Microseismic Monitoring in Blairmore, Alberta

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Pacific Geoscience Centre

INTERNAL REPORT 81-4

Earth Physics Branch

Department of Energy, Mines and Resources

1981

INTRODUCTION

In 1903, a devastating rock slide descended the east flank of Turtle Mountain and buried the town of Frank in SW Alberta. Since 1975, engineers from the University of Alberta have set up a program of monitoring widths of rock crevices at the top of Turtle Mountain in order to evaluate the future slide potential. In the Spring of 1981, the Alberta Department of Environment requested the Earth Physics Branch (EPB) through official channels to set up a seismic station in or near Blairmore, Alberta, on the west side of Turtle Mountain. This request was the direct result of persistent reports by a Blairmore resident, that her house was being shaken.

On 16 June 1981, EPB staff installed a regional package in Blairmore and monitored groundmotions until 1 September 1981. Although no events were reported felt, three swarms of very local high-frequency events with S-P times of less than a second, and ground velocities of the order of a few micrometers per second were observed which could be interpreted as natural events occurring in the vicinity of the slide area.

INSTRUMENTATION, STATION LOCATION AND OPERATION

A standard EPB regional package (Serial No. 25) was deployed by D. Monsees and D. Weichert on 16 June 1981. (see "Canadian Seismograph Operations" for instrumentation details). Geographical coordinates are 49° 36.2N $\pm$ 100 m and 114° 25.77'W $\pm$ 50 m., read from the 1:50000-scale map, sheet 82 G/9. The station was operated at a gain of 5000 in the velocity mode, i.e. within the passband of 1 Hz to 10 Hz the gain is approximately constant at 5 mm of record = 1 μ/m/s of ground velocity,

and dropping at about 6 db per octave outside the band. It was found necessary to switch the limiter on because of train noise: the station was about 400 m from the tracks, with 4 to 6 trains per day.

The station location was selected in the SE section of Blairmore on property belonging to Mrs. Anna Lissa, 3409 - 17th Ave., Box 691, Blairmore, Alberta TOK OEC (phone 403-562-2455) and not far from the house of the resident who initially had reported the groundshaking (see Figure 1). The cost to cover rent and electricity was $200 for the 2½ months.

In this area, a new housing development is built on a 30 to 50 m high gravel deposit, on the NW slope of Turtle Mountain, approximately opposite the 1903 rock slide, which was on the east or NE side. On the western edge of the gravel deposits, limestone bedrock steeply dipping to the west is exposed. The seismometer was set above ground on a limestone outcrop where heavily weathered surface rocks were removed and a flat slab cemented into place. The seismometer was protected by an inverted garbage can that was held in place by two rock bolts and two tension wires. The recorder was set up in a locked garage.

The house owner was not able to operate the station for us because of her holiday schedule. However, a very satisfactory arrangement was made with the staff of the road-side tourist information booth that was operated by the Alberta Department of Tourism between the towns of Frank and Blairmore. Two of the employees shared the work and EPB paid them 27.5¢/km for a 20 km daily round trip. The station was running between 16 June and 1 September, except for 30 July, and 1 to 5 August inclusive, when the postal strike caught up with the paper supply.

LOCAL ACTIVITY

Seismograms were read at the Pacific Geoscience Centre (PGC). Local Earthquake Summary Sheets are attached to this report in the Appendix.

The most obvious feature of the seismograms (Figures 2-4) is the train noise, slowly emerging from the background, reaching about 20-25 mm peak to peak and lasting up to 7 minutes. The next most easily identifiable event type has an S-P time of 5 to 6 sec, usually 6 sec, and appears to come from the Sparwood coal mining operations, 40 to 50 km away, cf. Figure 2. These events usually occur at about 18:15Z, although some exceptions are noted. Other smaller explosions with S-P times of 8 sec to 14 sec are recognized by their pronounced ground-roll Lg phases, and the preferential time-of-day of their occurrence. Only two regional earthquakes, at distances of a few hundred kilometers, were detected.

Most important was the observation, on three separate days, of swarms of very local events with S-P time intervals about one second. A swarm of about 6 events occurred on 26 June, between 19:47 Z and 21:30 Z (Figure 2). The count is doubtful because some events might be considered noise. The second swarm of about 20 events occurred on 9 July, 14:00 Z to 21:40 Z (Figure 3), and the third swarm of about 24 events with the largest amplitudes on 10 July, 18:32 Z to 23:47 Z (Figure 4). Some S-P times are near the resolution limit of the recording medium; they range from about 0.2 sec to 1.7 sec. The signal frequency is near the upper edge of the system band pass, and the true frequency and ground velocities may therefore be higher than apparent. Ground velocities are on the order of 1-3 μ/s.

A histogram of S-P times is given in Figure 5. If usual upper crustal velocities are assumed, the distances of these events would range from 3 or 4 km to 14 km: this would correspond to a distance range covering at least all of Turtle Mountain. However the 1.7s S-P at 17:14 Z on 09/07 could be incorrect. If an appropriately lower velocity for limestone is assumed, e.g. v_p = 4 km and $v_p/v_s = \sqrt{3}$, the 1s S-P gives a distance of 5.5 km, still further than to the old slide.

The small high-frequency events (10 Hz or more) are similar to events occasionally seen on other Canadian stations, e.g. Yellowknife or Arctic Stations during periods of strong temperature changes. A check of weather records was therefore made by Mr. T. Sneddon of the Alberta Department of Environment. He reports (priv. comm.) that no unusual weather phenoma temperature or pressure gradients or thunderstorm activity occurred during these days. On the other hand he reported some road blasting activity in the slide area on 25 June, on which date we cannot see any unusual activity on the seismogram. A systematic search for other blasting activities in the area was not made.

DISCUSSION

We consider the swarm activity on the three different days to be of natural origin, for perhaps three reasons. First, the large numbers of events during the rather restricted periods is atypical of blasting activity. Second, actually known blasting that occurred within the distance range of a few kilometers along the road below the Frank Slide area was not recorded: thus, unlikely numbers of much larger explosions are needed to explain the observed swarms on 26/06, 09/07 and 10/07. Finally, the increase in numbers per swarm, and increase in amplitude

from day to day does not appear typical of blasting. Against a natural origin could be argued by pointing out similar, but not identical times-of-day of the swarms, all within weekday working hours.

In 1953, Milne et al.* spent a summer in the same general area investigating "bumps" that had caused concern to the Mines Branch of EMR. These bumps were probably caused by strain adjustments in the actively worked coal mines. The coal mines near Blairmore have now been inactive for some time. However, it is not inconceivable that residual stresses are still present, and there are enough shafts (and open pits) west of Blairmore, towards Coleman and in the mountains, to qualify as possible causes for the swarm activity that was observed this year. Finally, we must consider amplitudes of the events. They correspond to about local magnitude zero, and according to accepted thresholds for felt-ground motion, 0.1 mm/s at these frequencies, the observed signals are at least a factor of 10 or 20 below the threshold of human perception. However, perception varies between individuals, especially in the range from 5 to 15 Hz where many of the resonances of the human body occur. Additional amplification of groundmotion would occur on the gravel slopes in the vicinity. It is therefore easily conceivable that events of the observed type could have been perceived in the past. It should be pointed out in this connection that other people in the area are also well aware of "bumps", not only those living on top of the hill, but below as well. However, as Mrs. Anctil made clear in an interview, though not in

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* W.G. Milne and W.R.H. White, 1958. A seismic investigation of mine "bumps" in the Crowsnest Pass coal field. The Canad. Min. and Metall. Bull. , 51 No. 559, p. 678-685.

her letter, the last time she herself heard or felt anything, or saw a picture move, was about Christmas 1980. During the time of the experiment, she says, she felt or heard nothing, but qualifies this by adding that she was not at home as much as last year.

CONCLUSIONS

Three swarms of what is thought to be natural seismic activity was observed near Blairmore during 2½ months of monitoring. The origin is uncertain since it could be in the Turtle Mountain area, as well as in the opposite direction in old coal workings or in any direction for that matter. Hypocentral distances range from perhaps 3 km to 10 km or more. This is too large a range to associate the swarm with either the old slide or the neighbouring rock walls that are currently investigated by U. of Alberta civil engineers.

Observed amplitudes are small, around a few micrometer per second, at 10 Hz or higher, at least an order of magnitude below felt-ground motion. Similar small signals are not uncommon in other areas of Canada, from varying causes. There is no reason to suspect that these events are premonitory for a mountain slide, except for the fact that there was such a slide some 80 years ago. Should a new series of felt-reports come from residents in the area, EPB should consider a tripartite array in the vicinity of the Frank Slide to determine hypocentres. Without such future activity, the Alberta Department of Environment might still consider the value of a more permanent seismic monitor of their own near the slide area.

LIST OF FIGURES

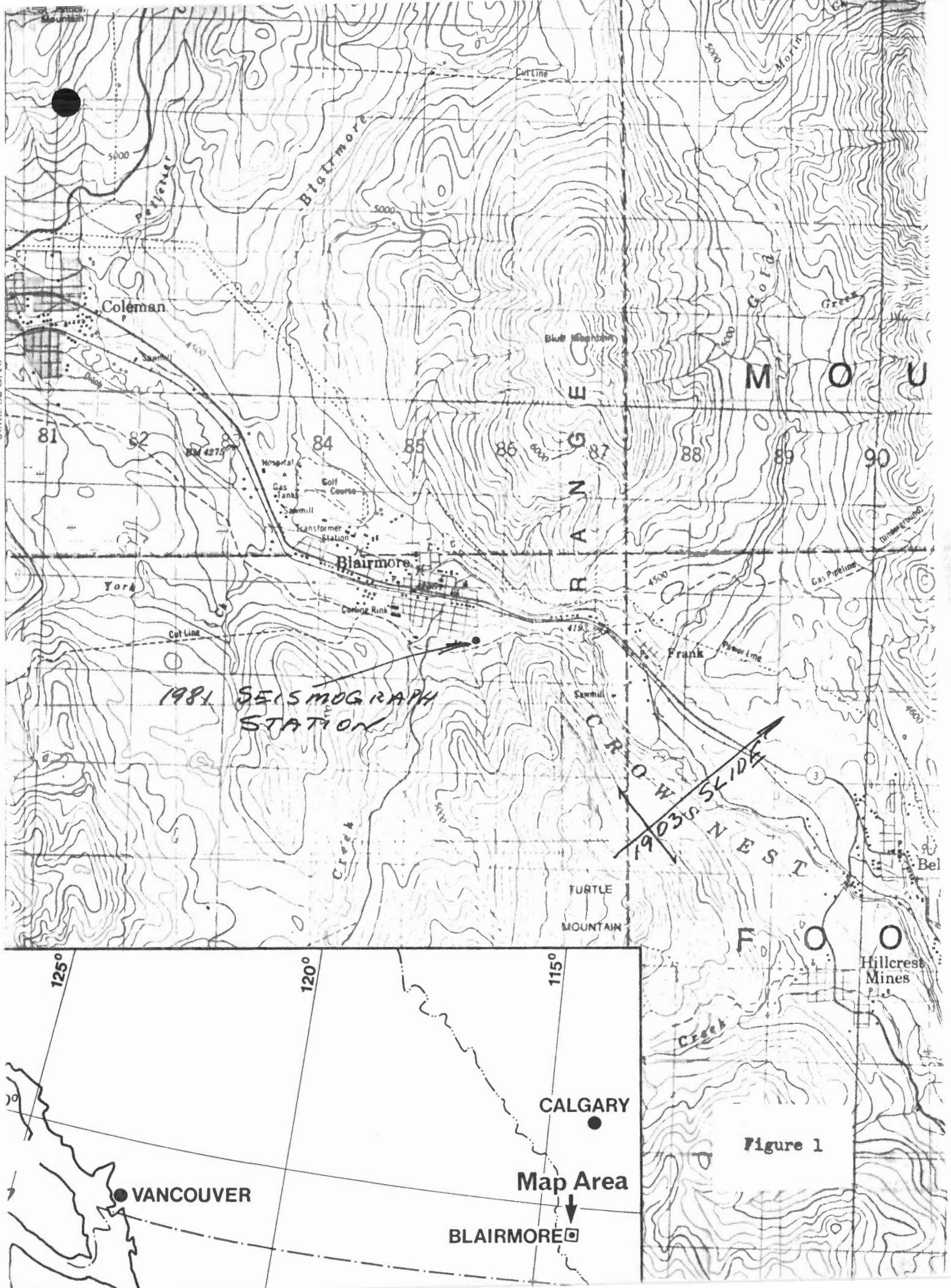
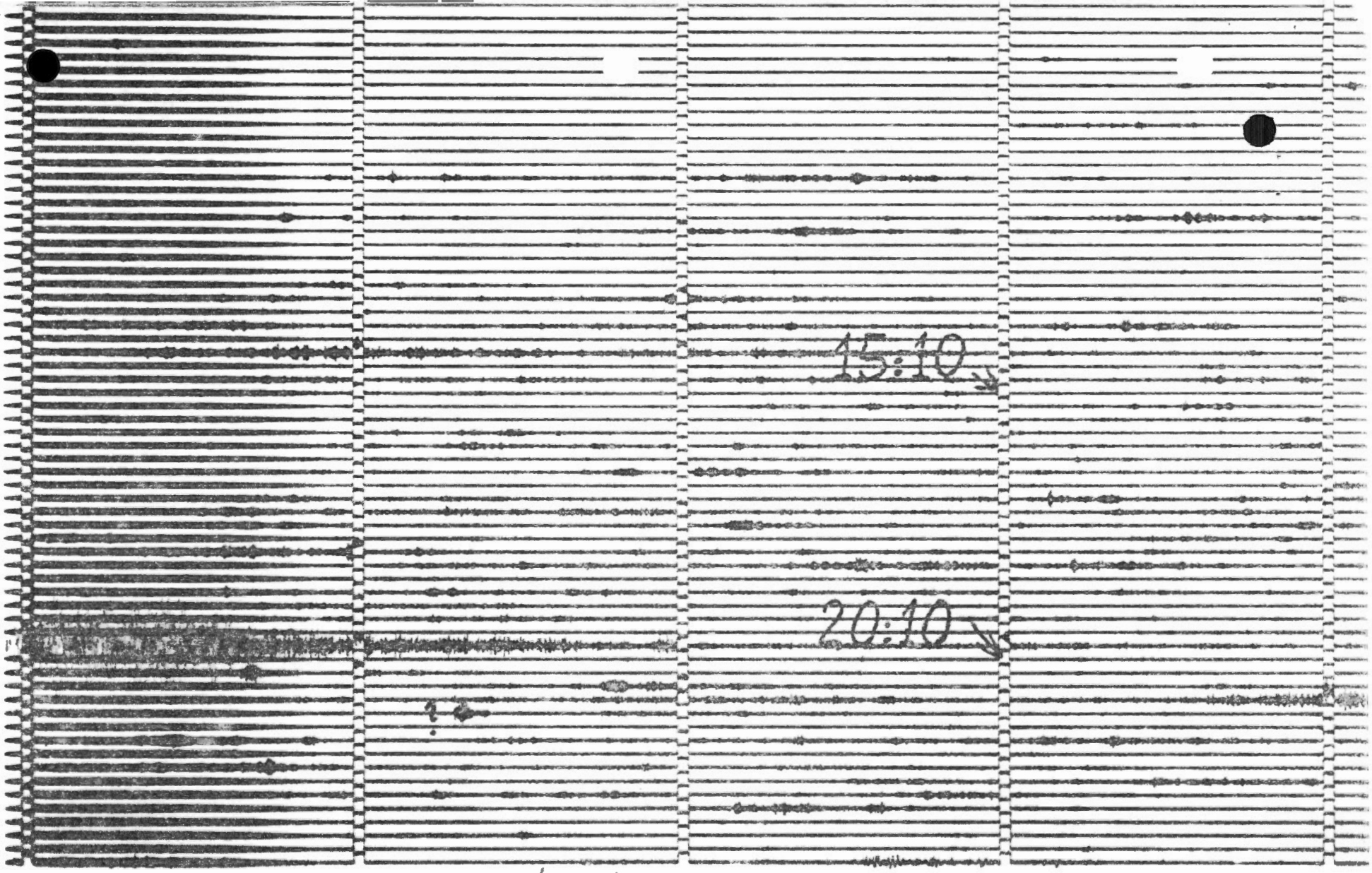

Coleman
Blairmore
Frank
Hillcrest Mines
TURTLE MOUNTAIN
1903 SLIDE
1984 SEISMOGRAPH STATION
Joins 82 G/10
CALGARY
VANCOUVER
Map Area
BLAIRMORE
125°
120°
115°

Figure 1



PREAMP05/1V/cm BA-SPZ

27 JUNE 81

FIG 2-a

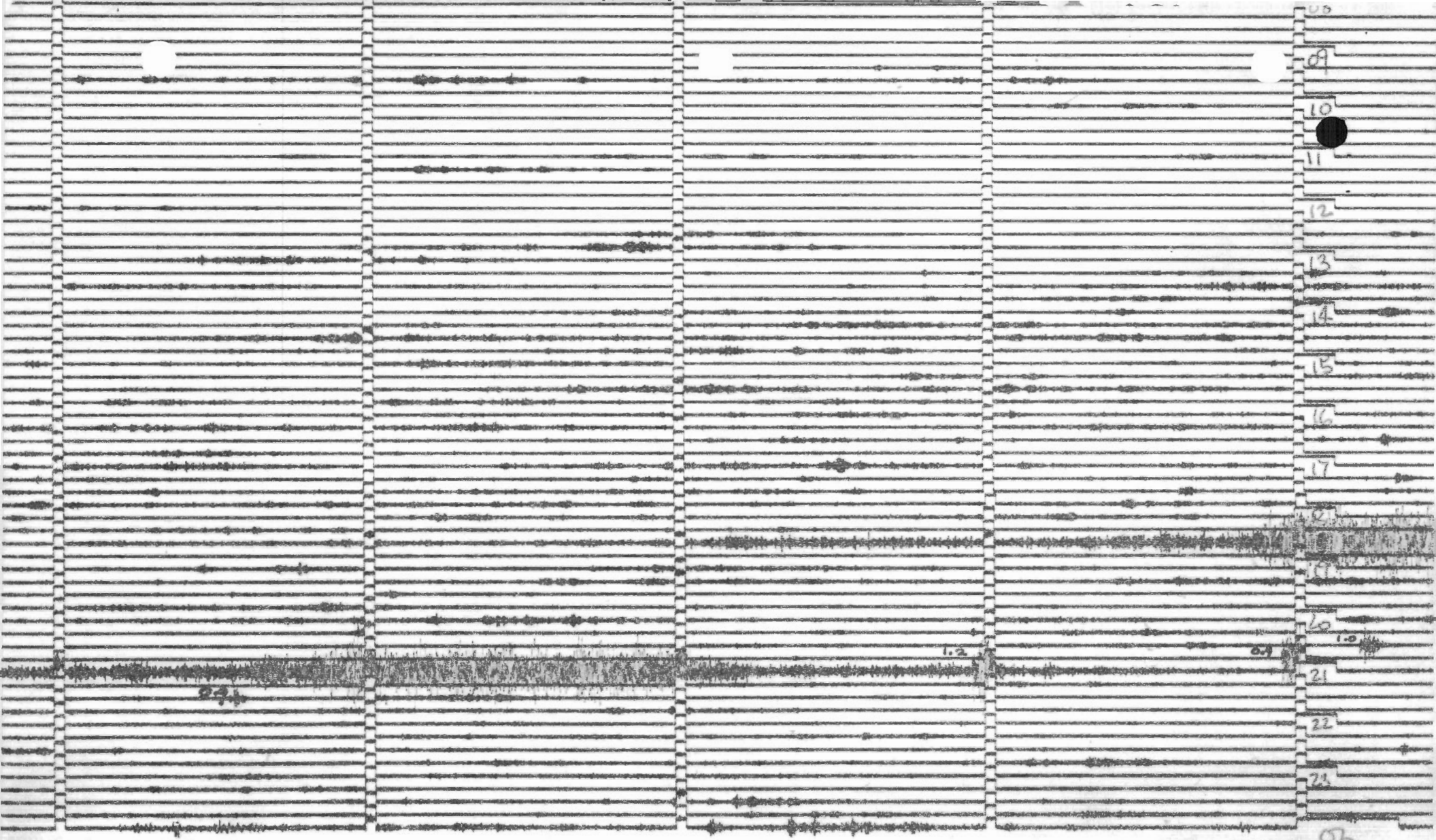


FIG 2-b

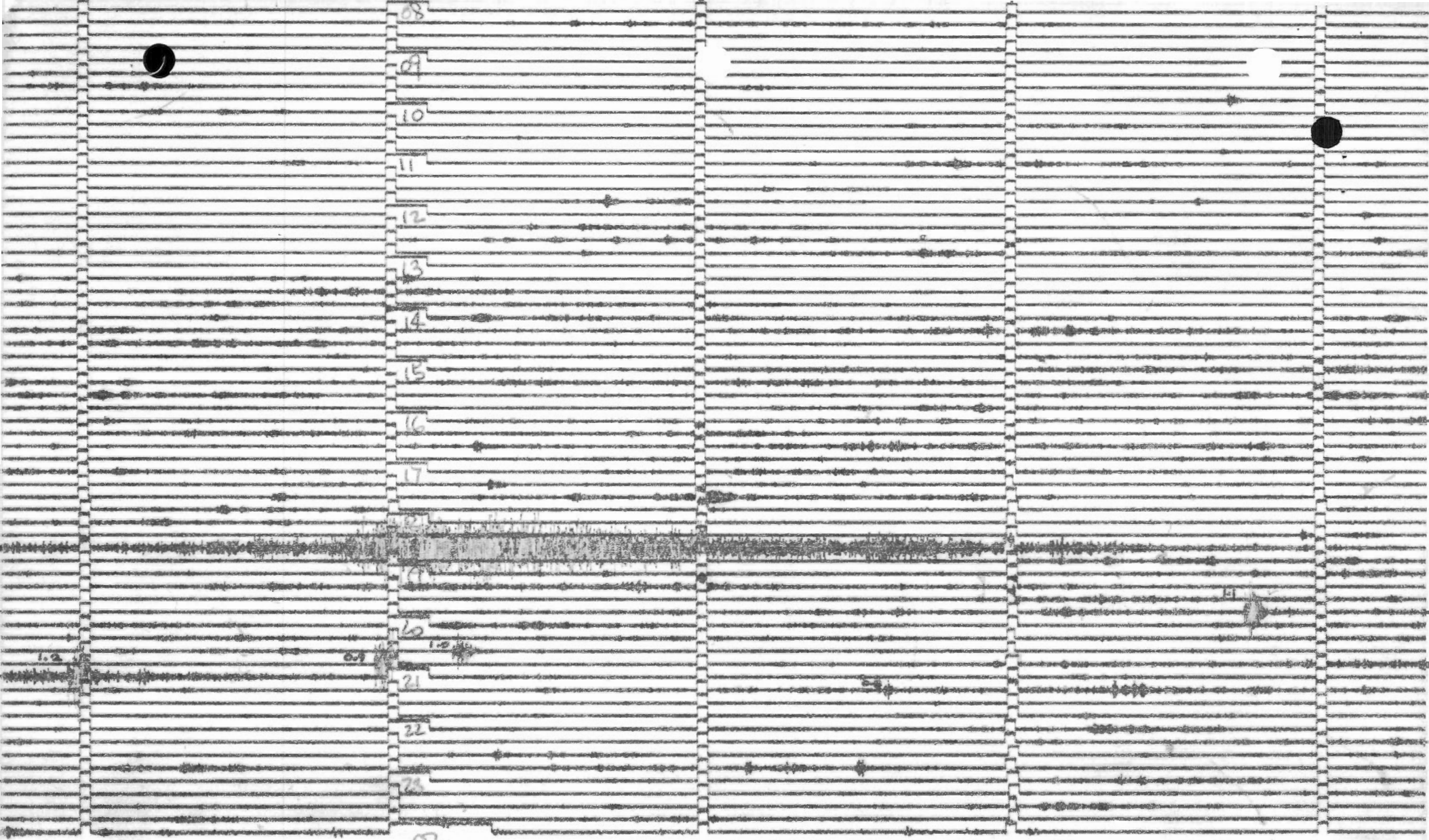
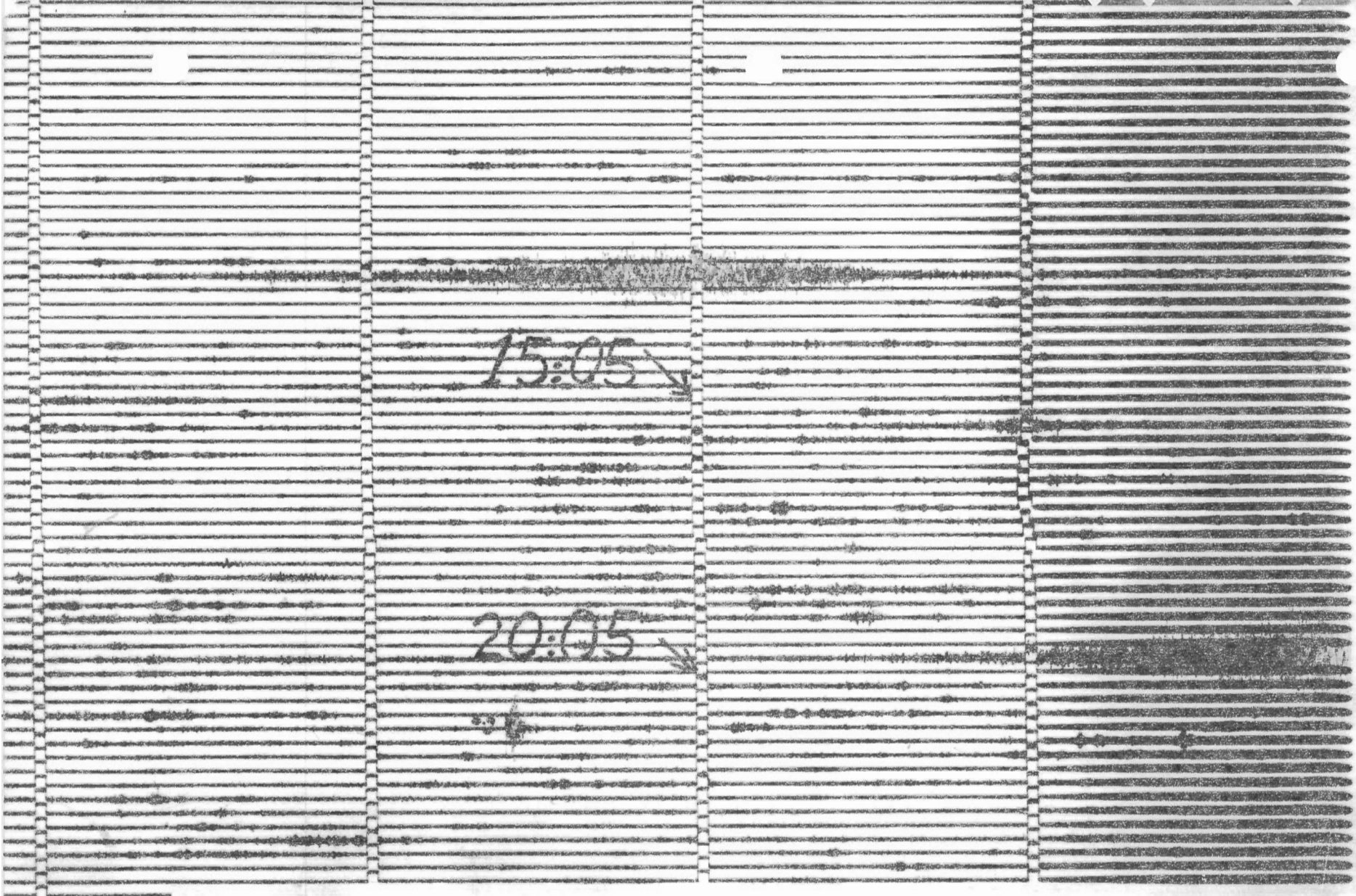


FIG 2-c



JUNE 27, 81

FIG2-d

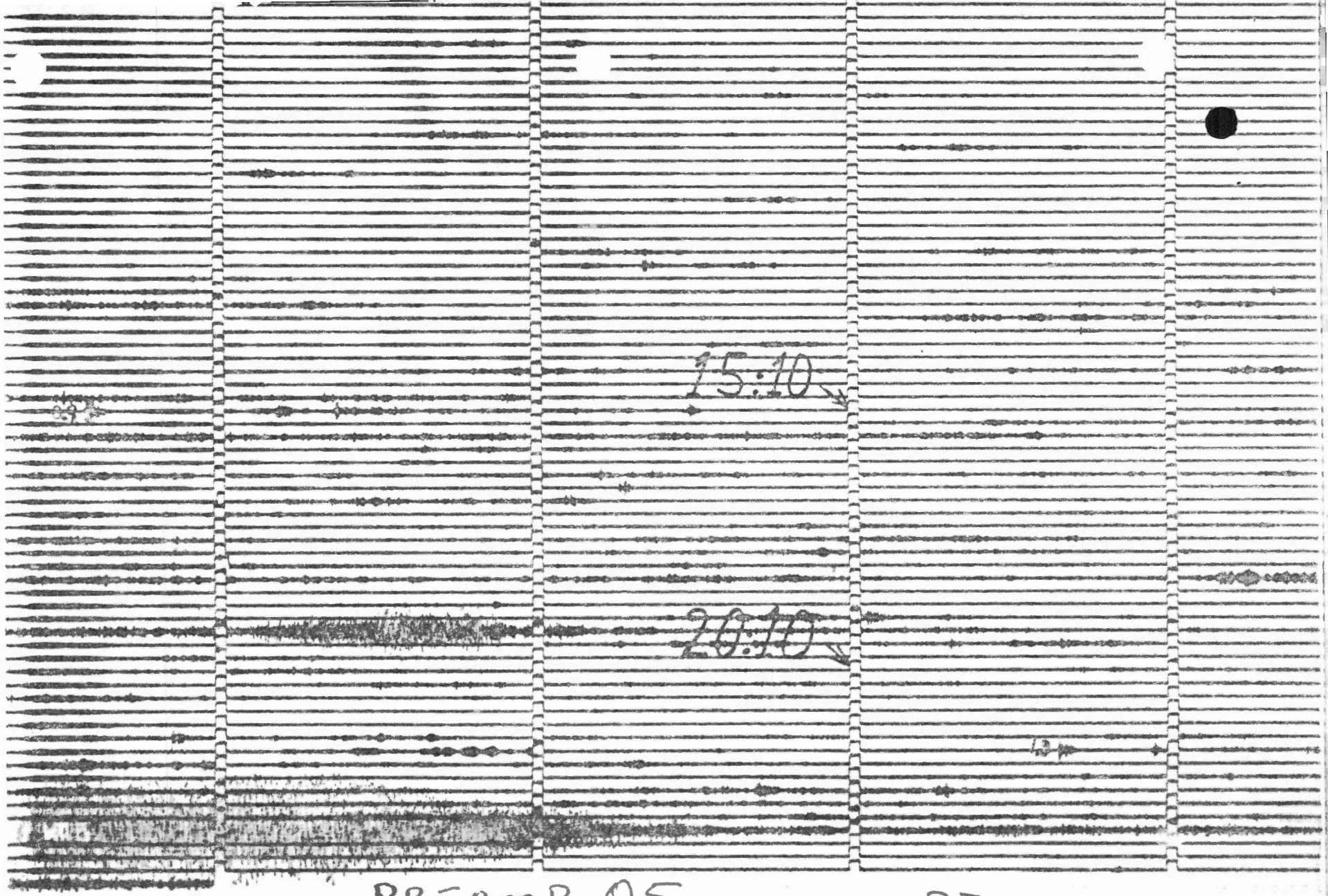
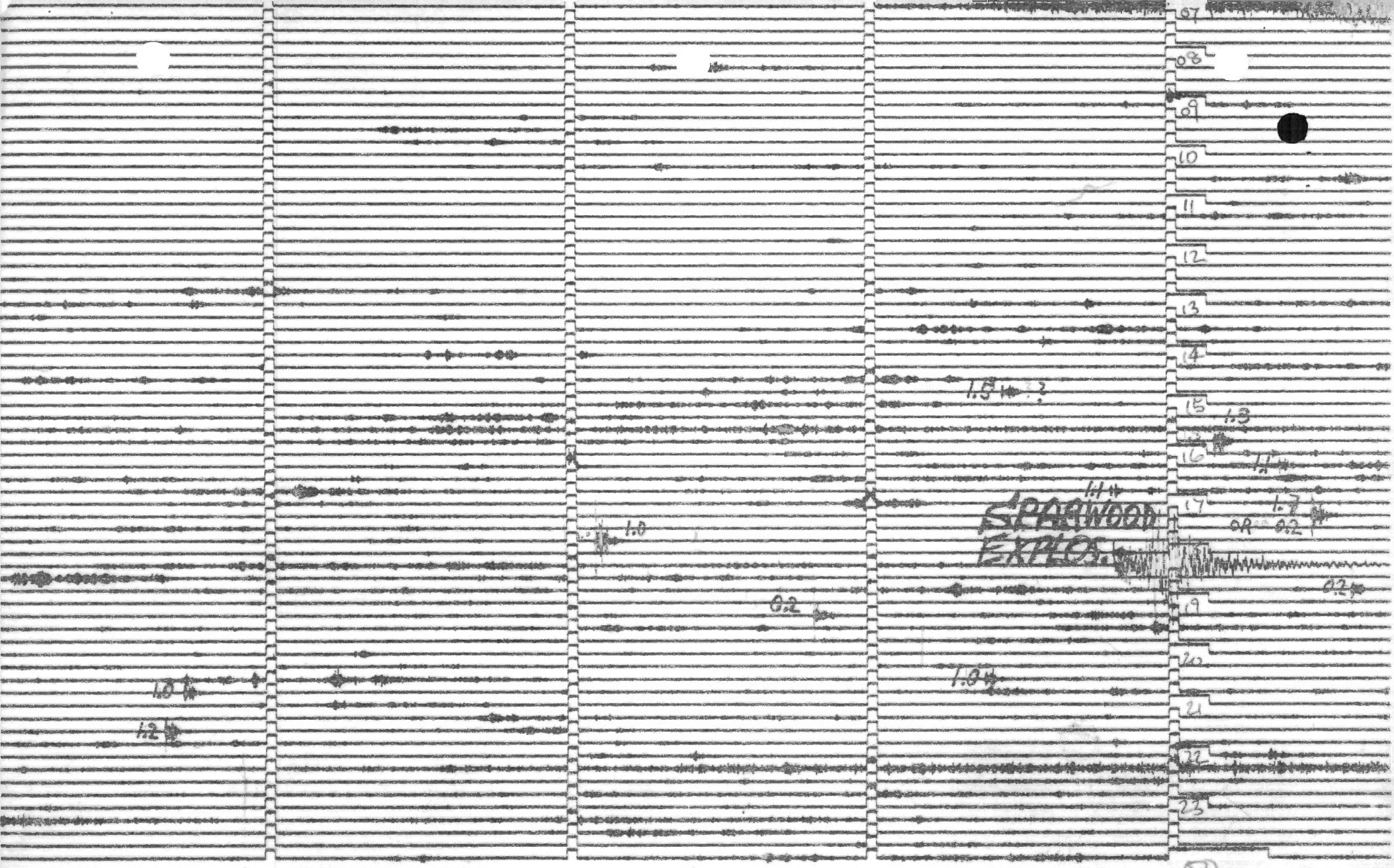


FIG 3-a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16
17
19
20
21
22
23
1.5
1.3
1.1
1.1
1.7
OR 0.2
SEAGWOOD
EXPLOS.
0.2
1.0
0.2
1.0
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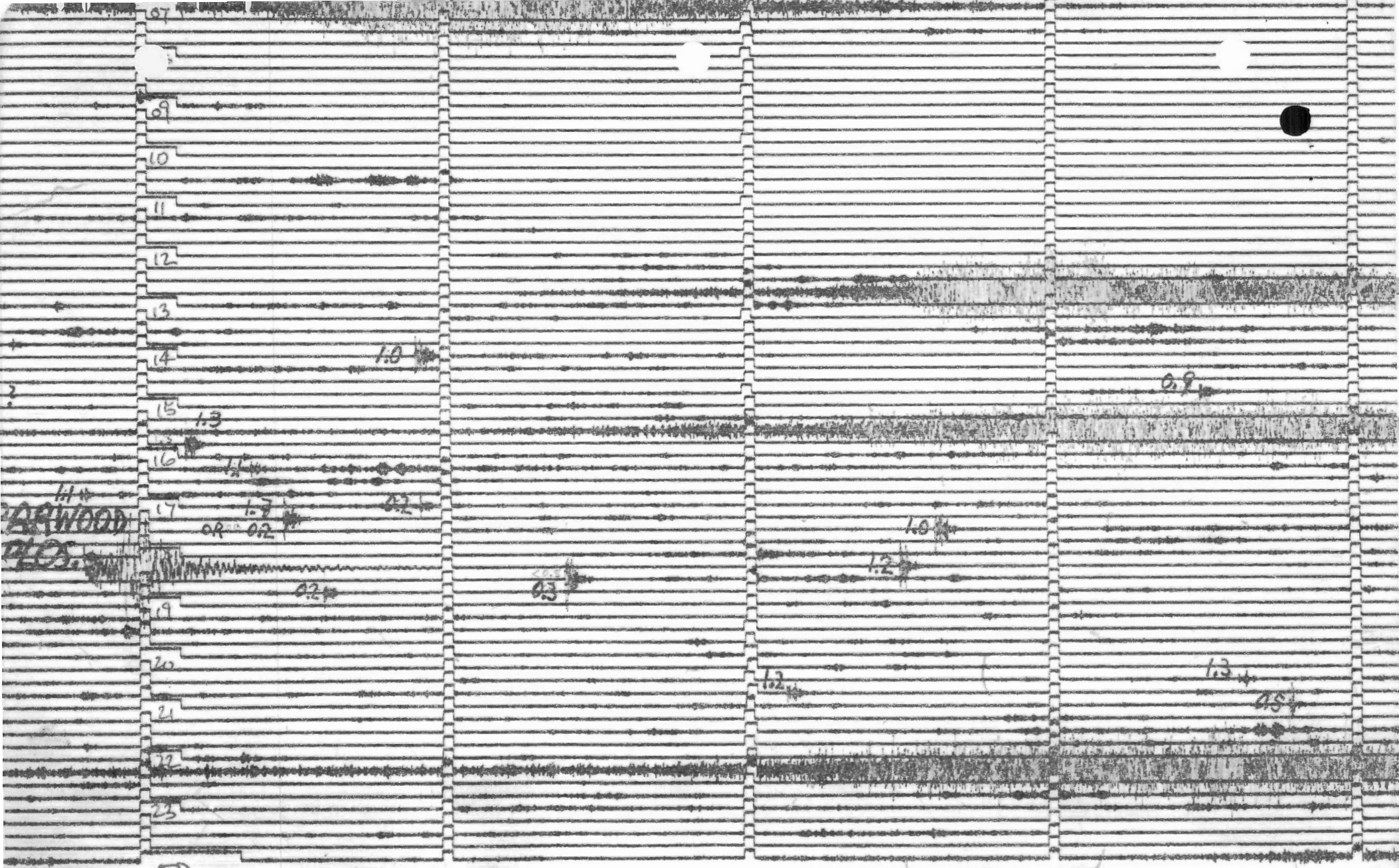
1.2

FIG 3-b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11
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17
19
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21
22
23
60
1.0
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1.4
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OR
0.2
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1.0
1.2
1.2
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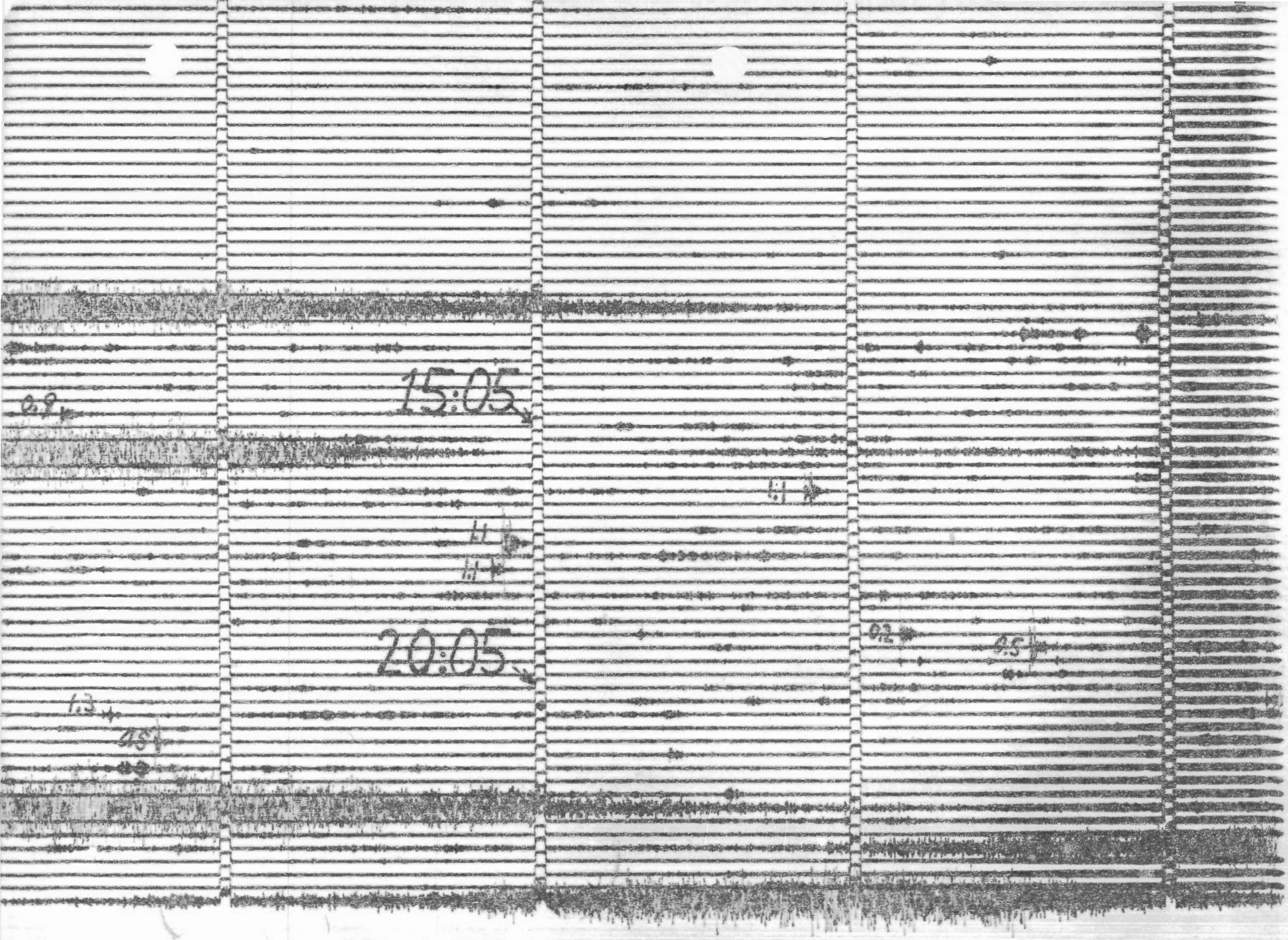
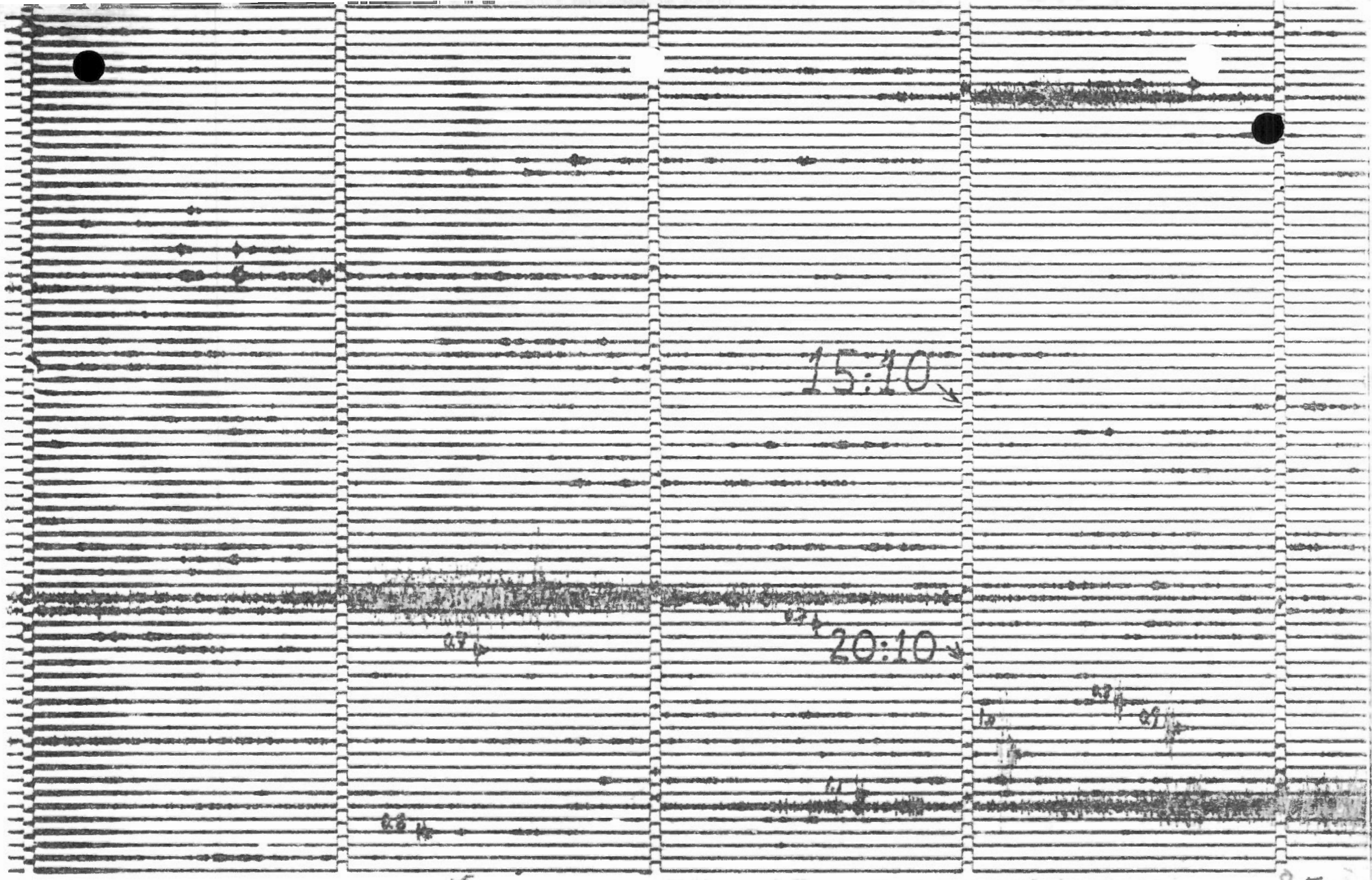
0.5

FIG 3-C



JULY 10, 81

FIG 3-d



11 JULY 81 PREAMP 05 / 1V/cm BA-SPZ

FIG 4-a

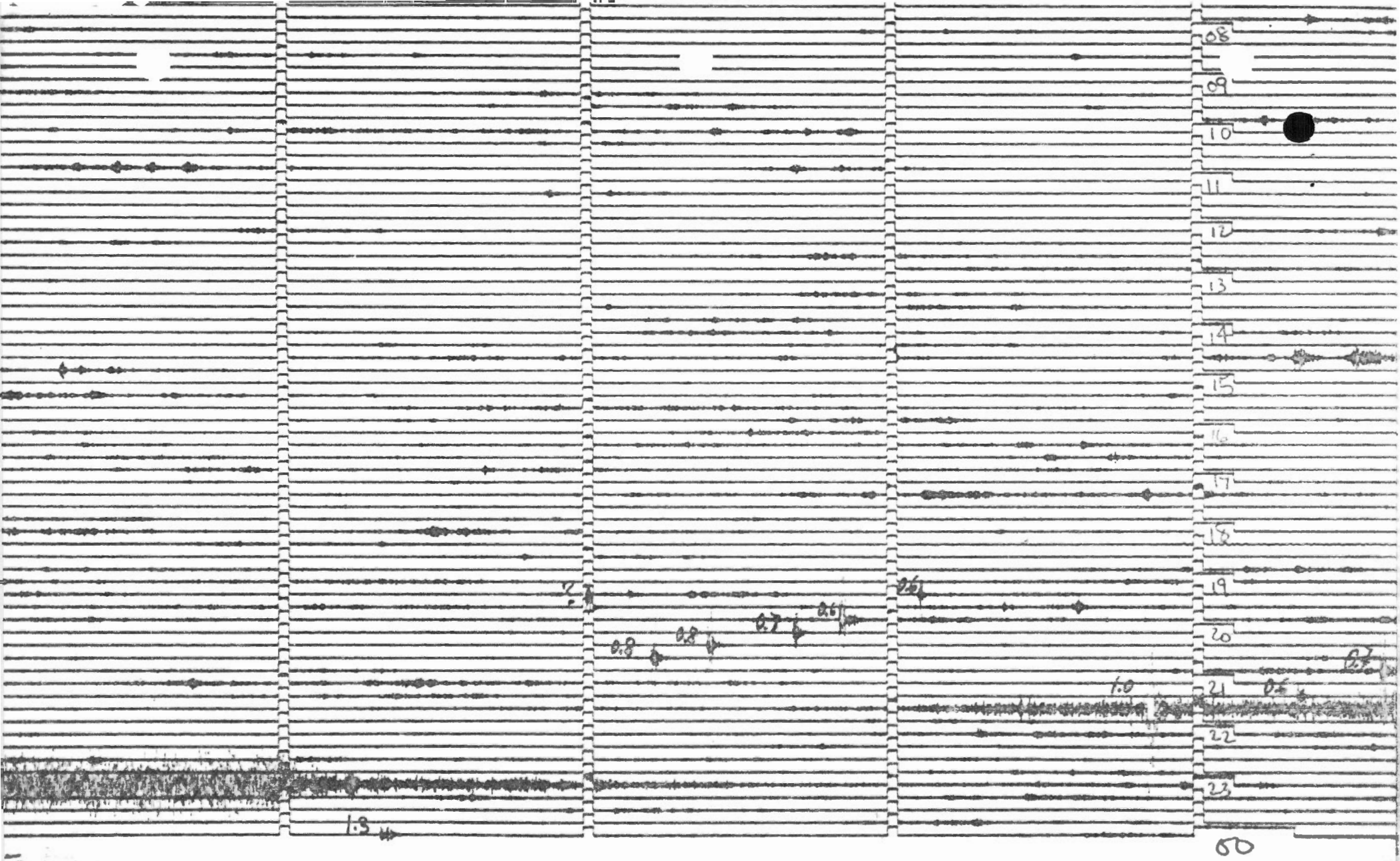


FIG 4-b

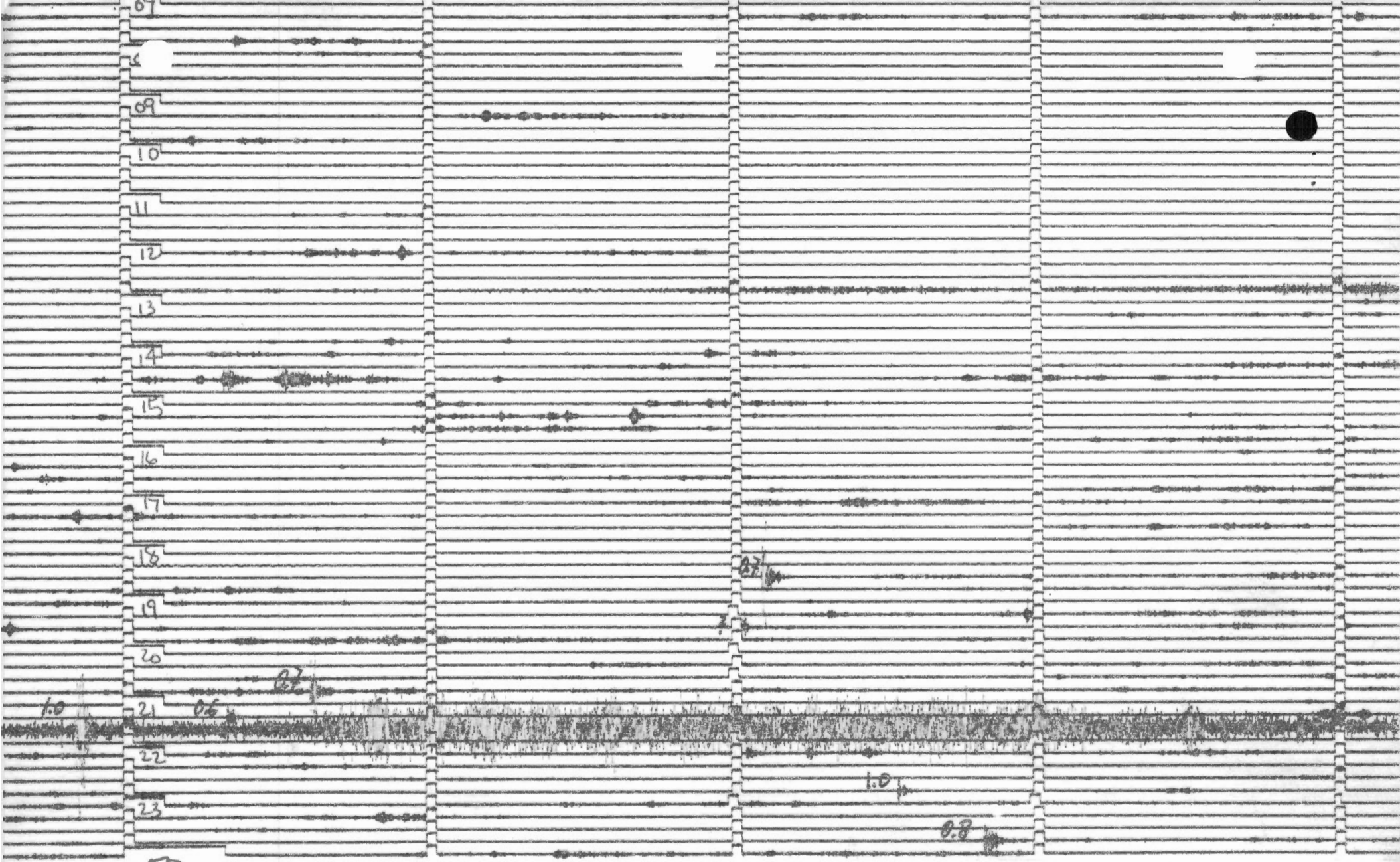
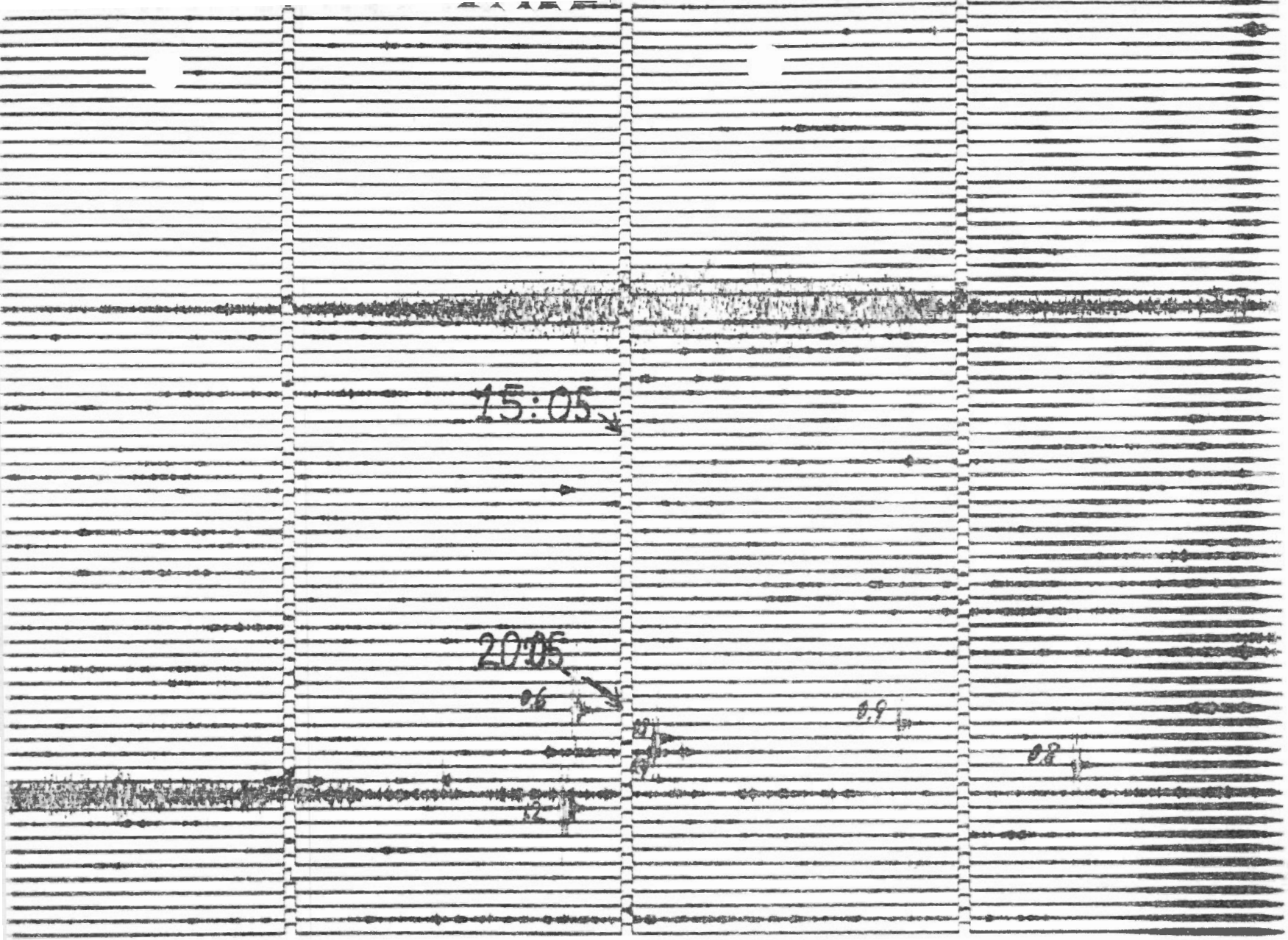


FIG4-c



JULY 11, 81

FIG 4 d

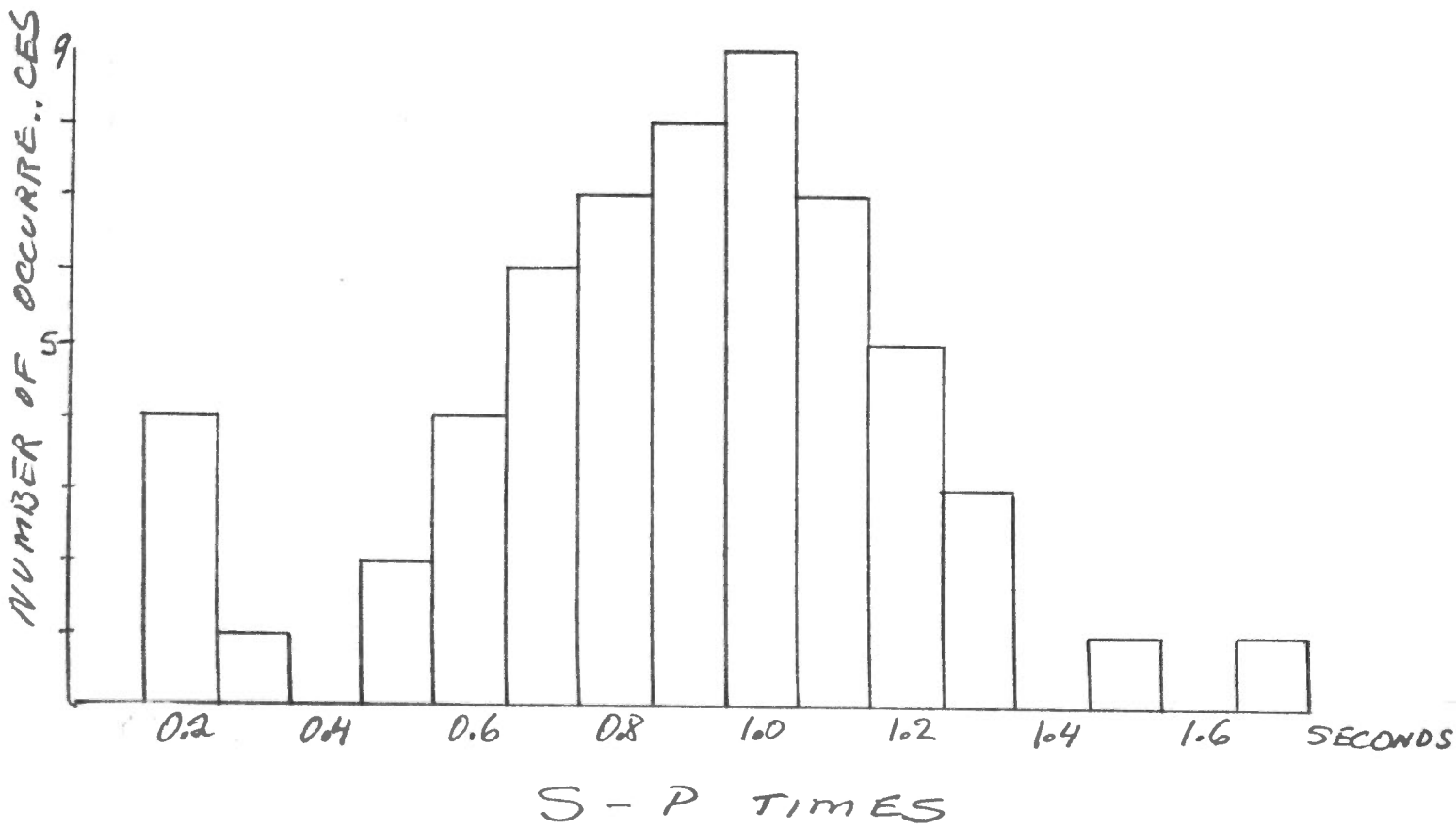

NUMBER OF OCCURRE.. CES
9
5
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
SECONDS
S - P TIMES

FIG. 5

APPENDIX

Local Earthquake Monthly Summary for Blairmore station

CANADIAN SEISMOGRAPH NETWORK / RESEAU SEISMOGRAPHIQUE CANADIEN

LOCAL EARTHQUAKE MONTHLY SUMMARY SHEET
RESUME MENSUEL DES SEISMES LOCAUX

STATION BA - BLAIRMORE / ALTA

YEAR / ANNEE 81

MONTH / MOIS JUN

PAGE 1

CODE	DATE Y/A	DATE M	DATE D/J	PHASE P T Q	TIME/HEURE H	TIME/HEURE M	TIME/HEURE S	P-P sec	S-P sec	Lg-P sec	MAX mm	T sec	REMARKS / REMARQUES	INIT.
BA	81	06	17	P	14	53	12.5		2		18.0	.3	NOISY P PASSI 2 SEC	DHW
			17	B	18	15	46		6		30.	.4		
			18	B	18	14	24		14		4.	.6	VERY SINUSOIDAL	
			18	B	18	17	48.5		55		25.	.4		
			18	B	18	06	07		85		9.	1.5	Lg	
			19	B	17	35	38		25		1.5	.3		
			19	B	18	14	55		50		34.	.9		
			19	P	21	35	02		8		4.	.8		
			21	B	17	46	55.5		55		11.	1.5		
			22	P	23	19	09		13		4.	.5		
			23	P	18	17	17		12		3.	.5		
			26	P	04	22	54		2		17.	.3	PROB. NOISE	
			26	P	19	47	46		1		10.	.2	NEXT 5 EVENTS VERY LOCAL	
			26	P	20	30	12.5		1		7.	.2		
			26	P	20	44	57.5		1				DOUBTFUL	
			26	P	20	58	58		15		16.	.2		
			26	P	21	04	25		1		12.	.2		
			27	B	19	16	00				3.		PDOR	

COLUMN 1: ENTER 0 (ZERO) IF TELEX SENT
COLONNE 1: INSCRIRE 0 (ZERO) SI UN TELEX A ETE ENVOYE.

JAN 78

CANADIAN SEISMOGRAPH NETWORK / RESEAU SEISMOGRAPHIQUE CANADIEN

LOCAL EARTHQUAKE MONTHLY SUMMARY SHEET
RESUME MENSUEL DES SEISMES LOCAUX

STATION BA - BLAIRMORE / ALTA

YEAR / ANNEE 81

MONTH / MOIS JUN / JUL

PAGE 2

CODE	DATE Y/A	DATE M	DATE D/J	PHASE P T Q	TIME/HEURE H	TIME/HEURE M	TIME/HEURE S	P-P sec	S-P sec	Lg-P sec	MAX mm	T sec	REMARKS / REMARQUES	INIT.
BA	81	06	28	B	16	31	33		7 5		2.	.7		DHW
	81	06	30	B	18	16	02		6 0		25.	1.2		
	81	07	01	B	21	12	22		12		5.	.8		
	81	07	02	B	18	16	03		06 0		26.	.6		
			02	B	23	32	52		08		10.	.5		
			03	B	18	13	12		11		2.	.5		
			03	B	18	15	32 5		6		32.	.5		
			09	P	14	00	55		1		7.	.2	1 CF. BELOW	
			09	P	15	07	36		1		7.	.2	ALL EVENTS FROM ITS	
			09	P	15	45	09		1		8.	.1	BOTTOM PAGE AREA REAL	
			09	P	16	20	52		1			.1	AND VERY LOCAL, EXCEPT FOR	
			09	P	17	15	28						2 BELOW	
			09	P	17	19	54		7		15.	.1		
			09	P	17	32	37		1		8.			
			09	P	17	43	55		1					
			09	P	17	58	49				5.			
			09	B	18	14	49		6		24.		2	
			09	P	18	31	24				18.			

COLUMN 1: ENTER 0 (ZERO) IF TELEX SENT
COLONNE 1: INSCRIRE 0 (ZERO) SI UN TELEX A ETE ENVOYE.

JAN 78

CANADIAN SEISMOGRAPH NETWORK / RESEAU SEISMOGRAPHIQUE CANADIEN

LOCAL EARTHQUAKE MONTHLY SUMMARY SHEET
RESUME MENSUEL DES SEISMES LOCAUX

STATION BA - BLAIRMORE / ALTA

YEAR / ANNEE 81

MONTH / MOIS JUL / AUG PAGE 3

CODE	DATE Y/A	DATE M	DATE D/J	PHASE P T Q	TIME/HEURE H	TIME/HEURE M	TIME/HEURE S	P-P sec	S-P sec	Lg-P sec	MAX mm	T sec	REMARKS / REMARQUES	INIT.
BA	81	07	10	P	18	32	06				29.	1.1	DURING NEXT 3 HRS, 20 SIMILAR	DHW
			11	B	18	15	10		6		39.	.8	EVENTS	
			14	B	18	30	14		12		4.	.7	APPROXMT.	
			17	B	18	17	19		6		33.	.6		
			17	B	18	38	19		45		4.	.7	TWO EVENTS SIMASOLIDAL TIME	
			22	B	21	00	03		6		29.	1.0	DIRPINPG SINSIG	
			23	B	18	05	48		11		6.	1.2		
			23	B	18	14	32		6		29.	.7		
			24	S	18	15	50				2.	.1		
			28	B	18	23	43		6		27.	.5		
			31	B	18	15	46		6		32.	.1		
	81	08	07	B	19	40	06		5		35.	2.	NOT THE VISUAL FREQ.	
			12	B	18	16	19		65		24.	.7		
			13	B	18	16	35		6		29.	.7		
			14	B	18	14	42		6		28.	.7		
			14	B	20	29	25		6		22.	.7		
			14	B	22	46	33		8		5.	.6		
			19	B	18	15	47		6		29.	.7		

COLUMN 1: ENTER 0 (ZERO) IF TELEX SENT
COLONNE 1: INSCRIRE 0 (ZERO) SI UN TELEX A ETE ENVOYE.

JAN 78

CANADIAN SEISMOGRAPH NETWORK / RESEAU SEISMOGRAPHIQUE CANADIEN

LOCAL EARTHQUAKE MONTHLY SUMMARY SHEET
RESUME MENSUEL DES SEISMES LOCAUX

STATION BA - BLAIRMORE

YEAR / ANNEE 81

MONTH / MOIS AUG PAGE 4

CODE	DATE Y/A	DATE M	DATE D/J	PHASE P T Q	TIME/HEURE H	TIME/HEURE M	TIME/HEURE S	P-P sec	S-P sec	Lg-P sec	MAX mm	T sec	REMARKS / REMARQUES	INIT.
BA	81	08	20	P	14	27	10.5		3.7	3.7	16.	.3		DHW
			20	B	18	15	32		6		24.	.5		
			21	B	18	16	11		6		25.	.1		
			21	B	21	17	12		11			.1		
			22	B	21	03	38		9		4.	.1		
			24	B	18	31	49		6		28.	.1		
			26	B	23	09	04		7		21.	.1		
			27	B	18	14	51		7		29.	2.0		
			30	B	22	28	27		7		11.	.5		
			26	P	16	36	54		25			.1	SIMILAR TO 17 14 53	
			28	P	19	31	24	.8	4.5	5.8	3.	.1		

COLUMN 1: ENTER O (ZERO) IF TELEX SENT
COLONNE 1: INSCRIRE O (ZERO) SI UN TELEX A ETE ENVOYE

JAN 78