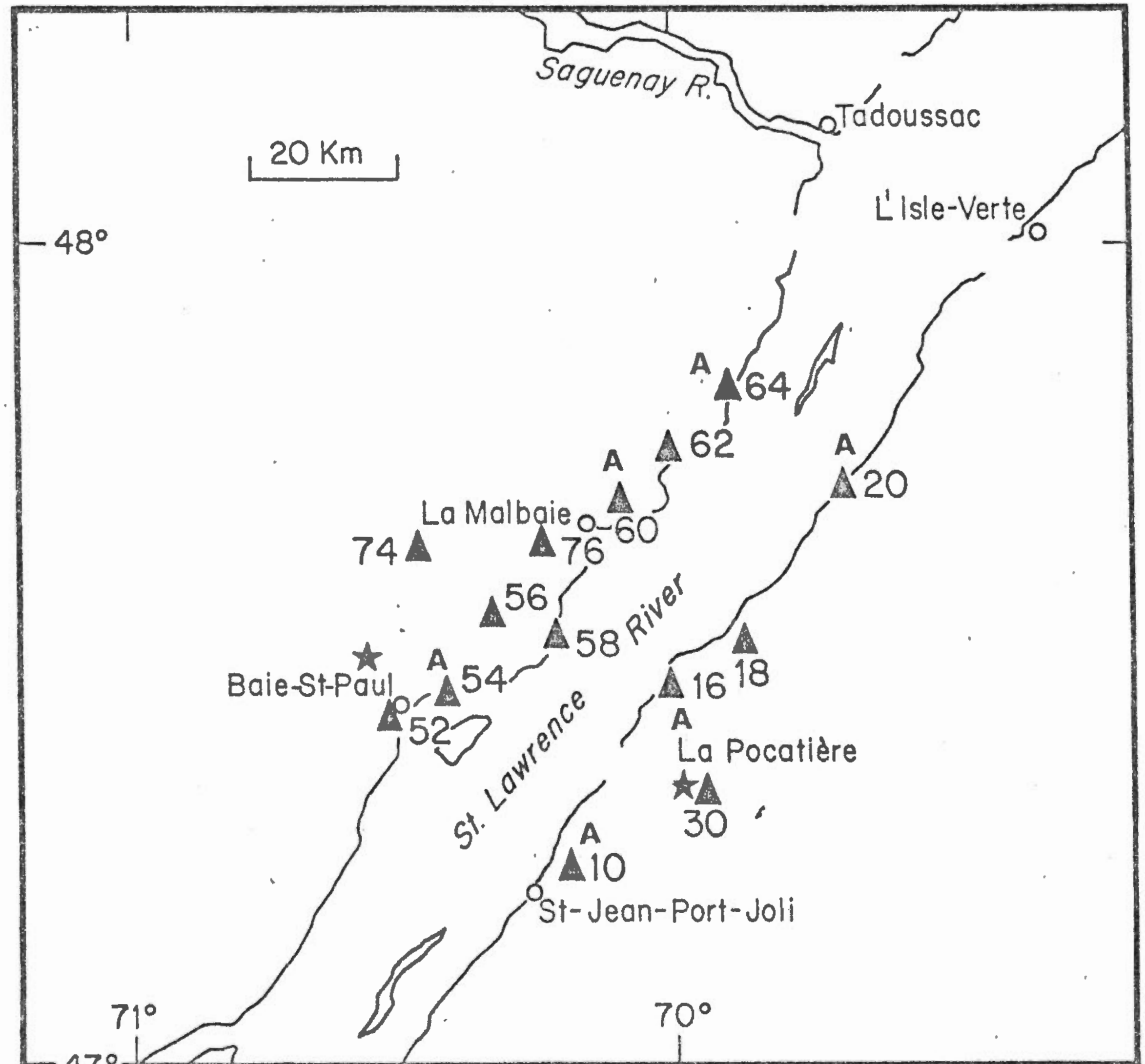
12. Reduced residuals relative to Shot 12, from the St. Jerôme Mine.

13. Continuation of Figure 12. At the bottom are the average shot residuals.

14. Reduced residuals relative to Shot 107, from La Pocatière.

15. Continuation of Figure 13. At the bottom are the average shot residuals.

A



Saguenay R.
Tadoussac
20 Km
48°
L'Isle-Verte
A
64
62
A
A
20
La Malbaie
60
74
76
56
58
River
A
54
Baie-St-Paul
52
16
18
A
La Pocatière
St. Lawrence
30
A
10
St-Jean-Port-Joli
71°
70°
47°

Fig. 1

LAPOCATIERE SHOT POINT

5 JUNE 78
(NOT TO SCALE)

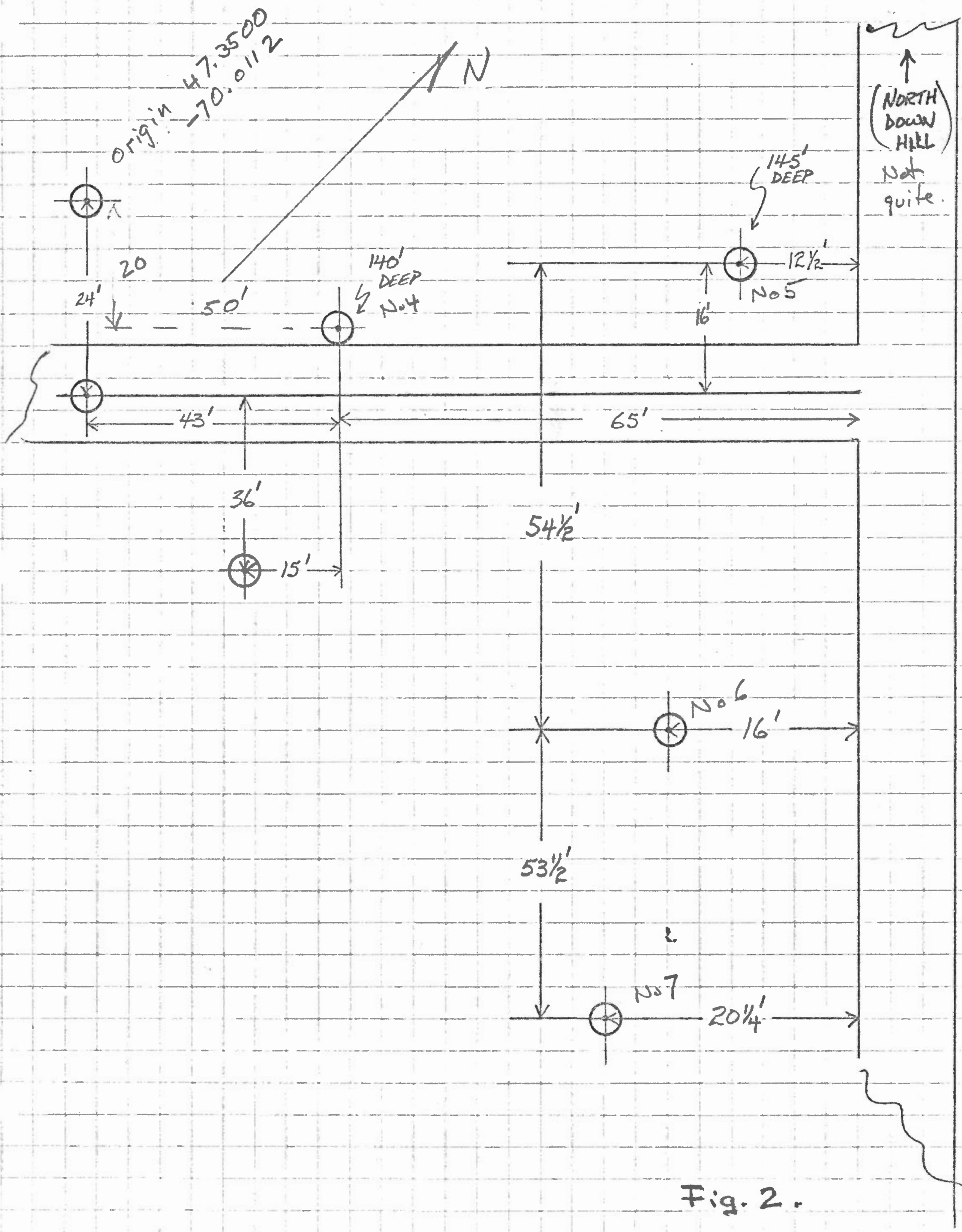


Fig. 2.

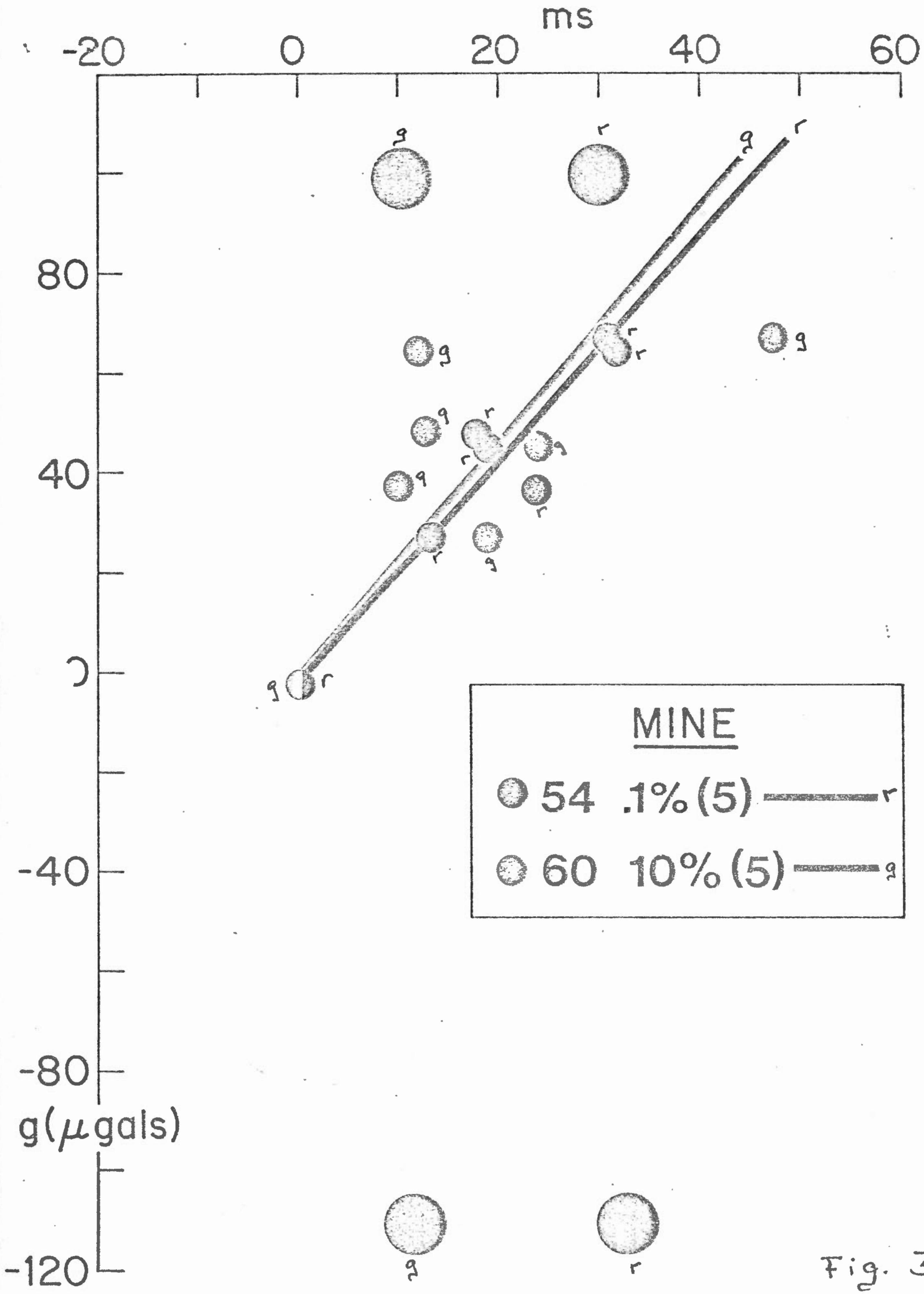


Fig. 3

ST. JEROME MINE
CROSS-CORRELATIONS
In: Milliseconds

SHOT No	3	4	5	6	7	8	9	10	11	12	13
DAY No / CONS.	204 / 1	267 / 429	350 / 877	243 / 1136	151 / 1408	152 / 1409	236 / 1493	306 / 1563	306 / 1563	178 / 1800	179 / 1801
DAY MO. YR / 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
52					BP 0		BP -2	BP 0	BP 1	BP -4	BP 8
54	A 0	A 14	BP 23	A 31	A 17	A 31	A 23	A 34	A 31	A 31	A 42
56			BP 0	BP 11	BP -4		A -6	A -7	A -8	A -5	A 12
58	A 0	A 22		BP 34				BP 16		BP 11	BP 22
60	A 0	A 22	BP 27	A 46	A 13	A BP 12 16	A 11	A 12	A 11	A 15	A 26
62					BP 0		BP 0	BP 0	BP 1	BP -3	
64				A 0	A -13	A -4	A -6	A 2	A 2	A 0	A 10
74			BP 0	BP 11	BP -10		BP -10	BP -10			
76				BP 0			BP -21	BP -22	BP -21	BP -25	BP -15
10/11	A 0	A 18		A 0	A -7	A 0	A -11	A 1	A -1	A -2	A 9
16					A 0	A 12	A 6	A 14	A 12	A 11	A 22
18	A 0	A 15		BP 26							
20/21				A 0	A -14		A -9	A 3	A -1	A -1	A 7
30	A 0	A 15		BP 27	BP 6		BP 6			BP 4	
50								BP 0	BP 1		

Fig 4

La Pocatière
CROSS - CORRELATIONS
IN MILLI SECS.

HCT RATE CONS. DAY.M.Y	101 280 1 7.10.75	102 302 389 28.10.76	103 351 438 16.12.76	104 242 694 30.8.77	105 150 967 30.5.78	106 235 1052 23.8.78	107 177 1359 26.6.79		
52					BP 0	BP 7			
54	A 0		BP 17	A 21	A 9		A 30		
56		BP 0	BP -3	BP -29	BP -39	A -37	A -46		
58	A 0	BP 23	BP 11	BP 14			BP 0		
60	A 0	BP 21	BP 16	A 30	A -8	A 2	A -6		
62				BP 0		BP 0	BP -13		
64				A 0	A -11	A 2	A 0		
74		BP 0		BP 7		BP -9			
76				BP 0	BP -9	BP 0	BP -10		
10/11				A 0	A -11	A 0	A -5		
16			BP 0		A 3	A 20	A 12		
18	A 0			BP 5					
20/21				A 0	A -16	A 0	A -4		
30	A 0				BP 1	BP 7	BP -6		

Fig. 5

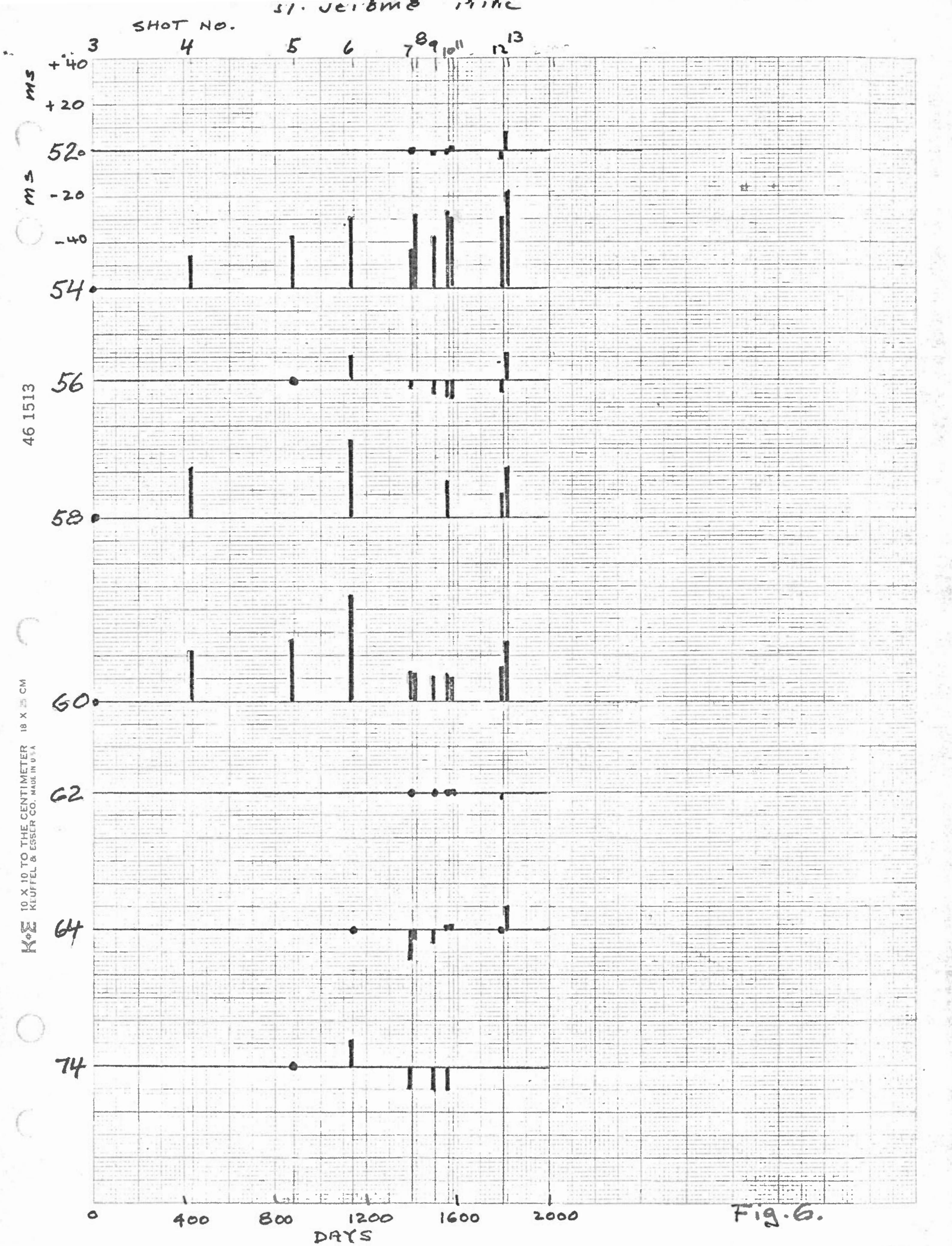

St. Jerome Mine
SHOT NO.
3
4
5
6
7
8
9
10
11
12
13
ms
+40
+20
52
ms
-20
-40
54
56
58
60
62
64
74
0
400
800
1200
1600
2000
DAYS
46 1513
K&E 10 X 10 TO THE CENTIMETER 18 X 25 CM
KEUFFEL & ESSER CO. MADE IN U.S.A.

Fig. 6.

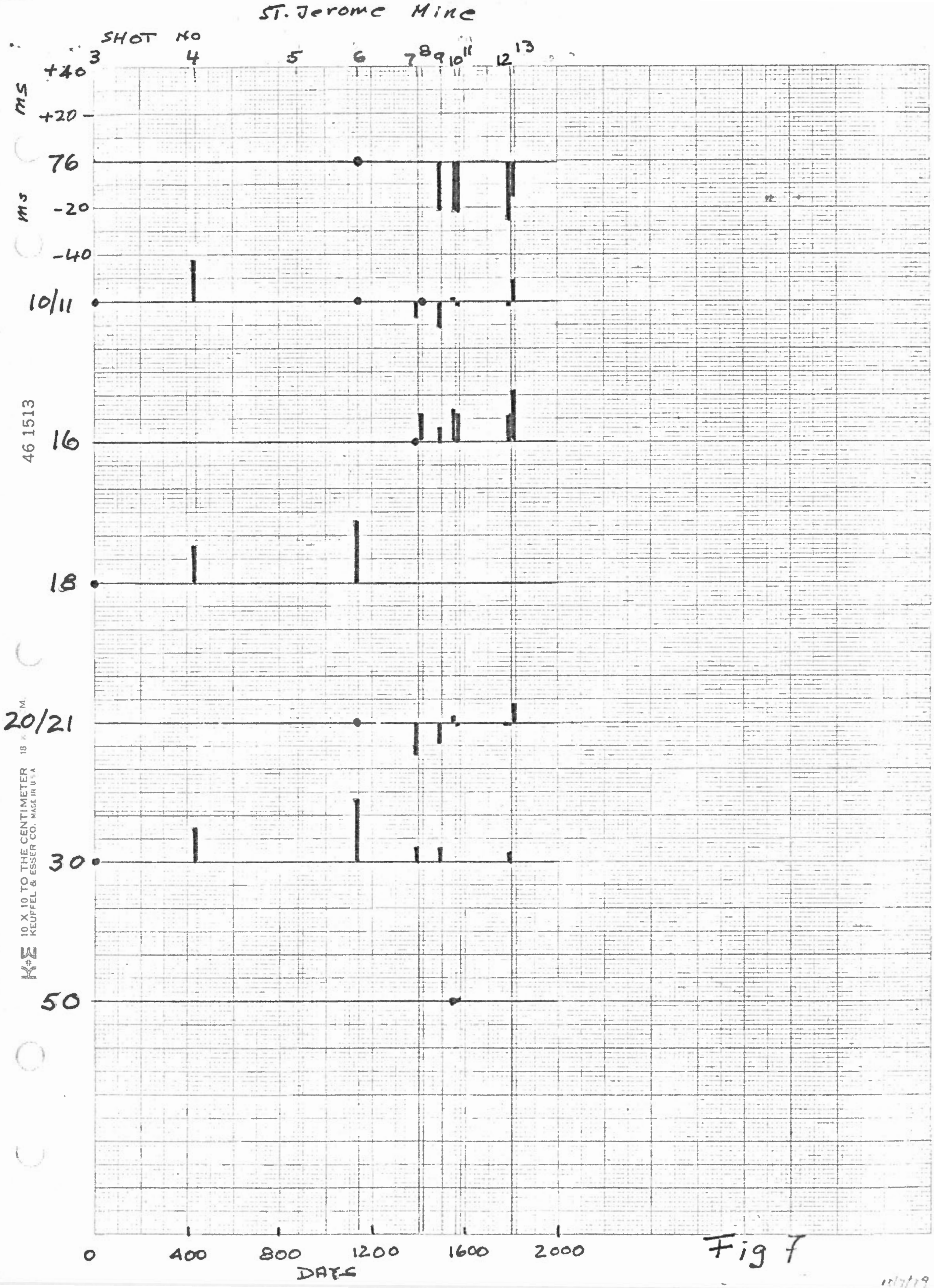

ST. Jerome Mine
SHOT NO
3
4
5
6
7
8
9
10
11
12
13
+40
+20
ms
76
ms
-20
-40
10/11
16
18
20/21
30
50
0
400
800
1200
1600
2000
DATE
46 1513
10 X 10 TO THE CENTIMETER
KEUFFEL & ESSER CO. MADE IN U.S.A.

Fig 7

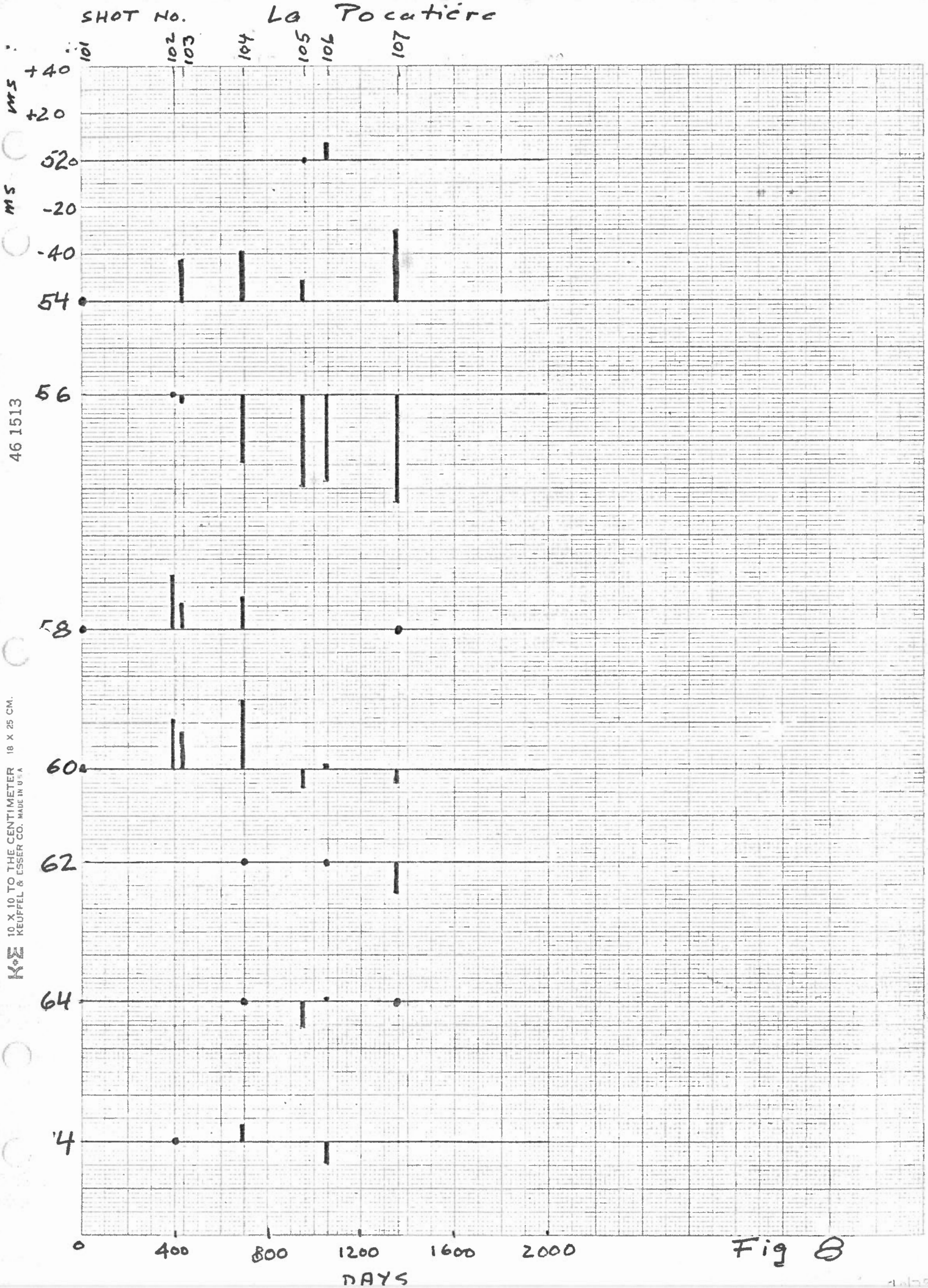
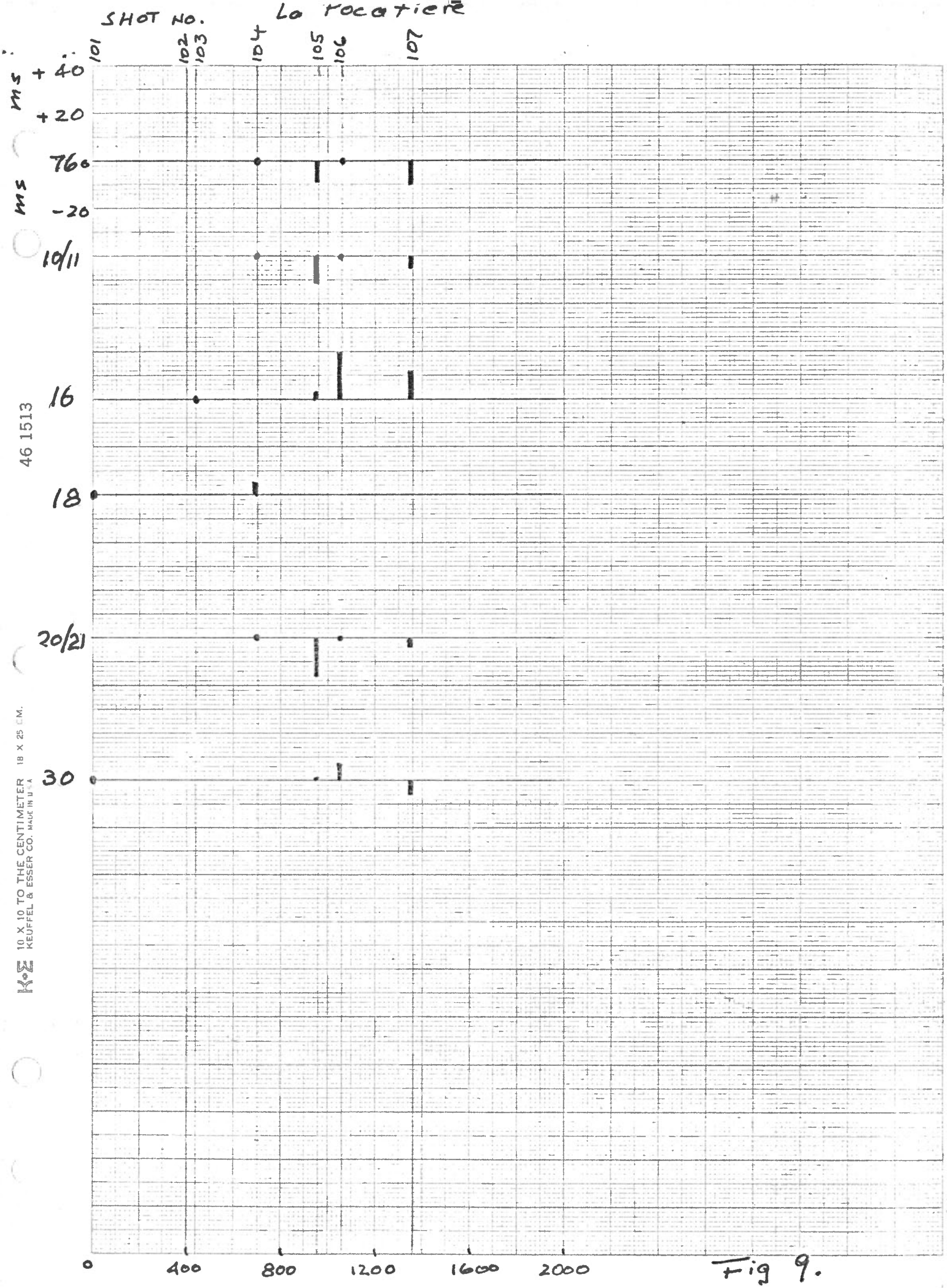
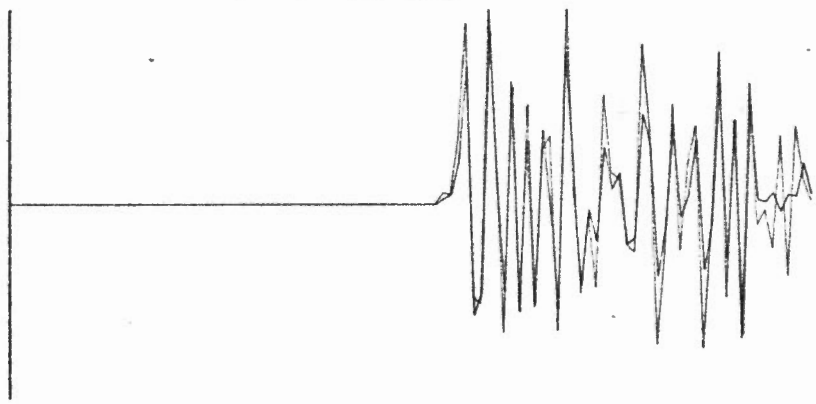

SHOT NO.
La Pocatiere
101
102
103
104
105
106
107
ms
+40
+20
52
ms
-20
-40
54
56
46 1513
58
60
62
64
4
10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.
0
400
800
1200
1600
2000
DAYS

Fig 8



SHOT NO.
La Pocatiere
101
102
103
104
105
106
107
ms +40
+20
760
ms
-20
10/11
16
18
20/21
30
46 1513
10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.
0
400
800
1200
1600
2000

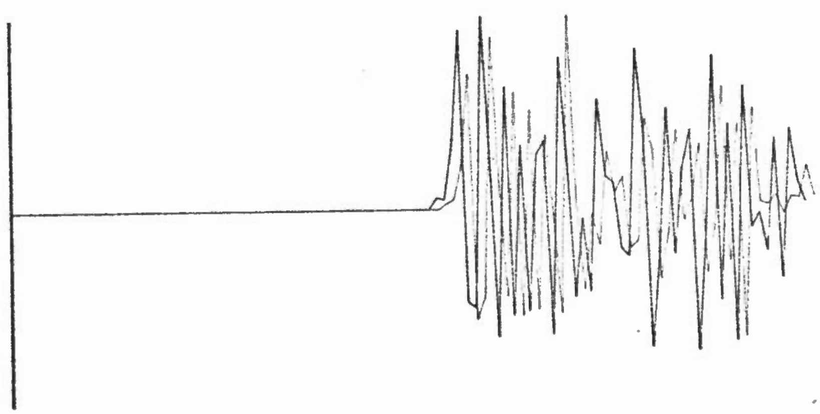
Fig 9.



A 56 12 27 JUN 79 22 0 0 2

A 56 13 28 JUN 79 22 0 0 2

LAG = -.0 CC = .928 DT = .018 13 LATE

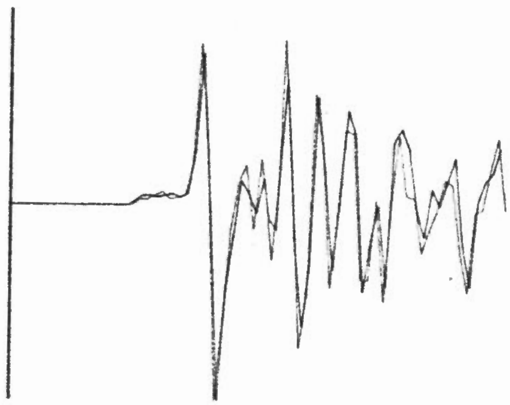


A 56 12 27 JUN 79 22 0 0 2

A 56 13 28 JUN 79 22 0 0 2

LAG = -.0 CC = .928 DT = .018 13 LATE

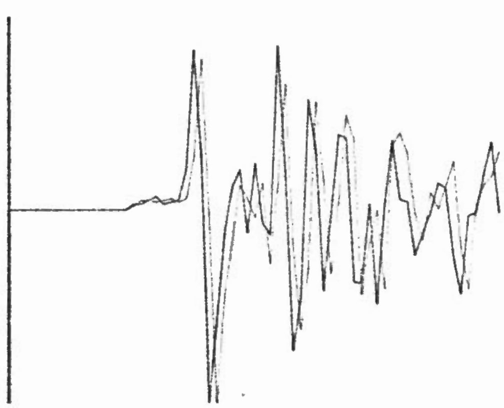
Fig. 10



BP58 12 27 JUN 79 22 0 0 4

BP58 13 28 JUN 79 22 0 0 4

LAG = 1.6 CC = .958 DT = .012 13 LATE



BP58 12 27 JUN 79 22 0 0 4

BP58 13 28 JUN 79 22 0 0 4

LAG = 1.6 CC = .958 DT = .012 13 LATE

Fig. 11.

ST. Jerome Mine

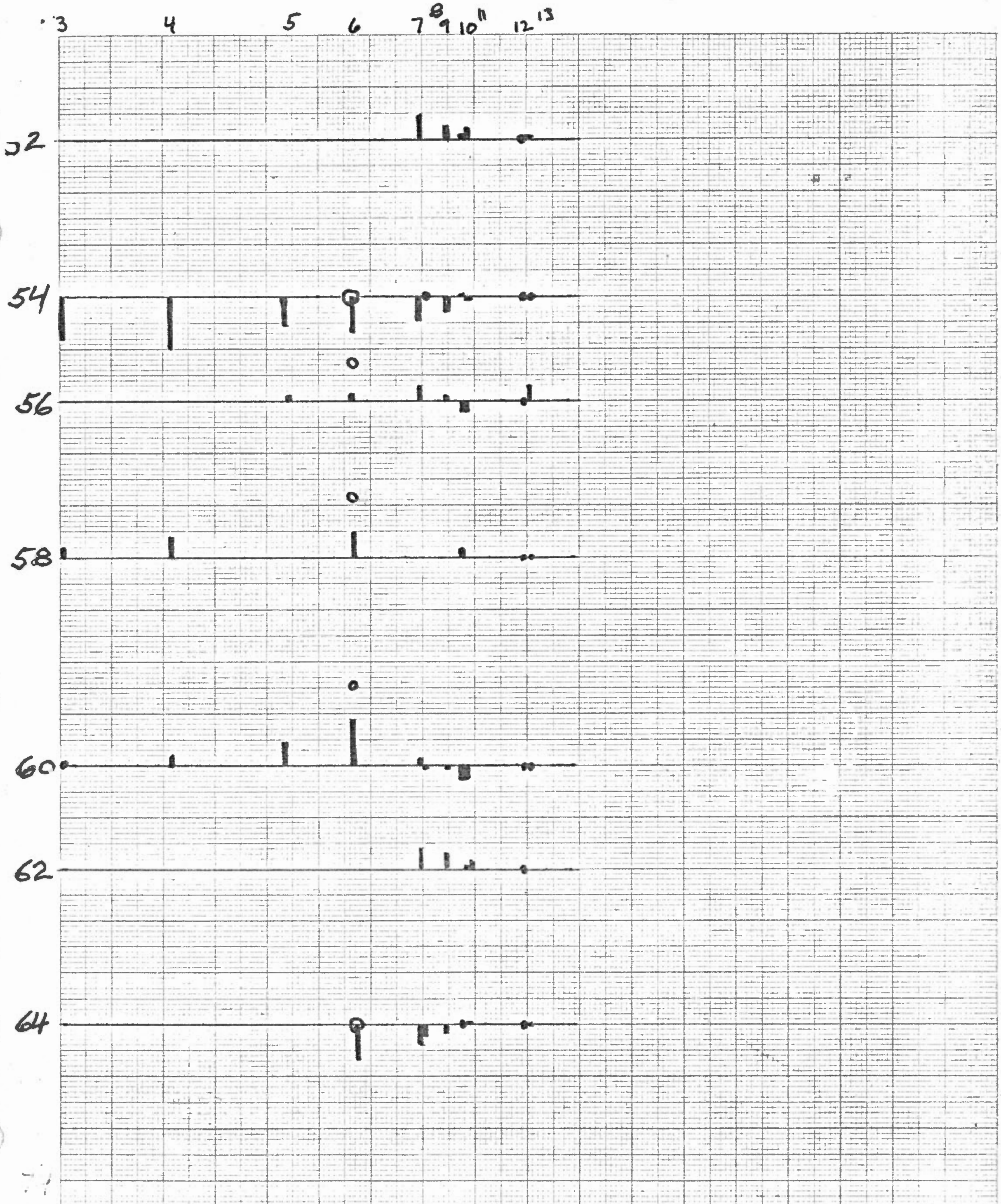


Fig 12

ST. Jerome Mine

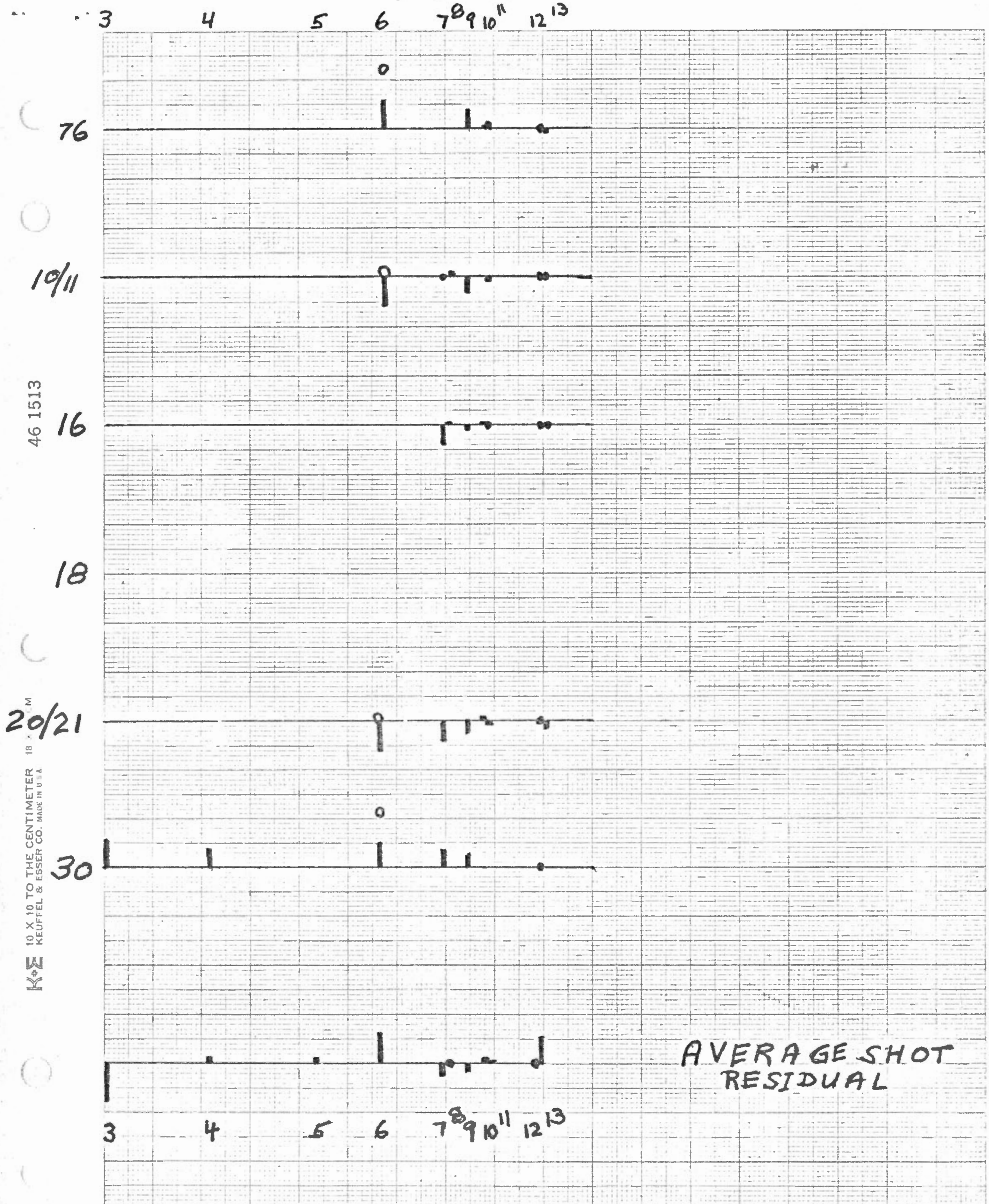


Fig. 13

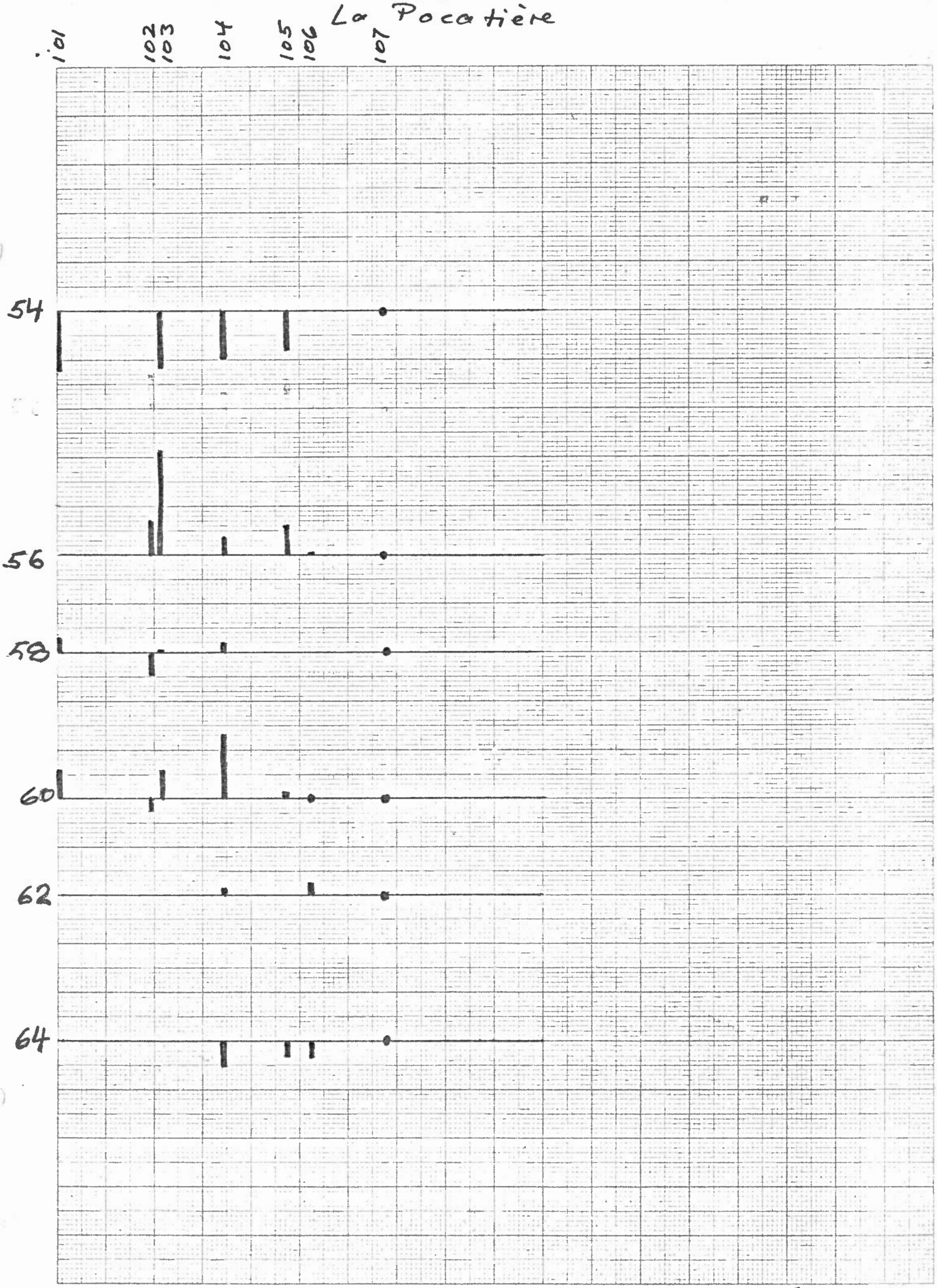


Fig. 14

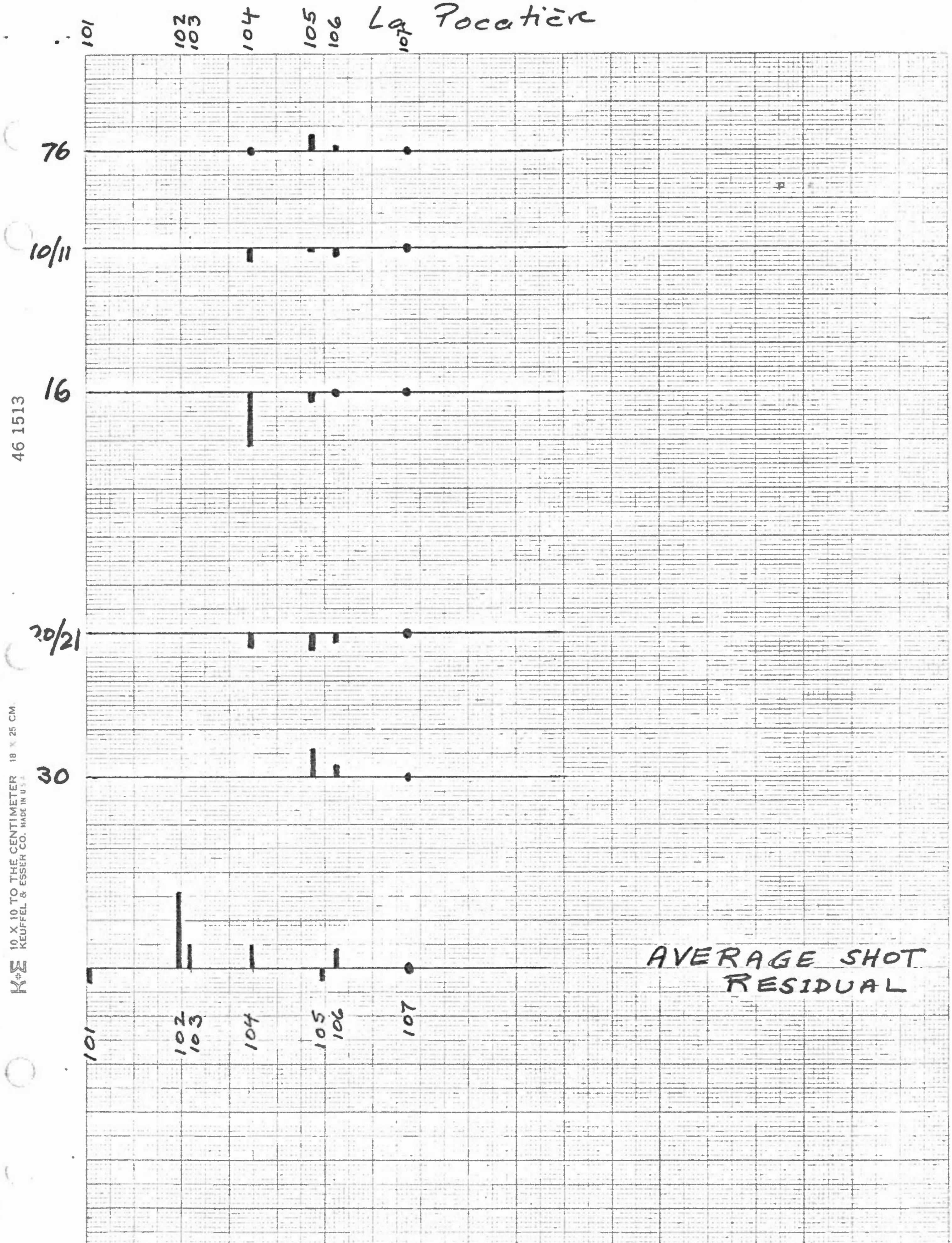

La Pocatière
101
102
103
104
105
106
107
76
10/11
16
20/21
30
AVERAGE SHOT RESIDUAL
101
102
103
104
105
106
107
46 1513
10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

Fig. 15

TABLES

TABLE 1

List of Explosions

La Pocatière Shot hole

47.3500° N 70.0112° W

No.	Date	Hour	Charge Size Lb.	Kg.
101	7 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

St-Jerome Mine

47.534° N 70.556° W

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	1 June 78 (152)	21:30:00.000 UT	500	230
9	24 Aug. 78 (236)	21:30:00.000 UT	2000	900
10	2 Nov. 78 (306)	05:00:00.000 UT	1500	680
11	2 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

Table 2.1

TRAVEL TIMES FOR LA MALBAIE AREA SHOTS

SHOT	DAY	DATE	ORIGIN TIME			ERRORS		CORRECTIONS ALL IN MS			
1	170	19. 6.1974	12	8	9.305	8	0	0	0	0	0

ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
52	T	11.460	7	5	0	0	0	0	2.155	.012
54	A	11.713	10	5	5	0	0	0	2.408	.015
56	S	12.150	23	5	0	112	0	0	2.957	.025
58	A	13.697	10	5	5	0	0	0	4.392	.015
60	A	15.812	10	5	5	0	-9	0	6.498	.015
62	S	17.137	24	5	0	-51	0	0	7.781	.026
74	S	11.597	32	5	0	-60	0	0	2.232	.033
76	T	13.767	7	5	0	0	0	0	4.462	.012
16	S	16.302	128	5	0	184	4	0	7.185	.128
20	T	20.664	49	5	0	0	0	0	11.359	.050

SHOT	DAY	DATE	ORIGIN TIME			ERRORS		CORRECTIONS ALL IN MS			
2	194	13. 7.1974	12	11	6.752	8	0	0	0	0	0

ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
52	T	8.890	7	5	0	0	0	0	2.138	.012
54	A	9.140	10	5	5	0	0	0	2.388	.015
58	A	11.129	10	5	5	0	0	0	4.377	.015
60	A	13.242	10	5	5	0	-9	0	6.481	.015
62	S	14.522	48	5	0	28	0	0	7.798	.049
74	S	8.826	18	5	0	54	0	0	2.128	.020

SHOT	DAY	DATE	ORIGIN TIME			ERRORS		CORRECTIONS ALL IN MS			
3	204	23. 7.1974	12	26	8.925	8	0	0	0	0	0

ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
52	T	11.081	7	5	0	0	0	0	2.156	.012
54	A	11.328	8	5	5	0	0	0	2.403	.013
58	A	13.300	10	5	5	0	0	0	4.375	.015
	A	15.415	10	5	5	0	-9	0	6.481	.015
[illegible]	S	11.003	33	5	0	16	0	0	2.094	.034
76	T	13.370	7	5	0	0	0	0	4.445	.012
10	A	16.195	10	5	0	0	0	0	7.270	.014
16	S	15.672	28	5	0	431	8	0	7.186	.030
18	A	17.832	10	5	0	0	0	0	8.907	.014
20	T	20.326	30	5	0	0	0	0	[illegible]	.031
30	A	17.909	10	5	0	0	0	0	8.984	.014

SHOT	DAY	DATE	ORIGIN TIME			ERRORS		CORRECTIONS ALL IN MS			
4	267	24. 9.1975	17	53	.036	8	0	0	0	0	0

ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
52	S	2.295	140	5	0	23	0	0	2.282	.140
54	A	2.444	4	5	5	0	0	0	2.408	.011
56	S	3.042	31	5	0	-73	0	0	2.933	.032
58	A	4.422	8	5	5	0	0	0	4.386	.013
60	A	6.550	8	5	5	0	-9	0	6.505	.013
62	S	7.931	43	5	0	-73	0	0	7.822	.044
10	A	7.318	5	5	5	0	0	0	7.282	.012
16	S	7.453	42	5	0	-226	8	0	7.199	.043
18	A	8.940	7	5	5	0	0	0	8.904	.013
20	S	11.356	46	5	0	49	8	0	11.377	.047
30	A	9.034	10	5	5	0	0	0	8.998	.015

SHOT	DAY	DATE	ORIGIN TIME			ERRORS		CORRECTIONS ALL IN MS			
5	350	15.12.1976	20	25	59.989	8	0	0	0	-26	0

ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
52	S	2.159	110	5	0	-8	5	0	2.141	.110
54	BP	2.422	8	5	5	22	-15	0	2.414	.013
56	BP	2.963	8	5	5	22	3	0	2.973	.013
58	S	4.514	72	5	0	-87	0	0	4.412	.073
60	S	6.713	36	5	0	-141	-9	0	6.548	.037
60	BP	6.517	10	5	5	22	-13	-9	6.502	.015
74	BP	2.160	8	5	5	22	-4	0	2.163	.013
76	S	4.561	56	5	0	-70	0	0	4.476	.057
	S	2.366	12	5	0	-89	0	0	2.262	.015

Table 2,2

10	S	7.292	97	5	0	-19	7	0	7.265	.097
SHOT	DAY	DATE	ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS			
6	243	31. 8.1977	20 30 0.000		2	5	5	4	-26	0
ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
52	S	2.188	3	10	0	-58	0	0	2.108	.013
54	A	2.429	4	4	0	10	0	0	2.417	.009
56	BP	2.980	8	2	4	22	-2	0	2.978	.012
58	BP	4.430	8	2	4	22	-6	0	4.424	.012
60	A	6.535	6	4	0	10	0	0	6.523	.010
64	A	9.699	4	4	0	10	0	0	9.687	.009
74	BP	2.177	8	2	4	22	-3	0	2.174	.012
76	BP	4.508	8	2	4	22	-6	0	4.502	.012
11	A	7.294	8	4	0	10	0	0	7.282	.012
18	BP	8.925	10	2	4	22	-7	0	8.918	.013
21	A	11.364	8	4	0	10	0	0	11.352	.012
30	BP	9.032	15	2	4	22	-4	0	9.028	.017
SHOT	DAY	DATE	ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS			
7	151	31. 5.1978	21 30 0.000		2	5	2	5	-35	0
ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
52	BP	2.180	4	2	0	2	-9	0	2.143	.007
54	A	2.432	4	2	0	11	0	0	2.413	.007
56	BP	3.008	4	2	0	2	-9	0	2.971	.007
56	A	2.985	4	2	0	11	0	0	2.966	.007
60	A	6.508	4	2	0	11	0	0	6.489	.007
64	A	9.706	4	2	0	11	0	0	9.687	.007
74	BP	2.183	4	2	0	2	-6	0	2.149	.007
11	A	7.288	8	2	0	11	0	0	7.269	.010
16	A	7.230	6	2	0	11	0	0	7.211	.009
30	BP	9.047	16	2	0	2	-26	0	8.993	.017
SHOT	DAY	DATE	ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS			
8	152	1. 6.1978	21 30 0.000		2	5	2	4	-35	0
T	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
54	A	2.417	4	2	0	34	0	0	2.420	.007
60	A	6.491	4	2	0	34	0	0	6.494	.007
60	BP	6.538	4	2	0	2	-6	0	6.503	.007
SHOT	DAY	DATE	ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS			
9	236	24. 8.1978	21 30 0.000		3	2	0	0	-35	0
ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
52	BP	2.199	2	5	3	2	-25	0	2.141	.007
54	A	2.424	4	5	3	29	0	0	2.418	.008
56	A	2.974	4	5	3	29	0	0	2.968	.008
60	A	6.500	4	5	3	29	0	0	6.494	.008
62	BP	7.850	4	5	3	2	-22	0	7.795	.008
64	A	9.687	6	5	3	29	0	0	9.681	.009
74	BP	2.217	4	5	3	2	-35	0	2.149	.008
76	BP	4.546	4	5	3	2	-34	0	4.479	.008
16	A	7.217	8	5	3	29	0	0	7.211	.011
21	A	11.356	8	5	3	29	0	0	11.350	.011
30	BP	9.030	16	5	3	2	-5	0	8.992	.017
SHOT	DAY	DATE	ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS			
10	306	2.11.1978	5 0 0.000		3	2	0	14	-35	0
ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
50	BP	4.867	4	5	3	2	-17	0	4.831	.008
52	BP	2.188	2	5	3	2	-27	0	2.142	.007
54	A	2.403	4	5	3	0	42	0	2.424	.008
56	A	2.949	4	5	3	0	42	0	2.970	.008
58	BP	4.437	4	5	3	2	-28	0	4.390	.008
60	A	6.472	4	5	3	0	42	0	6.493	.008
62	BP	7.842	8	5	3	2	-21	0	7.802	.011
64	A	9.670	8	5	3	0	42	0	9.691	.011
74	BP	2.192	4	5	3	2	-22	0	2.151	.008
76	BP	4.521	4	5	3	2	-24	0	4.478	.008
11	A	7.252	16	5	3	0	42	0	7.273	.017
16	A	7.211	8	5	3	0	42	0	7.232	.011
21	A	11.335	8	5	3	0	42	0	11.356	.011
SHOT	DAY	DATE	ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS			

Table 2.3

```
 11 306  2.11.1978     22  0  0.000        3        2       0     2  -35    0
 T INST ARR.TIME      ERRORS       CORRECTIONS         TRAVEL  TIME +/- ERRORS
 50 BP    4.875        4      5     3     2  -12      0  4.832    .008
 52 BP    2.205        2      5     3     2  -34      0  2.140    .007
 54  A    2.424        4      5     3     0   32      0  2.423    .008
 56  A    2.970        6      5     3     0   32      0  2.969    .009
 60  A    6.489        4      5     3     0   32      0  6.488    .008
 62 BP    7.850        4      5     3     2  -25      0  7.794    .008
 64  A    9.699        8      5     3     0   32      0  9.698    .011
 76 BP    4.543        4      5     3     2  -31      0  4.481    .008
 11  A    7.286        8      5     3     0   32      0  7.285    .011
 16  A    7.223        8      5     3     0   32      0  7.222    .011
 21  A   11.367        8      5     3     0   32      0 11.366    .011
 SHOT DAY     DATE          ORIGIN TIME       ERRORS         CORRECTIONS ALL IN MS
  12 178 27. 6.1979     22  0  0.000        2       0       0    15     0    0
 ST INST ARR.TIME      ERRORS       CORRECTIONS         TRAVEL  TIME +/- ERRORS
 52 BP    2.138        4      5     2   -16     2     0  2.139    .007
 54  A    2.353        4      5     2    50     0     0  2.418    .007
 56  A    2.910        4      5     2    50     0     0  2.975    .007
 58 BP    4.375        4      5     2   -12     2     0  4.380    .007
 60  A    6.432        4      5     2    50     0     0  6.497    .007
 62 BP    7.800        4      5     2   -12     2     0  7.805    .007
 64  A    9.610        8      5     2    50     0     0  9.675    .010
 76 BP    4.471        4      5     2   -15     2     0  4.473    .007
 11  A    7.207        8      5     2    50     0     0  7.272    .010
 16  A    7.150        8      5     2    50     0     0  7.215    .010
 21  A   11.293        8      5     2    50     0     0 11.358    .010
 30 BP    8.985       16      5     2    -8     2     0  8.994    .017
 SHOT DAY     DATE          ORIGIN TIME       ERRORS         CORRECTIONS ALL IN MS
  13 179 28. 6.1979     22  0  0.000        2       0       0    14     0    0
 ST INST ARR.TIME      ERRORS       CORRECTIONS         TRAVEL  TIME +/- ERRORS
 52 BP    2.147        4      5     2   -16     2     0  2.147    .007
 54  A    2.356        4      5     2    67     0     0  2.437    .007
     A    2.906        4      5     2    67     0     0  2.987    .007
    BP    4.392        4      5     2   -13     2     0  4.395    .007
 60  A    6.413        4      5     2    67     0     0  6.494    .007
 76 BP    4.482        4      5     2   -15     2     0  4.483    .007
 80 BP     .404        4      5     2   -13     2     0   .407    .007
 82 BP     .854        4      5     2   -11     2     0   .859    .007
```

Table 3.1

SHOT	DAY	DATE	ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS			
101	280	7.10.1975	15 16	0.000	8	0	0	0	-26	0
ST	**INST**	**ARR.TIME**	**ERRORS**			**CORRECTIONS**			**TRAVEL TIME**	**+/- ERRORS**
56	S	5.878	44	5	0	-33	0	0	5.819	.045
58	A	4.638	8	5	5	0	0	0	4.612	.013
60	A	6.847	8	5	5	0	8	0	6.829	.013
10	A	3.492	10	5	5	0	0	0	3.466	.015
16	S	2.863	18	5	0	-126	0	0	2.711	.020
20	S	8.703	14	5	0	-93	0	0	8.584	.017
30	A	1.254	4	5	5	0	0	0	1.228	.011
SHOT	**DAY**	**DATE**	**ORIGIN TIME**		**ERRORS**		**CORRECTIONS ALL IN MS**			
102	302	28.10.1976	16 26	0.000	8	0	0	0	-26	0
ST	**INST**	**ARR.TIME**	**ERRORS**			**CORRECTIONS**			**TRAVEL TIME**	**+/- ERRORS**
58	BP	4.667	8	5	5	22	-28	0	4.635	.013
74	BP	8.008	8	5	5	22	0	0	8.004	.013
8	S	6.498	197	5	0	24	0	0	6.496	.197
10	S	3.564	32	5	0	96	0	0	3.634	.033
16	S	2.658	27	5	0	45	0	0	2.677	.029
SHOT	**DAY**	**DATE**	**ORIGIN TIME**		**ERRORS**		**CORRECTIONS ALL IN MS**			
103	351	16.12.1976	17 26	0.000	8	0	0	0	-26	0
ST	**INST**	**ARR.TIME**	**ERRORS**			**CORRECTIONS**			**TRAVEL TIME**	**+/- ERRORS**
52	S	6.983	22	5	0	12	0	0	6.969	.024
54	BP	5.875	8	5	5	22	-10	0	5.861	.013
56	BP	5.892	8	5	5	22	-22	0	5.866	.013
58	S	4.551	76	5	0	117	-8	0	4.634	.077
58	BP	4.600	8	5	5	22	9	0	4.605	.013
60	S	6.969	88	5	0	-100	-8	8	6.843	.089

Table 3.2

60	BP	6.833	8	5	5	22	-4	8	6.833	.013
76	S	6.695	14	5	0	-70	-8	0	6.591	.017
8	S	6.635	36	5	0	-59	0	0	6.550	.037
16	BP	2.683	8	5	5	22	-4	0	2.675	.013
SHOT	DAY	DATE		ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS		
104	242	30. 8.1977	23 30	0.000	2	5	5	5	-26	0
ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
52	S	6.997	3	20	0	-42	0	0	6.934	.022
54	A	5.879	10	4	0	3	0	0	5.861	.013
56	BP	5.842	8	2	4	22	-1	0	5.842	.012
58	BP	4.617	8	2	4	22	-7	0	4.611	.012
60	A	6.871	8	4	0	3	0	0	6.853	.012
62	BP	7.742	8	2	4	22	-6	0	7.737	.012
64	A	9.206	4	4	0	3	0	0	9.188	.009
74	BP	8.008	8	2	4	22	-6	0	9.003	.012
76	BP	6.567	8	2	4	22	-6	0	6.562	.012
11	A	3.579	26	4	0	3	0	0	3.561	.027
18	BP	4.027	8	2	4	22	-4	0	4.024	.012
21	A	8.375	12	4	0	3	0	0	8.357	.015
SHOT	DAY	DATE		ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS		
105	150	30. 6.1978	21 30	0.000	2	5	2	7	-35	0
ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
52	BP	6.980	4	2	0	2	-13	-1	6.940	.007
54	A	5.913	4	2	0	1	0	0	5.886	.007
56	BP	5.878	4	2	0	2	-12	0	5.840	.007
60	A	6.855	6	2	0	1	0	2	6.830	.009
76	BP	6.592	4	2	0	2	-13	1	6.554	.007
11	A	3.582	4	2	0	1	0	2	3.557	.007
16	A	2.713	4	2	0	1	0	2	2.688	.007
21	A	8.369	4	2	0	1	0	2	8.344	.007
30	BP	1.258	4	2	0	2	-15	1	1.218	.007
SHOT	DAY	DATE		ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS		
106	235	23. 8.1978	21 30	0.000	3	2	0	10	-35	0
ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
56	A	5.853	4	5	3	16	0	0	5.844	.008
60	A	6.840	6	5	3	16	3	0	6.834	.009
76	BP	6.607	4	5	3	-25	2	2	6.561	.008
11	A	3.581	8	5	3	16	-5	0	3.567	.011
16	A	2.704	4	5	3	16	4	0	2.699	.008
21	A	8.362	8	5	3	16	5	0	8.358	.011
30	BP	1.263	4	5	3	2	-10	3	1.233	.008
SHOT	DAY	DATE		ORIGIN TIME		ERRORS		CORRECTIONS ALL IN MS		
107	177	26. 6.1979	23 0	0.000	2	0	0	23	0	0
ST	INST	ARR.TIME	ERRORS		CORRECTIONS				TRAVEL TIME	+/- ERRORS
56	A	5.785	4	5	2	32	0	0	5.840	.007
58	BP	4.583	6	5	2	-7	2	-2	4.599	.008
62	BP	7.717	4	5	2	-8	2	2	7.736	.007
74	BP	8.025	4	5	2	2	-24	0	8.026	.007
76	BP	6.538	4	5	2	-6	2	-1	6.556	.007
11	A	3.513	8	5	2	32	0	0	3.568	.010
30	BP	1.212	4	5	2	-20	2	4	1.221	.007

Table 4

ST	YR	DAY	SHOT	START TIME	CORRECTIONS CLOCKS	CORRECTIONS BP	CORRECT TIME	A-B	CROSS-CORR. COEFF.
76BP	77	243	6	4.433	-28	22	4.427	.044	CC = .981
76BP	78	236	9	4.450	-69	2	4.383		
	1.4	LAGS	DT=	.023 -.044=	-.021	9	EARLY		
30BP	78	151	7	8.775	-56	2	8.721	-.016	CC = .917
30BP	78	236	9	8.775	-40	2	8.737		
	-1.9	LAGS	DT=	-.015 .016=	.001	9	LATE		
52BP	78	151	7	2.100	-39	2	2.063	.021	CC = .961
52BP	78	236	9	2.100	-60	2	2.042		
	2.3	LAGS	DT=	.019 -.021=	-.002	9	EARLY		
62BP	78	151	7	7.800	-38	2	7.764	.019	CC = .929
62BP	78	236	9	7.800	-57	2	7.745		
	2.3	LAGS	DT=	.019 -.019=	.000	9	LATE		
74BP	78	151	7	2.150	-36	2	2.116	-.016	CC = .985
74BP	78	236	9	2.200	-70	2	2.132		
	-2.0	LAGS	DT=	-.017 .016=	-.001	9	EARLY		
10A	78	151	7	6.919	-19	0	6.900	-.006	CC = .816
10A	78	236	9	6.912	-6	0	6.906		
	-1.0	LAGS	DT=	-.008 .006=	-.002	9	EARLY		
16A	78	151	7	7.166	-19	0	7.147	-.006	CC = .752
16A	78	236	9	7.159	-6	0	7.153		
	-.1	LAGS	DT=	-.001 .006=	.005	9	LATE		
20A	78	151	7	11.256	-20	0	11.236	-.007	CC = .780
20A	78	236	9	11.249	-6	0	11.243		
	.0	LAGS	DT=	.000 .007=	.007	9	LATE		
56A	78	151	7	2.907	-19	0	2.888	-.009	CC = .762
56A	78	236	9	2.903	-6	0	2.897		
	-.4	LAGS	DT=	-.004 .009=	.005	9	LATE		
64A	78	151	7	9.591	-19	0	9.572	-.012	CC = .860
64A	78	236	9	9.590	-6	0	9.584		
	-.4	LAGS	DT=	-.004 .012=	.008	9	LATE		
54A	78	151	7	1.968	-19	0	1.949	-.013	CC = .989
54A	78	236	9	1.968	-6	0	1.962		
	-.9	LAGS	DT=	-.008 .013=	.005	9	LATE		
60A	78	151	7	6.443	-19	0	6.424	-.004	CC = .875
60A	78	236	9	6.434	-6	0	6.428		
	-.9	LAGS	DT=	-.008 .004=	-.004	9	EARLY		

Table 5

ST	YR	DAY	SHOT	START TIME	CORRECTIONS CLOCKS	BP	CORRECT TIME	A-B	CROSS-CORR. COEFF.
74BP	77	242	104	7.933	-27	22	7.928	.025	CC = .955
74BP	78	235	106	7.950	-49	2	7.903		
	.4	LAGS	DT=	.007 -.025= -.018		106	EARLY		
62BP	77	242	104	7.683	-27	22	7.678	.014	CC = .938
62BP	78	235	106	7.700	-38	2	7.664		
	.8	LAGS	DT=	.014 -.014= -.000		106	EARLY		
30BP	78	150	105	1.150	-42	2	1.110	-.010	CC = .972
30BP	78	235	106	1.150	-32	2	1.120		
	-.2	LAGS	DT=	-.001 .010= .009		106	LATE		
52BP	78	150	105	6.900	-42	2	6.860	.006	CC = .974
52BP	78	235	106	6.900	-48	2	6.854		
	1.5	LAGS	DT=	.013 -.006= .007		106	LATE		
56BP	78	150	105	5.825	-40	2	5.787	-.004	CC = .927
56A	78	235	106	5.800	-9	0	5.791		
	.0	LAGS	DT=	.000 .004= .004		106	LATE		
76BP	78	150	105	6.550	-39	2	6.513	.009	CC = .864
76BP	73	235	106	6.550	-48	2	6.504		
	2.2	LAGS	DT=	.018 -.009= .009		106	LATE		
10A	78	150	105	3.516	-25	0	3.491	-.018	CC = .958
10A	78	235	106	3.523	-14	0	3.509		
	-.9	LAGS	DT=	-.008 .018= .010		106	LATE		
16A	78	150	105	2.654	-25	0	2.629	-.024	CC = .762
16A	78	235	106	2.658	-5	0	2.653		
	-.7	LAGS	DT=	-.005 .024= .019		106	LATE		
20A	78	150	105	8.360	-25	0	8.335	-.015	CC = .975
20A	78	235	106	8.354	-4	0	8.350		
	.2	LAGS	DT=	.002 .015= .017		106	LATE		
64A	78	150	105	9.126	-25	0	9.101	-.010	CC = .731
64A	78	235	106	9.116	-5	0	9.111		
	.5	LAGS	DT=	.004 .010= .014		106	LATE		
60A	78	150	105	6.775	-25	0	6.750	-.018	CC = .852
60A	78	235	106	6.774	-6	0	6.768		
	-1.1	LAGS	DT=	-.009 .018= .009		106	LATE		

Table 6.1

ST	YR	DAY	SHOT	START TIME	CORRECTIONS CLOCKS	BP	CORRECT TIME	A-B	CROSS-CORR. COEFF.
58BP	77	243	6	4.283	-28	22	4.277	.024	CC = .961
58BP	78	306	10	4.300	-49	2	4.253		
	.4	LAGS	DT=	.005 -.024=	-.018	10	EARLY		
52BP	78	236	9	2.100	-60	2	2.042	-.012	CC = .955
52BP	78	306	10	2.100	-48	2	2.054		
	-1.3	LAGS	DT=	-.011 .012=	.001	10	LATE		
52BP	78	236	9	2.100	-60	2	2.042	.007	CC = .417
52BP	78	306	11	2.100	-67	2	2.035		
	1.1	LAGS	DT=	.010 -.007=	.003	11	LATE		
52BP	78	306	10	2.100	-48	2	2.054	.019	CC = .291
52BP	78	306	11	2.100	-67	2	2.035		
	2.4	LAGS	DT=	.020 -.019=	.001	11	LATE		
62BP	78	236	9	7.800	-57	2	7.745	-.015	CC = .978
62BP	78	306	10	7.800	-42	2	7.760		
	-1.8	LAGS	DT=	-.015 .015=	-.000	10	EARLY		
[illegible]8P	78	236	9	7.800	-57	2	7.745	.001	CC = .988
62BP	78	306	11	7.800	-58	2	7.744		
	.2	LAGS	DT=	.001 -.001=	.000	11	LATE		
62BP	78	306	10	7.800	-42	2	7.760	.016	CC = .963
62BP	78	306	11	7.800	-58	2	7.744		
	-2.0	LAGS	DT=	.017 -.016=	.001	11	LATE		
74BP	78	236	9	2.200	-70	2	2.132	-.027	CC = .965
74BP	78	306	10	2.200	-43	2	2.159		
	-3.4	LAGS	DT=	-.028 .027=	-.001	10	EARLY		
76BP	78	236	9	4.450	-69	2	4.383	-.024	CC = .986
76BP	78	306	10	4.450	-45	2	4.407		
	-3.0	LAGS	DT=	-.025 .024=	-.001	10	EARLY		
76BP	78	236	9	4.450	-69	2	4.383	-.005	CC = .983
76BP	78	306	11	4.450	-64	2	4.388		
	-.5	LAGS	DT=	-.004 .005=	.001	11	LATE		
76BP	78	306	10	4.450	-45	2	4.407	.019	CC = .986
76BP	78	306	11	4.450	-64	2	4.388		
	2.5	LAGS	DT=	.021 -.019=	.002	11	LATE		
50BP	78	306	10	4.600	-38	2	4.564	.007	CC = .996
50BP	78	306	11	4.600	-45	2	4.557		
	.9	LAGS	DT=	.008 -.007=	.001	11	LATE		

Table 6.2

10A	78	236	9	6.912	-6	0	6.906	-.013	CC = .785
10A	78	306	10	6.898	21	0	6.919		
	-.0	LAGS	DT=	-.000 .013=	.013	10	LATE		
10A	78	236	9	6.912	-6	0	6.906	-.017	CC = .603
10A	78	306	11	6.924	-1	0	6.923		
	-.6	LAGS	DT=	-.005 .017=	.012	11	LATE		
10A	78	306	10	6.898	21	0	6.919	-.004	CC = .598
10A	78	306	11	6.924	-1	0	6.923		
	-.6	LAGS	DT=	-.005 .004=	-.001	11	EARLY		
16A	78	236	9	7.159	-6	0	7.153	-.013	CC = .692
16A	78	306	10	7.145	21	0	7.166		
	-.8	LAGS	DT=	-.006 .013=	.007	10	LATE		
16A	78	236	9	7.159	-6	0	7.153	-.020	CC = .800
16A	78	306	11	7.174	-1	0	7.173		
	-1.7	LAGS	DT=	-.014 .020=	.006	11	LATE		
16A	78	306	10	7.145	21	0	7.166	-.007	CC = .830
16A	78	306	11	7.174	-1	0	7.173		
	-1.0	LAGS	DT=	-.009 .007=	-.002	11	EARLY		
20A	78	236	9	11.249	-6	0	11.243	-.014	CC = .863
20A	78	306	10	11.236	21	0	11.257		
	-.3	LAGS	DT=	-.002 .014=	.012	10	LATE		
20A	78	236	9	11.249	-6	0	11.243	.002	CC = .880
20A	78	306	11	11.242	-1	0	11.241		
	1.1	LAGS	DT=	.009 -.002=	.007	11	LATE		
20A	78	306	10	11.236	21	0	11.257	.016	CC = .922
20A	78	306	11	11.242	-1	0	11.241		
	1.4	LAGS	DT=	.012 -.016=	-.004	11	EARLY		
54A	78	236	9	2.345	-6	0	2.339	-.006	CC = .976
54A	78	306	10	2.324	21	0	2.345		
	.3	LAGS	DT=	.003 .006=	.009	10	LATE		
54A	78	236	9	2.345	-6	0	2.339	-.004	CC = .983
54A	78	306	11	2.344	-1	0	2.343		
	.3	LAGS	DT=	.002 .004=	.006	11	LATE		
54A	78	306	10	2.324	21	0	2.345	.002	CC = .986
54A	78	306	11	2.344	-1	0	2.343		
	-.1	LAGS	DT=	-.000 -.002=	-.002	11	EARLY		
56A	78	236	9	2.903	-6	0	2.897	-.010	CC = .777
56A	78	306	10	2.886	21	0	2.907		
	-1.7	LAGS	DT=	-.014 .010=	-.004	10	EARLY		
56A	78	236	9	2.903	-6	0	2.897	-.013	CC = .713

Table 6.3

56A	78	306	11	2.911	-1	0	2.910		
	-1.9	LAGS	DT= -.016	.013= -.003		11	EARLY		
56A	78	306	10	2.886	21	0	2.907	-.003	CC = .872
56A	78	306	11	2.911	-1	0	2.910		
	-.3	LAGS	DT= -.002	.003= .001		11	LATE		
60A	78	236	9	6.434	-6	0	6.428	.004	CC = .931
60A	78	306	10	6.403	21	0	6.424		
	.7	LAGS	DT= .006	-.004= .002		10	LATE		
60A	78	236	9	6.434	-6	0	6.428	-.007	CC = .925
60A	78	306	11	6.436	-1	0	6.435		
	-.7	LAGS	DT= -.006	.007= .001		11	LATE		
60A	78	306	10	6.403	21	0	6.424	-.011	CC = .979
60A	78	306	11	6.436	-1	0	6.435		
	-1.4	LAGS	DT= -.011	.011= -.000		11	EARLY		
64A	78	236	9	9.590	-6	0	9.584	-.008	CC = .969
64A	78	306	10	9.571	21	0	9.592		
	.0	LAGS	DT= .000	.008= .008		10	LATE		
64A	78	236	9	9.590	-6	0	9.584	-.015	CC = .982
64A	78	306	11	9.600	-1	0	9.599		
	-.9	LAGS	DT= -.008	.015= .007		11	LATE		
64A	78	306	10	9.571	21	0	9.592	-.007	CC = .945
64A	78	306	11	9.600	-1	0	9.599		
	-.9	LAGS	DT= -.008	.007= -.001		11	EARLY		

Table 7.1

ST	YR	DAY	SHOT	START TIME	CORRECTIONS CLOCKS	BP	CORRECT TIME	A-B	CROSS-CORR. COEFF.
56BP	76	350	5	52.900	9988	22	2.910	.003	CC = .718
56A	78	306	10	2.866	21	0	2.907		
	-.2	LAGS	DT=	-.004 -.003=	-.007	10	EARLY		
56BP	76	350	5	52.900	9988	22	2.910	-.021	CC = .626
56A	79	178	12	2.866	65	0	2.931		
	-1.6	LAGS	DT=	-.026 .021=	-.005	12	EARLY		
56BP	76	350	5	52.900	9988	22	2.910	-.039	CC = .709
56A	79	179	13	2.868	81	0	2.949		
	-1.6	LAGS	DT=	-.027 .039=	.012	13	LATE		
56A	78	306	10	2.866	21	0	2.907	-.024	CC = .848
56A	79	178	12	2.866	65	0	2.931		
	-2.3	LAGS	DT=	-.019 .024=	.005	12	LATE		
56A	78	306	10	2.866	21	0	2.907	-.042	CC = .822
56A	79	179	13	2.868	81	0	2.949		
	-2.3	LAGS	DT=	-.020 .042=	.022	13	LATE		
A	79	178	12	2.866	65	0	2.931	-.018	CC = .928
56A	79	179	13	2.866	81	0	2.949		
	-.0	LAGS	DT=	-.000 .018=	.018	13	LATE		
76BP	77	243	6	4.433	-28	22	4.427	.020	CC = .984
76BP	78	306	10	4.450	-45	2	4.407		
	-.1	LAGS	DT=	-.002 -.020=	-.022	10	EARLY		
76BP	77	243	6	4.433	-28	22	4.427	.025	CC = .979
76BP	79	178	12	4.400	0	2	4.402		
	.0	LAGS	DT=	.000 -.025=	-.025	12	EARLY		
76BP	77	243	6	4.433	-28	22	4.427	.026	CC = .959
76BP	79	179	13	4.400	-1	2	4.401		
	.7	LAGS	DT=	.011 -.026=	-.015	13	EARLY		
76BP	78	306	10	4.450	-45	2	4.407	.005	CC = .974
76BP	79	178	12	4.400	0	2	4.402		
	.3	LAGS	DT=	.002 -.005=	-.003	12	EARLY		
76BP	78	306	10	4.450	-45	2	4.407	.006	CC = .976
76BP	79	179	13	4.400	-1	2	4.401		
	1.7	LAGS	DT=	.014 -.006=	.008	13	LATE		
76BP	79	178	12	4.400	0	2	4.402	.001	CC = .984
76BP	79	179	13	4.400	-1	2	4.401		
	1.4	LAGS	DT=	.011 -.001=	.010	13	LATE		

Table 7.2

58BP	77	243	6	4.283	-28	22	4.277	.022	CC = .966
58BP	79	178	12	4.250	3	2	4.255		
	-.0	LAGS	DT=	-.001 -.022=	-.023	12	EARLY		
58BP	77	243	6	4.283	-28	22	4.277	.024	CC = .936
58BP	79	179	13	4.250	1	2	4.253		
	.7	LAGS	DT=	.012 -.024=	-.012	13	EARLY		
58BP	77	243	6	4.283	-28	22	4.277	.024	CC = .884
58A	74	204	3	13.178	-3925	0	4.253		
	-.6	LAGS	DT=	-.010 -.024=	-.034	6	LATE		
58BP	79	178	12	4.250	3	2	4.255	.002	CC = .958
58BP	79	179	13	4.250	1	2	4.253		
	1.6	LAGS	DT=	.014 -.002=	.012	13	LATE		
58BP	79	178	12	4.250	3	2	4.255	.002	CC = .879
58A	74	204	3	13.178	-3925	0	4.253		
	-1.1	LAGS	DT=	-.009 -.002=	-.011	12	LATE		
58BP	79	179	13	4.250	1	2	4.253	0.000	CC = .841
58A	74	204	3	13.178	-3925	0	4.253		
	-2.7	LAGS	DT=	-.022 0.000=	-.022	13	LATE		
52BP	78	151	7	2.100	-39	2	2.063	.009	CC = .954
52BP	78	306	10	2.100	-48	2	2.054		
	1.1	LAGS	DT=	.009 -.009=	-.000	10	EARLY		
52BP	78	151	7	2.100	-39	2	2.063	.012	CC = .987
52BP	79	178	12	2.050	-1	2	2.051		
	.9	LAGS	DT=	.008 -.012=	-.004	12	EARLY		
52BP	78	151	7	2.100	-39	2	2.063	.013	CC = .874
52BP	79	179	13	2.050	-2	2	2.050		
	2.5	LAGS	DT=	.021 -.013=	.008	13	LATE		
52BP	78	306	10	2.100	-48	2	2.054	.003	CC = .919
52BP	79	178	12	2.050	-1	2	2.051		
	-.2	LAGS	DT=	-.001 -.003=	-.004	12	EARLY		
52BP	78	306	10	2.100	-48	2	2.054	.004	CC = .882
52BP	79	179	13	2.050	-2	2	2.050		
	1.4	LAGS	DT=	.011 -.004=	.007	13	LATE		
52BP	79	178	12	2.050	-1	2	2.051	.001	CC = .866
52BP	79	179	13	2.050	-2	2	2.050		
	1.6	LAGS	DT=	.013 -.001=	.012	13	LATE		
62BP	78	151	7	7.800	-36	2	7.764	.004	CC = .909
62BP	78	306	10	7.800	-42	2	7.760		
	.5	LAGS	DT=	.004 -.004=	.000	10	LATE		

Table 7.3

62BP	78	151	7	7.800	-33	2	7.764	.009	CC = .927
62BP	79	178	12	7.750	3	2	7.755		
	.7	LAGS	DT=	.006 -.009=	-.003	12	EARLY		
62BP	78	306	10	7.800	-42	2	7.760	.005	CC = .973
62BP	79	178	12	7.750	3	2	7.755		
	.2	LAGS	DT=	.001 -.005=	-.004	12	EARLY		
30BP	78	236	9	6.775	-40	2	6.737	.003	CC = .977
30BP	79	178	12	6.725	7	2	6.734		
	.0	LAGS	DT=	.000 -.003=	-.003	12	EARLY		
30BP	78	236	9	6.775	-40	2	6.737	-.009	CC = .930
30A	74	204	3	17.671	-3925	0	6.746		
	-1.8	LAGS	DT= -.015	.009=	-.006	9	LATE		
30BP	79	178	12	6.725	7	2	8.734	-.012	CC = .838
30A	74	204	3	17.671	-3925	0	8.746		
	-1.9	LAGS	DT= -.016	.012=	-.004	12	LATE		
54A	74	204	3	11.219	-3925	0	2.294	-.051	CC = .904
54A	78	306	10	2.324	21	0	2.345		
	-2.1	LAGS	DT= -.017	.051=	.034	10	LATE		
54A	74	204	3	11.219	-3925	0	2.294	-.031	CC = .930
54A	79	178	12	2.260	65	0	2.325		
	.0	LAGS	DT=	.000 .031=	.031	12	LATE		
54A	74	204	3	11.219	-3925	0	2.294	-.043	CC = .915
54A	79	179	13	2.256	81	0	2.337		
	-.1	LAGS	DT= -.001	.043=	.042	13	LATE		
54A	78	306	10	2.324	21	0	2.345	.020	CC = .957
54A	79	178	12	2.260	65	0	2.325		
	2.3	LAGS	DT=	.019 -.020=	-.001	12	EARLY		
54A	78	306	10	2.324	21	0	2.345	.008	CC = .972
54A	79	179	13	2.256	61	0	2.337		
	2.1	LAGS	DT=	.017 -.008=	.009	13	LATE		
54A	79	178	12	2.260	65	0	2.325	-.012	CC = .988
54A	79	179	13	2.256	61	0	2.337		
	-.2	LAGS	DT= -.002	.012=	.010	13	LATE		
60A	74	204	3	15.351	-3934	0	6.417	-.007	CC = .811
60A	78	306	10	6.403	21	0	6.424		
	.6	LAGS	DT=	.005 .007=	.012	10	LATE		
60A	74	204	3	15.351	-3934	0	6.417	-.011	CC = .840
60A	79	178	12	6.363	65	0	6.428		
	.4	LAGS	DT=	.004 .011=	.015	12	LATE		
60A	74	204	3	15.351	-3934	0	6.417	-.026	CC = .833

Table 7.4

60A	79	179	13	6.362	81	0	6.443		
	-.1	LAGS	DT=	-.000 .026=	.026	13	LATE		
60A	78	306	10	6.403	21	0	6.424	-.004	CC = .972
60A	79	178	12	6.363	65	0	6.428		
	-.1	LAGS	DT=	-.001 .004=	.003	12	LATE		
60A	78	306	10	6.403	21	0	6.424	-.019	CC = .972
60A	79	179	13	6.362	81	0	6.443		
	-.6	LAGS	DT=	-.005 .019=	.014	13	LATE		
60A	79	178	12	6.363	65	0	6.428	-.015	CC = .965
60A	79	179	13	6.362	81	0	6.443		
	-.5	LAGS	DT=	-.004 .015=	.011	13	LATE		
64A	77	243	6	9.597	-12	0	9.585	-.007	CC = .960
64A	78	306	10	9.571	21	0	9.592		
	-.6	LAGS	DT=	-.005 .007=	.002	10	LATE		
64A	77	243	6	9.597	-12	0	9.585	0.000	CC = .979
64A	79	178	12	9.520	65	0	9.585		
	-.0	LAGS	DT=	-.000 0.000=	-.000	12	EARLY		
64A	77	243	6	9.597	-12	0	9.585	-.005	CC = .950
64A	79	179	13	9.509	81	0	9.590		
	.6	LAGS	DT=	.005 .005=	.010	13	LATE		
64A	78	306	10	9.571	21	0	9.592	.007	CC = .939
64A	79	178	12	9.520	65	0	9.585		
	.5	LAGS	DT=	.004 -.007=	-.003	12	EARLY		
64A	78	306	10	9.571	21	0	9.592	.002	CC = .922
64A	79	179	13	9.509	81	0	9.590		
	1.1	LAGS	DT=	.010 -.002=	.008	13	LATE		
64A	79	178	12	9.520	65	0	9.585	-.005	CC = .939
64A	79	179	13	9.509	81	0	9.590		
	.6	LAGS	DT=	.005 .005=	.010	13	LATE		
20A	77	243	6	11.261	-12	0	11.249	-.008	CC = .915
20A	78	306	10	11.236	21	0	11.257		
	-.6	LAGS	DT=	-.005 .008=	.003	10	LATE		
20A	77	243	6	11.261	-12	0	11.249	-.003	CC = .834
20A	79	178	12	11.187	65	0	11.252		
	-.5	LAGS	DT=	-.004 .003=	-.001	12	EARLY		
20A	77	243	6	11.261	-12	0	11.249	-.014	CC = .936
20A	79	179	13	11.182	81	0	11.263		
	-.9	LAGS	DT=	-.007 .014=	.007	13	LATE		
20A	78	306	10	11.236	21	0	11.257	.005	CC = .920
20A	79	178	12	11.187	65	0	11.252		

Table 7.5

	.0	LAGS	DT=	.000 -.005=	-.005	12	EARLY		
20A	78	306	10	11.236	21	0	11.257	-.006	CC = .892
20A	79	179	13	11.182	61	0	11.263		
	-.3	LAGS	DT= -.003	.006=	.003	13	LATE		
20A	79	178	12	11.187	65	0	11.252	-.011	CC = .860
20A	79	179	13	11.182	61	0	11.263		
	-.3	LAGS	DT= -.003	.011=	.008	13	LATE		
10A	77	243	6	6.917	-12	0	6.905	-.014	CC = .756
10A	78	306	10	6.898	21	0	6.919		
	-1.5	LAGS	DT= -.013	.014=	.001	10	LATE		
10A	77	243	6	6.917	-12	0	6.905	.001	CC = .675
10A	79	178	12	6.839	65	0	6.904		
	-.2	LAGS	DT= -.001	-.001=	-.002	12	EARLY		
10A	77	243	6	6.917	-12	0	6.905	-.012	CC = .650
10A	79	179	13	6.836	61	0	6.917		
	-.4	LAGS	DT= -.003	.012=	.009	13	LATE		
10A	78	306	10	6.898	21	0	6.919	.015	CC = .723
10A	79	178	12	6.839	65	0	6.904		
	1.1	LAGS	DT=	.010 -.015=	-.005	12	EARLY		
10A	78	306	10	6.898	21	0	6.919	.002	CC = .577
10A	79	179	13	6.836	61	0	6.917		
	1.0	LAGS	DT=	.008 -.002=	.006	13	LATE		
10A	79	178	12	6.839	65	0	6.904	-.013	CC = .792
10A	79	179	13	6.836	61	0	6.917		
	-.3	LAGS	DT= -.002	.013=	.011	13	LATE		
16A	78	151	7	7.166	-19	0	7.147	-.019	CC = .732
16A	78	306	10	7.145	21	0	7.166		
	-.6	LAGS	DT= -.005	.019=	.014	10	LATE		
16A	78	151	7	7.166	-19	0	7.147	-.010	CC = .865
16A	79	178	12	7.092	65	0	7.157		
	.2	LAGS	DT=	.001 .010=	.011	12	LATE		
16A	78	151	7	7.166	-19	0	7.147	-.021	CC = .908
16A	79	179	13	7.087	61	0	7.168		
	.1	LAGS	DT=	.001 .021=	.022	13	LATE		
16A	78	306	10	7.145	21	0	7.166	.009	CC = .865
16A	79	178	12	7.092	65	0	7.157		
	.6	LAGS	DT=	.007 -.009=	-.002	12	EARLY		
16A	78	306	10	7.145	21	0	7.166	-.002	CC = .834
16A	79	179	13	7.087	61	0	7.168		
	.6	LAGS	DT=	.007 .002=	.009	13	LATE		

Table 7.6

16A	79	173	12	7.092	65	0	7.157	-.011	CC = .944
16A	79	179	13	7.087	81	0	7.168		

-.0 LAGS DT= -.000 .011= .011 13 LATE

Table 8.1

ST	YR	DAY	SHOT	START TIME	CORRECTIONS CLOCKS	BP	CORRECT TIME	A-B	CROSS-CORR. COEFF.
56BP	76	302	102	5.783	-45	22	5.760	-.031	CC = .808
56A	78	235	106	5.800	-9	0	5.791		
	-4.1	LAGS	DT= -.068	.031=	-.037	106	EARLY		
56BP	76	302	102	5.783	-45	22	5.760	-.045	CC = .784
56A	79	177	107	5.752	53	0	5.805		
	-5.5	LAGS	DT= -.091	.045=	-.046	107	EARLY		
56A	78	235	106	5.800	-9	0	5.791	-.014	CC = .925
56A	79	177	107	5.752	53	0	5.805		
	-2.4	LAGS	DT= -.020	.014=	-.006	107	EARLY		
16BP	76	351	103	2.633	-30	22	2.625	-.028	CC = .761
16A	78	235	106	2.658	-5	0	2.653		
	-.5	LAGS	DT= -.008	.028=	.020	106	LATE		
16BP	76	351	103	2.633	-30	22	2.625	-.036	CC = .791
16A	79	177	107	2.604	57	0	2.661		
	-1.4	LAGS	DT= -.024	.036=	.012	107	LATE		
1	78	235	106	2.658	-5	0	2.653	-.008	CC = .931
16A	79	177	107	2.604	57	0	2.661		
	-1.6	LAGS	DT= -.015	.008=	-.007	107	EARLY		
76BP	77	242	104	6.500	-27	22	6.495	-.009	CC = .891
76BP	78	235	106	6.550	-48	2	6.504		
	-.5	LAGS	DT= -.009	.009=	.000	106	LATE		
76BP	77	242	104	6.500	-27	22	6.495	-.023	CC = .960
76BP	79	177	107	6.500	16	2	6.518		
	-2.0	LAGS	DT= -.033	.023=	-.010	107	EARLY		
76BP	78	235	106	6.550	-48	2	6.504	-.014	CC = .881
76BP	79	177	107	6.500	16	2	6.518		
	-2.9	LAGS	DT= -.024	.014=	-.010	107	EARLY		
62BP	77	242	104	7.683	-27	22	7.678	.014	CC = .938
62BP	78	235	106	7.700	-38	2	7.664		
	.6	LAGS	DT= .014	-.014=	-.000	106	EARLY		
62BP	77	242	104	7.683	-27	22	7.678	.009	CC = .853
62BP	79	177	107	7.650	17	2	7.669		
	-.3	LAGS	DT= -.004	-.009=	-.013	107	EARLY		
62BP	78	235	106	7.700	-38	2	7.664	-.005	CC = .876
62BP	79	177	107	7.650	17	2	7.669		
	-2.2	LAGS	DT= -.018	.005=	-.013	107	EARLY		

Table 8.2

58BP	77	242	104	4.500	-28	22	4.494	-.022	CC = .841
58BP	79	177	107	4.500	14	2	4.516		
-2.1	LAGS	DT= -.035	.022= -.013	107	EARLY				
58BP	77	242	104	4.500	-28	22	4.494	-.002	CC = .761
58A	75	280	101	4.522	-26	0	4.496		
-1.0	LAGS	DT= -.016	.002= -.014	104	LATE				
58BP	79	177	107	4.500	14	2	4.516	.020	CC = .842
58A	75	280	101	4.522	-26	0	4.496		
2.4	LAGS	DT= .020	-.020= .000	107	EARLY				
30BP	78	235	106	1.150	-32	2	1.120	.011	CC = .923
30BP	79	177	107	1.100	7	2	1.109		
-.2	LAGS	DT= -.002	-.011= -.013	107	EARLY				
30BP	78	235	106	1.150	-32	2	1.120	.013	CC = .810
30A	75	280	101	1.133	-26	0	1.107		
.7	LAGS	DT= .006	-.013= -.007	106	LATE				
30BP	79	177	107	1.101	7	2	1.109	.002	CC = .814
30A	75	280	101	1.133	-26	0	1.107		
.9	LAGS	DT= .006	-.002= .006	107	EARLY				
54A									
54A									
54A				SEE END OF TABLE					
54A									
54A									
54A									
60A	75	280	101	6.769	-18	0	6.771	.003	CC = .715
60A	78	235	106	6.774	-6	0	6.768		
.6	LAGS	DT= .005	-.003= .002	106	LATE				
60A	75	280	101	6.789	-18	0	6.771	.007	CC = .780
60A	79	177	107	6.708	56	0	6.764		
.1	LAGS	DT= .001	-.007= -.006	107	EARLY				
60A	78	235	106	6.774	-6	0	6.768	.004	CC = .902
60A	79	177	107	6.708	56	0	6.764		
-.5	LAGS	DT= -.004	-.004= -.008	107	EARLY				
64A	77	242	104	9.128	-18	0	9.110	-.001	CC = .941
64A	78	235	106	9.116	-5	0	9.111		
.2	LAGS	DT= .001	.001= .002	106	LATE				

Table 8.3

64A	77	242	104	9.128	-18	0	9.110	-.003	CC = .907
64A	79	177	107	9.055	58	0	9.113		
	-.4	LAGS	DT= -.003	.003= -.000	107	EARLY			
64A	78	235	106	9.116	-5	0	9.111	-.002	CC = .899
64A	79	177	107	9.055	58	0	9.113		
	-.7	LAGS	DT= -.005	.002= -.003	107	EARLY			
20A	77	242	104	8.367	-18	0	8.349	.014	CC = .917
20A	78	150	105	8.360	-25	0	8.335		
	-.3	LAGS	DT= -.002	-.014= -.016	105	EARLY			
20A	77	242	104	8.367	-18	0	8.349	.007	CC = .859
20A	79	177	107	8.283	59	0	8.342		
	.3	LAGS	DT= .003	-.007= -.004	107	EARLY			
20A	78	150	105	8.360	-25	0	8.335	-.007	CC = .950
20A	79	177	107	8.283	59	0	8.342		
	.6	LAGS	DT= .005	.007= .012	107	LATE			
10A	77	242	104	3.512	-18	0	3.494	.003	CC = .916
10A	78	150	105	3.516	-25	0	3.491		
	-1.0	LAGS	DT= -.008	-.003= -.011	105	EARLY			
10A	77	242	104	3.512	-18	0	3.494	-.003	CC = .876
10A	79	177	107	3.447	50	0	3.497		
	-.9	LAGS	DT= -.008	.003= -.005	107	EARLY			
10A	78	150	105	3.516	-25	0	3.491	-.006	CC = .975
10A	79	177	107	3.447	50	0	3.497		
	.0	LAGS	DT= .000	.006= .006	107	LATE			

Table 8.4

ST	YR	DAY	SHOT	START TIME	CORRECTIONS CLOCKS	BP	CORRECT TIME	A-B	CROSS-CORR. COEFF.
54BP	76	351	103	5.816	-36	22	5.802	.017	CC = .487
54A	75	280	101	5.811	-26	0	5.785		
	-.1	LAGS	DT=	-.001 -.017=	-.018	103	LATE		
54BP	76	351	103	5.816	-36	22	5.802	.007	CC = .877
54A	77	242	104	5.813	-18	0	5.795		
	.6	LAGS	DT=	.011 -.007=	.004	104	LATE		
54BP	76	351	103	5.816	-36	22	5.802	.013	CC = .761
54A	78	150	105	5.816	-27	0	5.789		
	.1	LAGS	DT=	.002 -.013=	-.011	105	EARLY		
54BP	76	351	103	5.816	-36	22	5.802	-.011	CC = .727
54A	79	177	107	5.762	51	0	5.813		
	-.0	LAGS	DT=	-.000 .011=	.011	107	LATE		
54A	75	280	101	5.811	-26	0	5.785	-.010	CC = .492
54A	77	242	104	5.813	-18	0	5.795		
	1.3	LAGS	DT=	.011 .010=	.021	104	LATE		
54A	75	280	101	5.811	-26	0	5.785	-.004	CC = .411
54A	78	150	105	5.816	-27	0	5.789		
	.4	LAGS	DT=	.003 .004=	.007	105	LATE		
	75	280	101	5.811	-26	0	5.785	-.028	CC = .424
[illegible]	79	177	107	5.762	51	0	5.813		
	.1	LAGS	DT=	.001 .028=	.029	107	LATE		
54A	77	242	104	5.813	-18	0	5.795	.006	CC = .873
54A	78	150	105	5.816	-27	0	5.789		
	-.9	LAGS	DT=	-.008 -.006=	-.014	105	EARLY		
54A	77	242	104	5.813	-18	0	5.795	-.018	CC = .834
54A	79	177	107	5.762	51	0	5.813		
	-1.3	LAGS	DT=	-.011 .018=	.007	107	LATE		
54A	78	150	105	5.816	-27	0	5.789	-.024	CC = .823
54A	79	177	107	5.762	51	0	5.813		
	-.3	LAGS	DT=	-.003 .024=	.021	107	LATE		

APPENDICES

A Coordinates of all recording stations

B Distances and azimuths from shot point La Pocatière to stations

C Distances and azimuths from shot point St. Jerôme to stations.

APPENDIX A

STATION COORDINATES

STATION NO.	LATITUDE N	LONGITUDE W
10	47.2460	-70.1930
11	47.2430	-70.1970
12	47.3200	-70.1200
16	47.4680	-70.0100
18	47.5190	-69.8640
20	47.7060	-69.6900
21	47.7040	-69.6900
22	47.9880	-69.4270
30	47.3360	-69.9410
50	47.7860	-70.7410
52	47.4270	-70.5200
54	47.4570	-70.4130
56	47.5500	-70.3270
58	47.5250	-70.2130
60	47.6920	-70.0930
62	47.7520	-70.0090
64	47.8270	-69.8910
66	48.0150	-69.8190
68	48.2160	-69.6820
74	47.6330	-70.4610
76	47.6430	-70.2410
80 00	47.5150	-70.5490
82 01	47.5780	-70.5760
1	47.5098	-70.3400
8	47.5635	-70.3847
T 2	47.6543	-70.1802
T 3	47.6823	-70.1399
T 5	47.7112	-70.0618
T 6	47.7342	-70.0293

APPENDIX B

DISTANCES AND AZIMUTHS
FROM LA POCATIERE TO STATIONS

STN. NO.		DIST	AZ(EP)	AZ(ST)	KM
	10	.162	230.01	49.87	17.98
	11	.166	229.82	49.68	18.42
	12	.080	247.96	67.88	8.88
	16	.118	.40	180.40	13.13
	18	.196	30.53	210.64	21.84
	20	.417	31.31	211.55	46.42
	21	.416	31.46	211.69	46.23
	22	.751	31.52	211.95	83.47
	30	.050	106.33	286.38	5.53
	50	.659	311.70	131.17	73.30
	52	.354	282.75	102.38	39.39
	54	.293	291.56	111.27	32.60
	56	.293	313.15	132.92	32.61
	58	.222	322.03	141.89	24.72
	60	.347	350.83	170.77	38.55
	62	.402	.21	180.21	44.73
	64	.484	9.63	189.72	53.84
	66	.678	10.97	191.12	75.39
	68	.895	14.25	194.49	99.47
	74	.416	313.03	132.70	46.28
	76	.332	332.09	151.92	36.92
80	00	.401	294.53	114.13	44.56
82	01	.446	300.97	120.56	49.59
	1	.275	305.73	125.49	30.53
	8	.331	310.26	129.99	36.86
T	2	.325	339.44	159.31	36.17
T	3	.344	345.35	165.25	38.22
T	5	.363	354.60	174.56	40.37
T	6	.385	358.18	178.17	42.77

APPENDIX C

DISTANCES AND AZIMUTHS

FROM ST. JEROME MINE TO STATIONS

STN. NO.	DIST	AZ(EP)	AZ(ST)	KM
10	.379	139.30	319.57	42.18
11	.380	139.91	320.17	42.24
12	.365	125.72	306.04	40.63
16	.376	99.91	280.31	41.82
18	.469	91.58	272.09	52.18
20	.611	73.31	253.95	67.90
21	.610	73.49	254.13	67.84
22	.887	58.77	239.61	98.62
30	.462	115.16	295.61	51.39
50	.281	333.69	153.55	31.30
52	.110	167.14	347.16	12.21
54	.124	128.41	308.52	13.77
56	.156	84.02	264.19	17.34
58	.233	92.09	272.34	25.87
60	.351	63.05	243.39	39.02
62	.429	59.27	239.67	47.75
64	.537	56.63	237.12	59.66
66	.692	45.66	226.20	76.94
68	.901	40.45	221.09	100.19
74	.118	32.96	213.03	13.13
76	.240	62.80	243.03	26.63
80 00	.020	165.99	345.99	2.18
82 01	.046	342.90	162.89	5.12
1	.148	99.31	279.47	16.50
8	.120	75.67	255.79	13.31
T 2	.281	64.54	244.81	31.29
T 3	.318	62.06	242.36	35.39
T 5	.378	61.88	242.24	42.08
T 6	.409	60.46	240.84	45.44