NORSAR

ROYAL NORWEGIAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

Scientific Report No. 1-82/83

SEMIANNUAL TECHNICAL SUMMARY

1 April - 30 September 1982

Linda Tronrud (ed.)

Kjeller, January 1983

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER F08606-79-C-0001	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (*and Subtitle*) SEMIANNUAL TECHNICAL SUMMARY 1 April - 30 September 1982		5. TYPE OF REPORT & PERIOD COVERED 1 Apr - 30 Sep 82
		6. PERFORMING ORG. REPORT NUMBER Sci. Report 1/82-83
7. AUTHOR(s) L.B. Tronrud (ed.)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS NTNF/NORSAR Post Box 51 N-2007 Kjeller, Norway		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NORSAR Phase 3
11. CONTROLLING OFFICE NAME AND ADDRESS AFTAC/HQ/TGX Patrick AFB FL 32925 USA		12. REPORT DATE Jan 1983
		13. NUMBER OF PAGES 72
14. MONITORING AGENCY NAME & ADDRESS(*if different from Controlling Office*)		15. SECURITY CLASS. (*of this report*)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (*of this Report*)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

17. DISTRIBUTION STATEMENT (*of the abstract entered in Block 20, if different from Report*)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (*Continue on reverse side if necessary and identify by block number*)

20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

This report describes the operation, maintenance and research activities at the Norwegian Seismic Array (NORSAR) for the period 1 April to 30 September 1982.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

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The new DP system implemented on IBM 4331/MODCOMP on 24 September is described in some detail in Section III. This system was not verified with respect to array calibration commands at the end of the reporting period, but Detection Processing and High Rate tape recording functioned satisfactorily. By December 1982 the same Array Monitor possibilities that were in the old system are expected to be available. Appendix III.1 describes the new tape format.

Section IV describes improvements, modifications and maintenance activity in connection with the NORSAR field instrumentation.

The research activity is briefly described in Section VI. Subsection 1 discusses on-line event detection and location based on NORESS data. Subsection 2 presents the continuing extensive analysis of noise level variations at the NORESS stations. Subsection 3 gives some preliminary results on the stability of P coda and Lg for magnitude estimates for events from the Eastern Kazakh test site. Subsection 4 presents preliminary results for research into seismic energy and stress drop from moment tensor analysis. Subsection 5 presents the Global Digital Seismograph Network software package developed at NORSAR to provide seismic waveform data from SRO, ASRO and DWWSSN stations.

AFTAC Project Authorization No.	:	VELA VT/0702/B/PMP, Amendment 1
ARPA Order No.	:	2551
Program Code No.	:	0F10
Name of Contractor	:	Royal Norwegian Council for Scientific and Industrial Research
Effective Date of Contract	:	1 October 1979
Contract Expiration Date	:	30 September 1982
Project Manager	:	Frode Ringdal (02) 71 69 15
Title of Work	:	The Norwegian Seismic Array (NORSAR) Phase 3
Amount of Contract	:	$3.500.000
Contract Period Covered by the Report	:	1 April - 30 September 1982

This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by AFTAC, Patrick AFB FL 32925, under contract no.

NORSAR Contribution No. 329

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I. SUMMARY

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II. OPERATION OF ALL SYSTEMS

II.1 Detection Processor (DP) Operation

There have been 131 breaks in the otherwise continuous operation of the NORSAR online system within the current 6-month reporting interval. The SPS had been working well until it broke down on 24 September. Most of the downtime in the period was caused by CPU and disk drive problems. From 24 September the new DP online system has been running. The uptime percentage for the period is 92.3 as compared to 91.9 for the previous period.

Fig. II.1.1 and the accompanying Table II.1.1 both show the daily DP downtime for the days between 1 April 1982 and 30 September 1982. The monthly recording times and percentages are given in Table II.1.2.

The breaks can be grouped as follows:

a)	SPS malfunction	16
b)	Errors on the multiplexer channel	0
c)	Stops related to possible program errors	15
d)	Maintenance stops	3
e)	Power jumps and breaks	9
f)	Hardware problems	57
g)	Magnetic tape and disk drive problems	27
h)	Stops related to system operation	2
i)	TOD error stops	2

The total downtime for the period was 341 hours and 6 minutes. The mean-time-between-failures (MTBF) was 1.4 days as compared with 1.3 days for the previous period.

J. Torstveit

LIST OF BREAKS IN DP PROCESSING THE LAST HALF-YEAR

DAY	START		STOP		COMMENTS...........
94	7	16	7	27	CE MAINTENANCE
95	1	58	6	32	CPU ERROR
106	15	8	18	34	CPU ERROR
107	7	7	16	27	CPU ERROR
109	4	49	6	10	CPU ERROR
110	8	1	8	45	SPS ERROR
110	20	42	22	34	POWER BREAK
112	6	43	7	15	DISK ERROR
112	23	4	24	0	DISK ERROR
113	0	0	6	27	DISK ERROR
116	9	30	11	19	DISK ERROR
116	18	52	20	0	DISK ERROR
117	22	12	24	0	DISK ERROR
118	0	0	6	31	DISK ERROR
119	3	22	5	37	DISK ERROR
120	3	56	6	12	DISK ERROR
122	13	48	24	0	CPU ERROR
123	0	0	6	18	CPU ERROR
128	15	19	16	30	CPU ERROR
129	12	50	13	58	CPU ERROR
131	12	39	13	0	CE MAINTENANCE
134	11	28	12	3	CPU ERROR
134	18	0	19	1	CPU ERROR
138	18	33	18	59	CPU ERROR
142	14	33	17	26	MT ERROR
143	4	7	8	53	SPS ERROR
143	9	51	10	8	SPS ERROR
143	18	6	19	35	SPS ERROR
143	22	23	24	0	CPU ERROR
144	0	0	5	12	CPU ERROR
144	15	25	18	43	CPU ERROR
145	2	16	7	11	CPU ERROR
145	11	7	11	33	CPU ERROR
148	7	31	10	47	EOC ERROR
149	3	42	7	19	CPU ERROR
149	18	19	20	4	CPU ERROR
150	11	28	16	17	CPU ERROR
151	0	34	1	18	CPU ERROR
154	8	6	8	37	CE MAINTENANCE
155	11	54	12	41	MT ERROR
155	16	41	17	30	CPU ERROR
156	9	47	10	0	MT ERROR
156	13	15	16	58	POWER BREAK
157	13	46	14	47	CPU ERROR
157	16	20	17	26	CPU ERROR
157	20	39	21	14	CPU ERROR
157	23	28	24	0	CPU ERROR
158	0	0	9	54	CPU ERROR
158	11	11	11	36	CPU ERROR
158	12	31	13	30	POWER BREAK
158	21	29	22	31	CPU ERROR
159	3	54	8	39	CPU ERROR
159	10	1	12	24	CPU ERROR
162	2	13	7	40	CPU ERROR
166	9	10	9	45	POWER BREAK
167	11	32	11	57	CPU ERROR
167	15	6	17	36	CPU ERROR
169	7	41	8	9	DISK ERROR
175	6	56	7	12	DISK ERROR
175	11	50	12	6	SPS ERROR
175	18	40	19	46	CPU ERROR
176	12	11	19	10	TOD ERROR
177	3	37	7	4	CPU ERROR
178	5	18	8	12	CPU ERROR
178	8	31	8	55	CPU ERROR
180	6	14	6	44	SPS ERROR
180	9	31	9	41	SPS ERROR
180	12	39	12	50	MT ERROR
181	9	45	12	31	DP 4331 TEST
185	7	12	9	50	CPU ERROR
185	23	57	24	0	CPU ERROR
186	0	0	7	23	CPU ERROR

Table II.1.1 (page 1 of 2)

LIST OF BREAKS IN DP PROCESSING THE LAST HALF-YEAR

DAY	START		STOP		COMMENTS...........
194	19	30	20	29	SPS ERROR
195	12	56	13	7	CPU ERROR
196	22	31	24	0	POWER BREAK
197	0	0	0	29	POWER BREAK
197	1	49	14	10	CPU ERROR
198	22	56	24	0	SOFTWARE NEW DP
199	0	0	8	37	SOFTWARE NEW DP
200	7	48	9	44	SOFTWARE NEW DP
202	9	30	9	36	CHANGE NEW TO OLD DP
202	14	13	18	53	CPU ERROR
202	21	45	24	0	CPU ERROR
203	0	0	10	1	CPU ERROR
203	15	46	18	12	CPU ERROR
203	20	42	22	45	CPU ERROR
204	8	42	9	42	SPS ERROR
204	12	10	12	43	POWER BREAK
204	15	51	21	22	SPS ERROR
207	6	50	7	11	OPER ERROR
207	21	35	24	0	DISK ERROR
208	0	0	7	19	DISK ERROR
209	11	42	12	4	POWER BREAK
210	10	55	11	16	SPS ERROR
210	15	8	15	21	SPS ERROR
210	20	45	21	18	DISK ERROR
211	14	33	14	52	DISK ERROR
211	17	51	18	3	DISK ERROR
212	11	13	12	13	DISK ERROR
213	18	53	19	11	CPU ERROR
214	11	3	11	15	CPU ERROR
214	11	47	11	57	CPU ERROR
215	11	47	13	18	CPU ERROR
216	10	3	24	0	COOLING PROBLEM
217	0	0	11	42	COOLING PROBLEM
223	10	37	10	40	PROG CHANGE
223	12	18	12	55	CPU ERROR
224	17	7	24	0	PROG ERROR
225	0	0	7	50	PROG ERROR
226	9	48	12	12	LACK OF DISK CAPASITY
229	7	20	8	37	PROG CHANGE
231	6	17	6	30	DISK ERROR
233	0	49	4	44	CPU ERROR
234	3	50	5	15	CPU ERROR
236	12	8	12	20	SPS ERROR
237	6	45	6	54	CPU ERROR
237	14	3	18	31	POWER BREAK
238	8	10	9	6	PROG CHANGE
239	10	41	10	51	PROG CHANGE
241	21	0	21	17	SPS ERROR
242	11	43	11	52	DISK ERROR
242	12	58	13	5	DISK ERROR
243	4	42	11	48	CPU ERROR
244	12	35	12	53	SPS ERROR
247	10	25	10	59	CPU ERROR
249	7	48	8	24	CPU ERROR
249	16	10	17	29	MT ERROR
255	5	1	9	39	CPU ERROR
256	7	16	8	14	MT ERROR
256	10	36	10	51	TOD ERROR
260	21	3	24	0	DISK ERROR
261	0	0	9	54	DISK ERROR
261	20	40	21	8	DISK ERROR
262	7	7	8	43	DISK ERROR
263	4	48	6	35	DISK ERROR
265	9	14	10	32	POWER BREAK
267	7	25	7	55	POWER FAILURE CPU
267	8	51	13	23	SPS ERROR, START NEW DP
270	13	8	13	38	TEST NEW DP
270	15	35	15	44	TEST NEW DP
271	7	33	7	49	TEST NEW DP
271	11	18	11	24	TEST NEW DP
271	13	11	13	15	TEST NEW DP
272	7	14	8	10	TEST NEW DP

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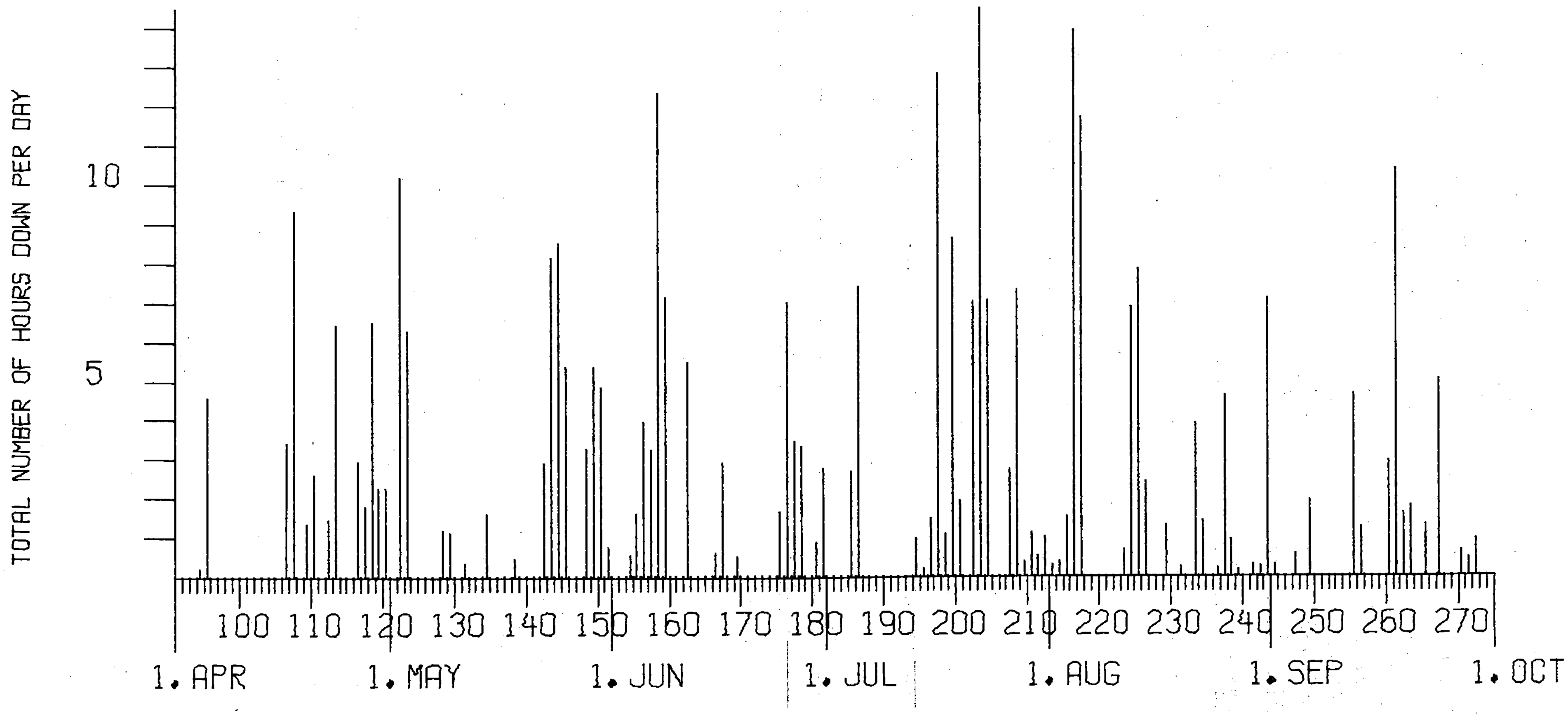

Fig. II.1.1 Detection Processor downtime in the period 1 April 1982 - 30 September 1982.

Month	DP Uptime (hrs)	DP Uptime (%)	No. of DP Breaks	No. of Days with Breaks	DP MTBF* (days)
Apr	674.83	93.7	14	13	1.9
May	684.28	92.0	20	15	1.4
Jun	662.87	92.1	30	16	0.9
Jul	665.18	89.4	25	18	1.1
Aug	678.00	91.1	22	20	1.2
Sep	686.33	95.3	20	14	1.4
	4051.49	92.3	131	96	1.3

*Mean-time-between-failures = (Total uptime/No. of up intervals)

TABLE II.1.2

Online System Performance
1 April 1982 - 30 September 1982

II.2 Event Processor Operation

In Table II.2.1 some monthly statistics of the Event Processor operation are given:

	Teleseismic	Core Phases	Sum	Daily
Apr 82	234	66	300	10.0
May 82	258	73	331	10.7
Jun 82	232	62	294	9.8
Jul 82	254	59	313	10.1
Aug 82	242	48	290	9.4
Sep 82	225	100	325	10.8
	1445	408	1853	10.1

TABLE II.2.1

B. Kr. Hokland

II.3 Array Communication

Table II.4.1 reflects the performance of the communications system throughout the reporting period.

In addtion to 'ordinary' irregularities in the communication system itself, the table also reflects other prominent conditions, such as:

- CTV power failure (high voltage and ripple)
- Line switching between the Modcomp processor and the SPS
- Maintenance visits
- Tests from NDPC.

In the reporting period the Modcomp communications processor took over the online task due to SPS/2040 CPU outages, as follows:

- 16-21 Jul, IBM 2040 CPU stop
- 5-16 Aug, SPS cooling problems
- Since 21 Sept, SPS problems after a power break.

While Modcomp did online processing (5-16 Aug) resync problmes caused high outage figures with respect to 06C.

Summary

Apr: 01A cable caused ICW outage (week 17)

01B intermittent operation probably caused by SLEM power unit (week 16). A card was replaced in the modem (week 16)

03C communications cable tested by NTA in the Rena area. 'Pupin' coils replaced.

04C,06C Relatively high outage figures due to extensive use of the two subarrays.

May: Most subarrays involved in connection with Modcomp tests.

01A was down (week 19 and 21) due to open line towards the CTV.

02B down due to power outage (week 18)

03C resync problems caused spikes in data. A test 19 May did not reveal which part of the system caused the problem.

Jun: 01A was out of operation from 10-11 June. NTA involved.

03C still unreliable. Several attempts made to localize the source of the problem, such as: adapter card replacement, modem swapping, cable changes, SLEM equipment replacement and modem/line tests.

06C affected 27,30 June and 1 July, most certainly line outages after thunderstorms in the area. As usual subarrays were switched to the Modcomp for test purposes.

Jul: Between 1 and 5 new attempts were made to localize the 03C sync problem, by routing the 03C SPS adapter via the 04C communications system to site 04C (with ID 7) and the 04C SPS adapter via the 03C comm. system to site 03C (and with ID 5). During the days the systems were swapped we have no problems with the 04C adapter routed to 03C, while the 03C SPS adapter still had resync problems while using the 04C comm. system. Based on these facts the SPS had to be the source of the problem, in spite of card replacements in the adapter itself. It was, however, decided to remeasure the 03C comm. system with respect to Group Delay and Attenuation Distortion (NTA task).

02B was affected by 50 Hz noise, causing ICW errors.

02C was out of operation for periods (week 29,30) due to open line toward the CTV.

06C was affected (week 27) with max. error rate on the ODW's.

Aug: Between 5 and 16 the Modcomp system had resync problems with the 06C comm. system. Probably a software bug.

02B still affected by 50 Hz noise on a local cable (weeks 31,32).

03C comm. system remeasured with respect to Attenuation and Delay Distortion. (NTA Hamar and Lillestrøm).

Sep: As previously mentioned the Modcomp Communications Processor has been online since 21 September when the SPS stopped after a power break.

06C comm. system was out of operation from week 38 due to a damaged cable in the Hamar area.

03C working well with the Modcomp processor, which should prove that the line is within specifications.

04C was used in Modcomp connection week 37.

Table II.3.2 indicates distribution of outages with respect to the individual subarrays.

O.A. Hansen

Sub-Array	APR (4) (5.4-2.5)		MAY (4) (3-30.5)		JUN (5) (31.5-4.7)		JUL (4) (4.7-1.8)		AUG (5) (2.8-5.9)		SEP ( ) (6.9-3.10)		AVERAGE ½ YEAR	
	>20	>200	>20	>200	>20	>200	>20	>200	>20	>200	>20	>200	>20	>200
01A	0.2	14.7	0.3	24.0	-	3.9	0.2	0.2	-	-	0.2	9.3	0.1	8.7
01B	-	4.0	0.3	0.3	-	3.1	0.2	0.2	0.5	0.2	-	-	-	0.6
02B	-	0.2	0.2	5.1	0.8	1.7	6.7	2.0	13.0	3.2	-	1.0	3.4	2.2
02C	-	4.7	1.1	0.9	1.3	0.4	0.2	19.4	-	0.3	1.2	1.0	0.6	4.4
03C	-	8.0	-	18.7	-	18.7	-	43.0	0.3	4.6	-	13.8	-	17.8
04C	0.2	1.2	-	0.8	4.2	0.5	-	-	0.4	0.2	0.2	5.2	0.8	1.3
06C	9.6	2.4	6.0	1.7	-	13.0	-	8.6	-	9.3	-	58.9	11.1	15.6
AVER	1.4	5.0	1.1	7.3	0.9	5.9	1.0	10.4	2.0	2.5	0.2	12.7	2.2	7.2
	06C	01A	06C	01A		03C		02C		06C		06C	06C	03C
LESS		06C		03C		06C		03C						04C
	0.01	2.5	0.3	1.7		1.9		2.2		1.4		5.5	0.8	3.4

TABLE II.4.1

Communications (degraded performance >20/outages >200)
Figures in per cent of total time. Month four or five weeks, as indicated.
(1 April - 30 September 1982)

Week/	Subarray/per cent outage						
Year	01A	01B	02B	02C	03C	04C	06C
14/82	-	-	-	-	4.0	-	1.0
15	-	-	-	17.7	3.4	0.3	0.9
16	0.3	15.1	-	0.3	12.0	0.3	1.5
17	58.4	0.9	0.9	0.9	12.9	4 4	6.4
18	1.5	-	18.4	1.8	5.2	0.4	0.6
19	69.0	0.3	0.3	0.3	16.8	1.0	5.9
20	15.3	0.6	1.9	1.0	44.5	0.9	0.4
21	10.1	0.4	-	0.6	8.3	0.9	-
22	0.4	-	-	-	24.8	-	-
23	18.7	10.0	0.6	0.6	18.0	0.4	0.4
24	0.3	3.4	0.3	0.3	28.5	0.4	0.3
25	-	0.9	1.0	1.0	7.1	1.6	0.9
26	-	1.2	6.8	11.2	18.0	0.4	64.3
27	-	-	2.5	-	93.1	0.4	33.9
28	0.6	0.6	4.0	0.6	57.9	-	-
29	-	-	1.3	32.7	7.0	-	0.4
30	-	-	-	44.3	14.0	0.3	-
31	-	-	15.3	-	11.1	-	5.5
32	-	-	-	-	-	-	33.9
33	0.3	0.4	0.4	0.4	3.4	0.7	0.3
34	-	-	-	0.6	6.2	-	0.7
35	0.3	0.3	0.3	0.4	2.2	0.3	12.0
36	30.3	-	-	-	3.6	-	55.1
37	6.7	-	4.1	0.3	18.7	21.0	3.0
38	0.4	-	-	2.1	32.9	-	77.8
39	-	-	-	1.8	-	-	100.0

TABLE II.4.2

III. NORSAR ON-LINE SYSTEM USING IBM 4331/4341 AND MODCOMP CLASSIC

On 24 September 1982 at 13.23 GMT, we started full DP operation using the MODCOMP and IBM 4331 system.

This was a week before the expected operational start of the system, where we had plans to do all routine processing with the new system and use SPS as backup during needed corrections of software. However, the SPS broke down again and gave us no indications of where the problem was, only that it was more serious than ever. After two weeks of intense work with the SPS to locate the problem by our people and local IBM representatives, we have since given lower priority to the repair of the SPS. Since the MODCOMP system has functioned satisfactorily, the SPS is now considered redundant, and has been moved to Stange for storage.

The system that was initiated on 24 September was not verified with respect to array calibration commands, but Detection Processing and High Rate tape recording has been functioning satisfactorily. From 11 October we have also been able to do measurements and adjustments on LP instruments, and Channel Evaluation programs have been run using tape input. By December 1982 we will have the same Array Monitor possibilities that were in the old system.

The MODCOMP system is functioning practically in the same manner as the SPS. That is, subarray data is collected using a binary synchronous communication, full duplex 2400 baud, with each of the 7 subarrays. The data collection is performed by sending a 120 bit command (ICW) to the subarray (to the SLEM) 20 times per second. In response to the ICW, the SLEM returns the data in a 120 bit data message (ODW). The ODW contain short period data from 6 instruments, and one sample from one selected channel on the SLEM. The SLEM has several additional analog channels that may be sampled, and the ICW will tell which channel to sample now (random data address). The LP instruments are connected to these channels, and by rotating the random data address among a set of 20 different addresses, we may sample the LP data with a frequency of 1 Hz. This sampled value is called submultiplexed data. After having collected ODW's from all subarrays, the MODCOMP converts the data into High Rate data block, and after having 0.5 seconds of data, the block is transmitted to IBM 4331. Parallel to this, another task uses the unpacked data, filters the data with a 1.2-3.2 Hz and 1.6-3.6 Hz filter and does subarray beamforming. The resulting 20 different filtered subarray beams per subarray are transmitted together with the High Rate tape block to IBM 4331 for Detection Processing. In exchange for the data block, the IBM 4331 will transmit a message block to MODCOMP. This block contains manual subarray and instrument status to be used in the beamforming process. Moreover, any Array Monitor command necessary to send to the SLEM is included in this message. In fact, we may change the table of random data addresses occasionally to sample one LP instrument at 20 Hz rate. This is done for LP free period measurements. This message may also contain instructions for MODCOMP to re-synchronize any of the subarray communication lines.

Additionally and parallel to the above, the MODCOMP has connected a 32 channel A/D converter which is sampled at 40 Hz rate. These data are also added to the High Rate block and transmitted to the IBM.

On the IBM side, we receive the data and record it on IBM 3370 fixed block disks. The time of the data determine which disk to use and which direct access block to use. Using one 3370 disk, we are currently having, at any time, the latest 30 hours of data available on direct access disk (all NORSAR array data and 28 of the MODCOMP analog channels). The time to disk block algorithm ensures always a 'Round Robin' data base system.

Parellel to the disk recording, the IBM 4331 does the Detection Processing. This involves array beamforming and STA/LTA thresholding. There are 244 different array beams, and both coherent and incoherent beamforming is performed. The detection information is stored on the same type of disk, using direct access. The area on the online disks reserved for DPX information (20 bytes per DPX), may contain up to 179150 detections. Moreover, the IBM 4331 uses the same disk for communication with IBM 4341 using special disk blocks for information exchange. The two computers have shared access to the disks. The disk recording and data retrieval systems are programmed by NORSAR, and no use of the VM/CMS file system is necessary, due to use of direct access to fixed blocks rather than file access. The 4331 system reads one block containing commands from the 4341 system. When calibration commands are wanted, the 4331 will pick up the commands from a reserved area on the disk. Another block will tell the 4341 system about the status of the 4331 system, i.e., one block is read only for 4331 and writeable by 4341, and the other block has opposite read/write characteristics. In this way the two systems may do hand-shaking of messages.

The 4341 system has access to all the information on the online disks. The disk-to-tape recording is done once a day, and by the use of 6250 bpi density, we may store 11 hours of NORSAR array data, and data from 16 of the MODCOMP A/D converter on one 2400 ft tape. The tape recording program keeps track of the data tape intervals, and automatically gives the start time of present copy job. Appendix III.1 describes the new tape format.

A program has been developed that makes it possible for anyone to monitor the status of the subarrays, status of disk and tape recording, display any of the instruments from the NORSAR array or from the instruments coupled to the MODCOMP A/D converter on Tectronix high resolution graphic screens. The program will also allow DP operators to initiate synchronization commands and array status commands (password protected). Moreover, the same program may use High Rate tapes as input for a quick look at data older than 30 hours (back to 1971 if wanted).

The offline Event Processing (AUTOEP) is performed by the 4341 system, using the data available on disk. For each detection above a selected SNR threshold, the program generates a CMS file containing 2 minutes of data for the detections. Then event processing is performed using these files as input. After inspections by the anlyst, the files of no particular interest are erased. There are, however, plans to make a system where the latest, say one or two weeks, such event files available on disk.

Array calibration is initiated by a separate program, which has all of the known calibration sequences earlier performed by SPS. This program gives instructions to IBM 4331 via disk, and another program will update an Array Status File for information to the calibration analysis programs. These programs will update the Array Status File with results.

The EOC, which was earlier used for Array Status displays, will be exchanged by standard terminals with output from new programs. The Tectronix type terminals will be used for graphic monitor. A program will go through the data each night and report subarray status with respect to SLEM communication errors, CTV status, calibration status, etc.

Our experience with the system so far is that we have had some stops due to our own changes to the programs, some stops due to AC power breaks, and one stop due to MODCOMP memory error. We experience data checks (CRC faults) once per hour on the MODCOMP-to-IBM communication line (230.4 Kbaud). This means 0.5 seconds of data per hour have bit errors, but this occurs only in a few cases in the first half of the block containing raw data. The data loss due to communication problems between IBM and MODCOMP is therefore of the order of 1-2 seconds per 24 hours.

The communication link between MODCOMP and IBM consists of two special modems, one MODCOMP synchronous interface and one IBM 2701 synchronous data adapter. The IBM 2701 is close to the age where IBM no longer guarantees spare parts and constitutes the weakest link in the system.

We expect future stops to be mainly due to AC power breaks, and excluding IBM 2701, we expect very reliable operation of the MODCOMP and IBM systems.

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Appendix III.1 High Rate Tape Format

S.1 HIGH RATE TAPE FORMAT

See also NORSAR Scientific Report No 1-76/77
FINAL REPORT NORSAR PHASE 3 1 JULY - 30 SEPTEMBER 1976 .

There are now in addition to labels, 4 different records on the NORSAR High Rate Tape. The records of type AC and NR is defined in the above documentation. The NR-type records are now blocked to 10 seconds per tape block, rather than 2 seconds as in the 1976 format. There are also changes in the general indicators in the NR-block.
The new record types are
AG - record for Array Geometry information.
NA - record for data collected by the MODCOMP A/D-convertor.

Tape layout:

Record	File	Number Bytes	Contents
1	1	80	Standard ISRSPS Volume Label
2	1	80	Standard ISRSPS Header Label
3	1	2	Standard IBM tape mark (END-OF-FILE mark)
1	2	260	AC-record
2	2	8800	AG-record , 110*80 EBCDIC Characters describing NORSAR array and MODCOMP analog channels.
.	2	27440	NR-record , 20 High-Rate data blocks of 1372 bytes each. (10.0 seconds data).
.	2	12960	NA-record , 20 data-blocks of data from MODCOMP A/D-convertor 648 bytes each.
N	2	2	Standard IBM tape mark (END-OF-FILE mark)
1	3	80	Standard ISRSPS End-of-File label
1	4	2	STANDARD IBM tape mark (END-OF-FILE mark)
1	5	2	STANDARD IBM tape mark (END-OF-FILE mark)

S.2 'NA'-DATA BLOCK OF 648 BYTES

BYTES	CONTENT
000-001	Identifier 'NA'
002-005	Time of first sample in this block
006-007	Number of channels (16, i.e. channel 1-16 on A/D-convertor) If this number is X'FFFF' (-1), the data block contain online system test recordings, and not instrument data.
008-647	640 bytes of data at 40 Hz rate for 0.5 second. 2 bytes per channel. Multiplexed data. 2*16*40*0.5 = 640 BYTES.

'NR'-DATA BLOCK OF 1372 BYTES

```
.D  BYTES

0000-0001 Record ID 'NR'  X'D5D9'
0002-0005 Binary ISRSFS Time = IDAY*864000+IH*36000+IM*600+IS*10+IDS.
          Where IDAY is Julian date (DAY-OF-YEAR 1-366), IH is hour, IM is minute, IS is seconds,
          and IDS is deciseconds (which will always be 0 or 5).
0006-0007 General indicators.
          BITS
          00-02 Spare
            -03 TOD Failure, interpolated time. Not used.
            -04 Change in field 3 status, not used.
            -05 Change in field 4 status, not used.
            -06 Change in field 5 status.
            -07 Change in field 6 status.
            -08 Analog data collection has been resynchronized.
            -09 MODCOMP to IBM communication error occured during transmission of this block.
            -10 No data was received from MODCOMP for this half second
          11-15 Spare
0008-0009 AUTOMATIC SUBARRAY STATUS.
          Not presently used.
0010-0030 AUTOMATIC SEISMOMETER STATUS.
          Not presently used.
0031-0032 MANUAL    SUBARRAY STATUS. 2 bits per subarray, according to the following code.
          00   OK
          01   All sequentail channles invalid    (SP)
          10   All submultiplex channles invalid  (LP)
          11   ALL channles (SP AND LP) invalid , or subarray not defined.
0033-0053 MANUAL     SEISMOMETER STATUS. 24 bits per subarray according to the following code.
          Bits
          00-05 1 Bit for each sequential channel (SP) is set if invalid channel.

          08-21 1 Bit for each submultiplex channel (LP) is set if invalid channel.
                These 16 Bits corresponds to Random Data Adresses 0 through 15.
                Random Data adresses 4,5,6 corresponds to LP Z,NS,EW.
          22-23 Spare.
0054-0060 MULTISAMPLE SUBARRAY INDICATORS. 1 byte per subarray.
          BITS
          0 Line decommissioned
          1 Subarray in total ICW scan.  Not used.
          2 Subarray being synchronized.
          3 Phone line being tested.  '  Not used.
          4-7 Spare.
    -0061 PADDING BYTE, contains X'AA'
0062-0323 1ST LOGICAL RECORD. (0.1 second data). 262 bytes.
          BYTES
          000-009 10 bytes of status
                  BYTES
                   -0 Length of this status field (X'0A')
                   -1 Version of this status . (X'01')
                  2-3 High Rate sensor subjected to DC offset thresholding.
                      Not presently used. If used:
                      Bit 0- 1 Reserved
                      Bit  - 2 Set if sensor failed threshold.
                      Bit 3-15 Sensor number.
                  4-5 Low Rate sensor, otherwise as in bytes 2-3.
                  6-8 Discrete Output Feilds transmitted as follows:(DOF)
                      BIT  0- 7 Subarray number to which transmitted
                      BIT  8-15 DOF1
                      BIT 16-23 DOF2
                      (DOF'S are special commands transmitted to SLEM under calibration).
                   -9 Spare
          010-027 18 Bytes SUBARRAY DATA BLOCK,subarray 1,(0.05 second data).
                  BYTES
                  00-03 Sample period indicators
                     00 BIT 0 ICW SYNC error occured
                     00 BIT 1 ICW POLY error occured
                     00 BIT 2 ODW SYNC error occured
                     00 BIT 3 ODW POLY error occured
                        If these bit is set no data is valid.
                     00 BIT 4-7 Spare
                     01 BIT 0 ODW received late in previous period.
                              Not used.
```

```
                       01 BIT 1 Sample repeated . Not used.
                       01 BIT 2 Data present this period.
                                *THIS BIT ON ALONE SIGNALS GOOD DATA*
                       01 BIT 3 Redundant ODW received. Not used.
                       01 BIT 4-7 Spare
                       02 BIT 0-3 Spare
                       02 BIT 4-7 Contain received random data adress (RDA)
                                  and defines the content of submultiplex data value
                       03 BIT 0-5 Contain FUNCTION ROUTE reflected from SLEM (FRS)
                       03 BIT 6-7 Contain FUNCTION SELECT reflected from SLEM  (FS)
                    04-05 SUBMULTIPLEX CHANNEL DATA VALUE, defloated with extended sign
                          right-justified in bits 00-13, bits 14,15 are zero
                          (In other words, a 16 bit integer you must divide by 4 to get
                           actual sampled value, wich shall be between -8192 and +8192).
                    06-17 6 Sequential channel data values in same format as submultiplex.
              028-045 18 Bytes subarray data block,subarray 1,(0.05 second data).
              046-063 18 Bytes subarray data block,subarray 2,(0.05 second data).
              064-081 18 Bytes subarray data block,subarray 2,(0.05 second data).
              082-099 18 Bytes subarray data block,subarray 3,(0.05 second data).
              100-117 18 Bytes subarray data block,subarray 3,(0.05 second data).
              118-135 18 Bytes subarray data block,subarray 4,(0.05 second data).
              136-153 18 Bytes subarray data block,subarray 4,(0.05 second data).
              154-171 18 Bytes subarray data block,subarray 5,(0.05 second data).
              172-189 18 Bytes subarray data block,subarray 5,(0.05 second data).
              190-207 18 Bytes subarray data block,subarray 6,(0.05 second data).
              208-225 18 Bytes subarray data block,subarray 6,(0.05 second data).
              226-243 18 Bytes subarray data block,subarray 7,(0.05 second data).
              244-261 18 Bytes subarray data block,subarray 7,(0.05 second data).
   0324-0585 2nd LOGICAL RECORD. (0.1 second data). 262 bytes.
   0586-0847 3rd LOGICAL RECORD. (0.1 second data). 262 bytes.
   0848-1109 4th LOGICAL RECORD. (0.1 second data). 262 bytes.
   1110-1371 5th LOGICAL RECORD. (0.1 second data). 262 bytes.
```

5.4 Program examples

THE FOLLOWING IS PARTS OF A FORTRAN G1 PROGRAM THAT CAN EXTRACT DATA FROM NORSAR HIGH RATE DATA BLOCK.

```
      LOGICAL*1 NRDATA(1372)                                                  ONL00740
      LOGICAL*1 NRID(2),NRTIME(4),NRGEN(2),AUTSA(2),AUTSEI(21)                ONL00750
      LOGICAL*1 MANSA(2),MANSEI(21),MULTI(7),PAD,LOGR1(262),LOGR2(262)        ONL00760
      LOGICAL*1 LOGR3(262),LOGR4(262),LOGR5(262),LOGR(1310)                   ONL00770
C                                                                             ONL00780
      EQUIVALENCE (NRDATA,NRID),(NRDATA(3),NRTIME),(NRDATA(7),NRGEN),         ONL00810
     *(NRDATA(9),AUTSA),(NRDATA(11),AUTSEI),(NRDATA(32),MANSA),               ONL00820
     *(NRDATA(34),MANSEI),(NRDATA(55),MULTI),(NRDATA(62),PAD),                ONL00830
     *(NRDATA(63),LOGR1,LOGR),(NRDATA(325),LOGR2),(NRDATA(587),LOGR3),        ONL00840
     *(NRDATA(849),LOGR4),(NRDATA(1111),LOGR5)                                ONL00850
C                                                                             ONL00860
      LOGICAL*1 LOGREC(262),STATUS(10),SDBL(18,2,7)                           ONL00870
      INTEGER*2 SDB(9,2,7)                                                    ONL00880
      EQUIVALENCE(LOGREC,STATUS),(LOGREC(11),SDBL,SDB)                        ONL00890
C
```

```
C
C   PICK UP SINGLE SENSORS, SP FROM NORSAR ARRAY                    ONL02000
C                                                                   ONL02010
C   N2040 = 1 FOR 10 HZ                                             ONL02020
C   N2040 = 2 FOR 20 HZ                                             ONL02020
C                                                                   ONL02030
      DO 3000 ILOG=1,5                                              ONL02040
C                                                                   ONL02050
      ILDISP =(ILOG-1)*262                                          ONL02060
C                                                                   ONL02080
      DO 2100 I=1,262                                               ONL02090
 2100 LOGREC(I) = LOGR(I+ILDISP)                                    ONL02100
C                                                                   ONL02110
      DO 2600 I20=1, N2040                                          ONL02120
C                                                                   ONL02130
C                                                                   ONL02160
      DO 2400 ISUB=   1,  7                                         ONL02170
C                                                                   ONL02180
      ICWODW = SDB(1,I20,ISUB)                                      ONL02190
C                                                                   ONL02200
C     IF( ICWODW .NE. 32 ) GO TO ERROR                              ONL02210
C                                                                   ONL02230
      DO 2320 ISNS=     1,    6                                     ONL02240
C                                                                   ONL02340
 2400 CONTINUE                                                      ONL02350
C                                                                   ONL02360
C                                                                   ONL02480
 3000 CONTINUE                                                      ONL02490
C                                                                   ONL02500
```

```
C                                                               ONL02640
C   Low Rate sensor data extraction                             ONL02640
C                                                               ONL02050
      INT2=0                                                    ONL02060
C                                                               ONL02070
       DO 3000 ILOG=ILOG1,ILOG2                                 ONL02080
C                                                               ONL02100
         ILDISP = (ILOG-1)*262                                  ONL02110
C                                                               ONL02120
         DO 2100 I=1,262                                        ONL02130
 2100    LOGREC(I) = LOGR(I+ILDISP)                             ONL02140
C                                                               ONL02150
C                                                               ONL02170
           DO 2400 ISUB=ISUB1,ISUB2                             ONL02190
C                                                               ONL02200
C                                                               ONL02230
           ICWODW = SDB(1,1,ISUB)                               ONL02240
           IF( ICWODW.NE.32 ) GO TO  2200                       ONL02250
C                                                               ONL02260
           IRDA    = SDB(2,1,ISUB)                              ONL02270
           IFSRS   = IRDA-(IRDA/256)*256                        ONL02280
           IRDA    = IRDA/256                                   ONL02290
           IFS     = IFSRS-(IFSRS/4)*4                          ONL02300
           IFRS    = IFSRS/4                                    ONL02310
           MUXVAL = SDB(3,1,ISUB)/4                             ONL02320
           IF( IRDA.LT.    4 ) GO TO 2400                       ONL02350
           IF( IRDA.GT.    6 ) GO TO 2400                       ONL02360
C
C ICOMP = 1 for LP Z
C ICOMP = 2 for LP NS
C ICOMP = 3 for LP EW
C NCOMP = 3
C IT1   = Time of first sample
C ITT   = Time of first sample in present 0.5 second block
C IDSEC = 10 ( 10 dsec = 1 sec )
C NCH2  = NCOMP*7
C
           ICOMP   = IRDA-    4+1                               ONL02370
C                                                               ONL02390
           ICHAN = (ISUB-    1)*NCOMP + ICOMP                   ONL02480
           ISAMP = (( ITT+(ILOG-1)-IT1)/IDSEC)*NCH2 +ICHAN      ONL02490
           SAMP(ISAMP) = MUXVAL                                 ONL02500
C                                                               ONL02520
C                                                               ONL02540
           GO TO 2400                                           ONL02550
C                                                               ONL02560
 2200      CONTINUE                                             ONL02570
 2400      CONTINUE                                             ONL02690
C                                                               ONL02700
C                                                               ONL02780
 3000  CONTINUE                                                 ONL02790
C                                                               ONL02800
```

IV. FIELD INSTRUMENTATION

Improvements and modifications

Reference is made to Tables IV.1 and IV.2 indicating the status of the NORSAR SP instruments (original array), the modified NORESS array, and the expanded 02B subarray (connected to the NDPC analog channels).

The work with the expansion of the 02B subarray (telemetry stations) continued in September, but the completion date was delayed due to different circumstances in connection with the data line (NTA responsibility). (On 5 November 1982 the array was fully operational, partly operational 21 October.) Figure IV.1 shows the expanded 02B array and Table IV.3 gives preliminary coordinates for the new stations.

Preparation and installation of the 06C, NORESS array continued throughout the reporting period, and week 40 two sets of 3-component SP instruments SS-1 were installed, of which one set was installed in the LPV station 2, and the other set at station 6. In addition to the SP seismometers a wind station was installed at site 2 (LPV) week 39, indicating wind direction and speed.

Data from the above-mentioned instruments is transmitted via the new analog line together with the analog instruments to the MODCOMP communications processor for digitization and processing.

Fig. IV.2 shows the 06C, NORESS array.

At the subarray 01A a few changes to the original instrumentation have been made. Reference is made to Table IV.1.

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Subarray Normally	Instr. No. within SA	Ch. No. on NORSAR Data Tape	Time of change 10/08/82	10/28/82	10/29/82
01A	1	1	-	-	8 Hz filter
(1)	2	2	1)	-	8 Hz filter
	3	3	-	2)	-
	4	4	-	-	-
	5	5	-	3)	-
	6	6	-	-	Normal
01B	1	7	-	-	-
(2)	2	8	-	-	-
	3	9	-	-	-
	4	10	-	-	-
	5	11	-	-	-
	6	12	-	-	-
02B	1	13	-	-	-
(3)	2	14	-	-	-
	3	15	-	-	-
	4	16	-	-	-
	5	17	-	-	-
	6	18	-	-	-
02C	1	19	-	-	-
(4)	2	20	-	-	-
	3	21	-	-	-
	4	22	-	-	-
	5	23	-	-	-
	6	24	-	-	-

1) Data from borehole at site 1 (60 m hole) to SP ch 02 (in CTV)
2) Wind speed to SP ch 03 (in CTV)
3) Wind direction to SP ch 05 (in CTV)

TABLE IV.1

Status of NORSAR SP instruments recorded on data tape.
(Page 1)

Subarray Normally	Instr. No. within SA	Ch. No. on NORSAR Data Tape	Time of Change		
			10/08/82	10/28/82	10/29/82
03C	1	25	-	-	-
(5)	2	26	-	-	-
	3	27	-	-	-
	4	28	-	-	-
	5	29	-	-	-
	6	30	-	-	-
04C	1	31	-	-	-
(6)	2	32	-	-	-
	3	33	-	-	-
	4	34	-	-	-
	5	35	-	-	-
	6	36	-	-	-
06C	1	37	-	NORESS station no. 1 (Fig. IV.2)	-
(7)	2	38	-	- " - 3	-
	3	39	-	- " - 8	-
	4	40	-	- " - 9	-
	5	41	-	- " - 10	-
	6	42	-	- " - 11	-

TABLE IV.1

(Page 2)

Subarray Normally	NORSAR Analog ch. at NDPC	Time of Change 10/30/81	10/04/82	10/21/82
06C (NORESS)	1	NORESS station nr. 1 *	-	NORESS sta. no. 2, VERT seis SS-1
	2	- " - 3	-	- " - NS seis SS-1
	3	- " - 4	-	- " - EW seis SS-1
	4	- " - 5	NORESS sta. no. 6, VERT seis SS-1	-
	5	- " - 7	- " - NS seis SS-1	-
	6	- " - 6	- " - EW seis SS-1	-
	7	- " - 8	-	- " - Wind direction
	8	- " - 9	-	- " - Wind speed
	9			02B (telemetry) 1 S-500
	10			- " - 2 "
	11			- " - 3 "
	12			- " - 4 "
	13			- " - 5 "
	14			- " - 6 "
	15			
	16			
	17			
	18			

* (see Fig. IV.2)

TABLE IV.2

Status of NORESS and 02B (telemetry stations) and their connections to analog channels at NDPC (1-14)

Station No.	Latitude (N)	Longitude (E)
1	61.068344	11.156468
2	61.101196	11.161124
3	61.091309	11.166824
4	61.107315	11.174083
5	61.084824	11.174442
6	61.049728	11.158080

TABLE IV.3

Preliminary geographical coordinates for the new 02B stations.

NORSAR 02B expansion

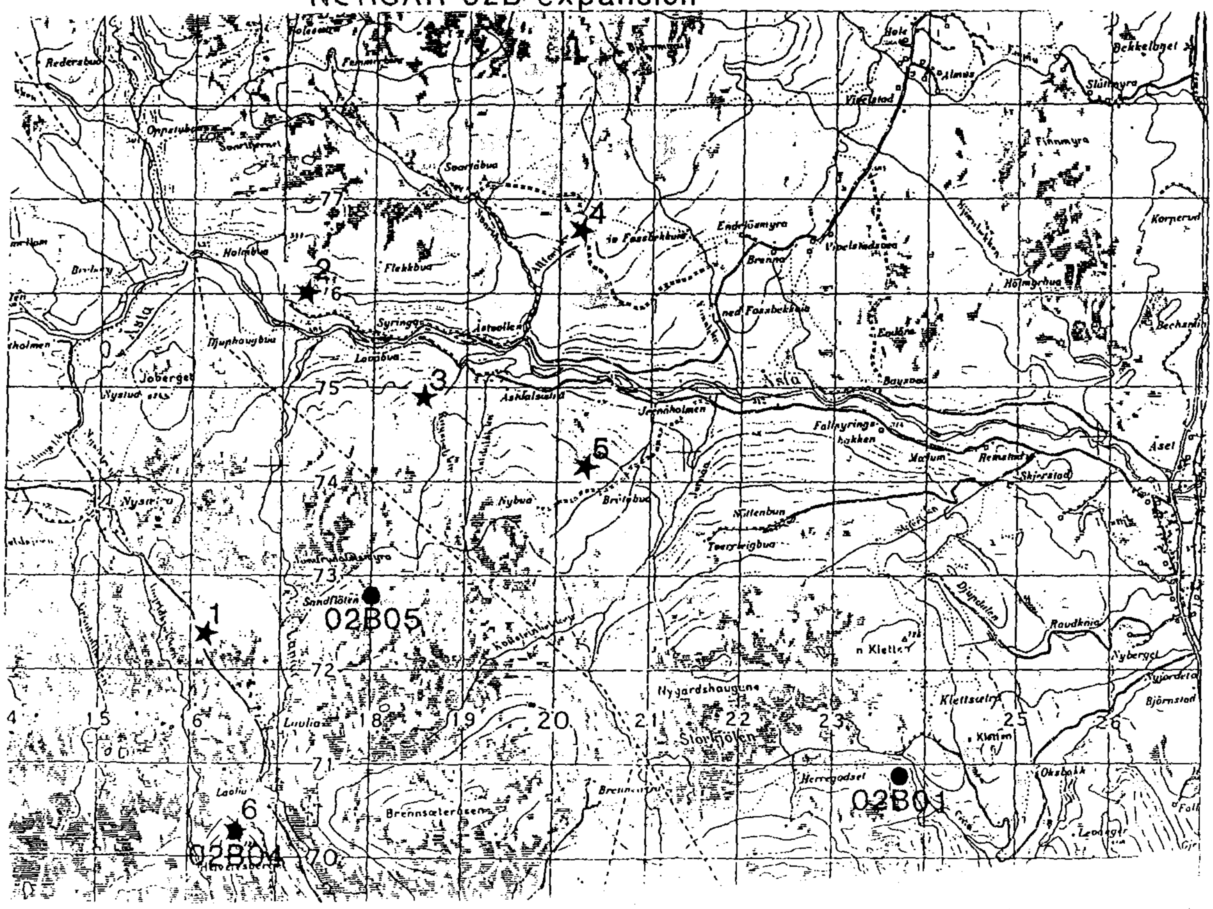

Fig. IV.1 The six new stations in the expanded 02B array.

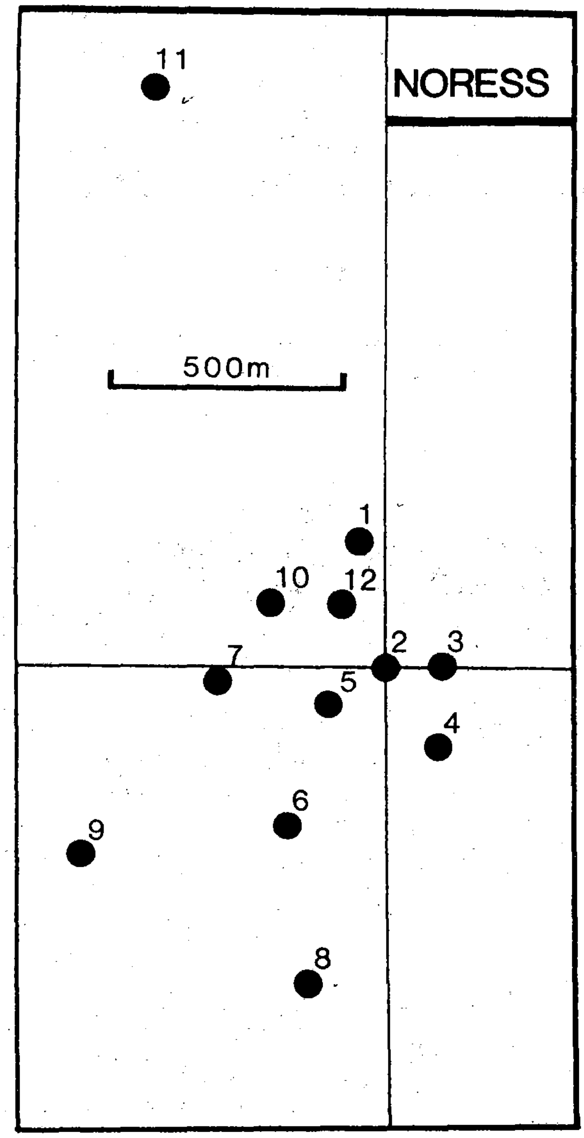

Fig. IV.2 Station numbering in the NORESS array.

Field Maintenance Activity

This section outlines in brief the field maintenance activity during the reporting period. In addition to ordinary maintenance activities in the original array, much time has been spent on preparation/installation of the new telemetry stations in the 02B area. Also a good deal of work has been laid down in the 06C area, in connection with localizing new sites (NORESS), installation of new SP instruments and wind stations (the latter also at 01A).

Table IV.4 gives the number of visits to the NORSAR subarrays during the reporting perod. The average number of visits to each subarray is 7.0, not including the work with the new stations in the 02B area.

A number of visits have been made to stations in the Southern Norway Seismic Network (SNSN).

Maintenance Visits

Subarrays	01A	01B	02B	02C	03C	04C	06C/NORESS	Total
No. of Visits	15	12	5	2	8	3	4	49

TABLE IV.4

Number of visits to the NORSAR subarrays including NORESS in the period 1 Apr - 30 Sep 1982

Preventive Maintenance Projects

Table IV.5 indicates preventive maintenance work of the NORSAR instrumentation and facilities. Tolerances before adjustments were within limits.

Unit	Action	No. of Actions
Seismometer	MP adjust (in field)	2
	FP -"- -"-	3
Line Termination Amplifier	Adjustment of channel gain (SP)	4
	- " - (LP)	2
	DC offset (SP)	3
	RA-5 gain	1
Emergency Power	Battery and charger check	4
Cleaning of CTV		2
Replacements of wooden cover		3
Other constructions		3

TABLE IV.5

Preventive maintenance work in the period
1 April - 30 September 1982

Corrective Maintenance

Required adjustments and replacements are given in Table IV.6.

Unit	Characteristics	SP		LP	
		Repl.	Adj.	Repl.	Adj.
Seismometer	FP (in field)				3
	MP (in field)				3
	RCD (FP)			2	
	Power supply for Mass. Pos. ind.			1	
Seismometer Ampl. RA/5, Ithaco	Protection card	3			
Line Termination Amplifier	Gain		2		
	DC offset		1		
	LTA card	4			
SLEM	Test gen.		4		
	EPU	4	5		
	Mux/ADC/RSA	1			
Modem		1			
	Card	1			
Power charger/ Rectifier	Timer & regulator card	1			

TABLE IV.6

Total number of required adjustments and replacements of NORSAR field equipment in the period 1 April - 30 September 1982.

Power Outages, Cable Breakages, Communications Faults

Broken/damaged cables were repaired at 01A 00, 03; 01B 01, 04, 05. One power outage required action from the NORSAR Maintenance Center (NMC). Irregularities in connection with communications required NMC assistance four times.

Array Status

As of 30 September 1982 the following channels deviated from tolerances: 01A V; 01B V,EW,04,05; 02B V,EW,01; 02C EW; 03C 06; 04C EW; 06C 03,05,EW. Channels with nonstandard status (per 30 Oct 82) are:

01A	01	8 Hz filter
01A	02	8 Hz Filter, 60 m hole
01A	03	Wind speed measurements
01A	04	Attenuated 40 dB
01A	05	Wind direction measurements

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ABBREVIATIONS

CTV	-	Central Terminal Vault
EPU	-	External Power Unit
EW	-	East-West
FP	-	Free period
LP	-	Long period
MP	-	Mass position
MUX	-	Multiplexer
NDPC	-	NORSAR Data Processing Center
NORESS	-	NORSAR Experimental Small-Aperture Subarray
NS	-	North-South
NTA	-	Norwegian Telegraph Administration
RCD	-	Remote centering device
SLEM	-	Seismic short and long period electronics module
SA	-	Subarray
SP	-	Short period
WHV	-	Well head vault

V. DOCUMENTATION DEVELOPED

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L.B. Tronrud

VI. SUMMARY OF TECHNICAL REPORTS/PAPERS PREPARED

VI.1 On-line event detection and location based on NORESS data

In previous semiannual reports and elsewhere (cf. Mykkeltveit and Ringdal, 1981; Mykkeltveit et al, 1983), we have reported on analysis of data from the small-aperture NORESS array.

Recently, a Regional On-line Array Processing Package (RONAPP) was developed and tested in an off-line mode on NORESS data (Mykkeltveit et al, 1982). The package consists of a conventional STA/LTA detector, a phase identification procedure based on phase velocity derived from frequency-wavenumber analysis, and a location procedure based on observed travel time differences and a common azimuth between the observed primary and secondary phases. By permitting association of P and Lg phases with travel time differences less than 6 minutes, RONAPP locates regional events within about 20°. In the following, an account is given of our experience with the same processing package operated in an on-line mode.

On-line experiment

Since October 29, 1982, standard 20 Hz data have been recorded from 6 sensors within NORESS (stations 1, 3, 8, 9, 10 and 11 in Fig. VI.1.1). RONAPP reads the data sequentially directly off the recording medium through a shared disk access between the recording computer (IBM 4331) and the computer (IBM 4341) on which RONAPP is running, and performs the detection and event location analysis. This process results in a detection as well as a location record, with the latter based on our phase association procedure. Fig. VI.1.2 gives an extract of the detection record for day 319, 1982, and location results for the local event at 17.42.13.0. The two phases finally associated are marked by arrows in the detection record.

On-line detection and location performance

RONAPP was operated in an on-line mode over a total of 80 hours distributed over 10 days in November 1982 (mainly day time to ensure recording artificial events, which are generally more abundant than local/regional earthquakes).

The off-line evaluation of the performance of RONAPP was done as follows: all events located by RONAPP were checked by plotting the relevant data traces (like those in Fig. VI.1.2) and carefully reviewing the corresponding detection and location records before accepting or rejecting the 'events'. In addition, RONAPP performance for all detections by the NORSAR on-line system corresponding to an SNR ≥ 5.0 were checked. The output from this evaluation is summarized in Table VI.1.1.

Out of the 19 regional events declared by RONAPP, 14 were found to be wholly acceptable. 'Acceptable' simply means that P and Lg phases have been correctly determined and associated, and that the azimuth and distance estimates are deemed to be reasonable. Locations cannot, however, be checked independently as the majority of these events are small (M_L typically around 1.5-2.5) and cannot be reliably located by the regional network. Previous experience (Mykkeltveit & Ringdal, 1981), indicates that RONAPP locations are typically uncertain by 30 km. Out of the 14 events, 3 were not detected by the NORSAR detection processor (DP), having a threshold SNR equal to 3.0. Three events (all very weak) declared by RONAPP were rated questionable as it was not possible to determine whether these were real or corresponded to association of noise detections. None of the 3 'events' were detected by the NORSAR DP. Two were definitely erroneously declared as local. Both corresponded to the situation where f-k analysis of detections in the P-coda (within 10 seconds of the first P) of teleseismic events resulted in Lg-type velocities. We expect to prevent such situations by the improvement of the array geometry.

From a total of 16 other detections by DP with SNR ≥ 5.0, 12 corresponded to teleseismic events and were recognized as such by RONAPP (all RONAPP detections processed resulted in (relatively high) P-type phase velocities). Three DP detections had no corresponding detections by RONAPP, and one single detection by DP, probably corresponding to a local event, did not result in a location by RONAPP, as only one phase (Lg) was detected by RONAPP.

In view of the limited number of sensors participating in this experiment, we deem the above on-line location results to be very encouraging.

Further improvements in RONAPP

In spite of the promising results in RONAPP on-line performance, there is room for further improvement. We are underway with the inclusion of 'true' beams in the detector, in addition to the vertical beams in the present version of RONAPP. Sixteen beams corresponding to eight equally distributed azimuths spaced at 45^o intervals and phase velocities of 4.5 km/s and 8.0 km/s have been implemented. These new beams have contributed to a lowering of the detection threshold, especially for high-frequency Lg phases, which tend to be 'smeared out' by the vertical beamforming.

S. Mykkeltveit
H. Bungum

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RONAPP ONLINE DETECTION AND LOCATION PERFORMANCE

Test period : 80 hours

Events located by RONAPP :	19
Acceptable :	14 (3 not detected by DP)
Questionable, not detected by DP :	3
Wrong, both teleseismic P :	2
Other detections by DP with SNR 5.0 :	16
Teleseismic, recognized as such by RONAPP :	12
No detection with RONAPP, not local :	3
Probably local, RONAPP detection, but no location :	1

Table VI.1.1 RONAPP evaluation statistics. DP is the detection processor for the entire NORSAR system.

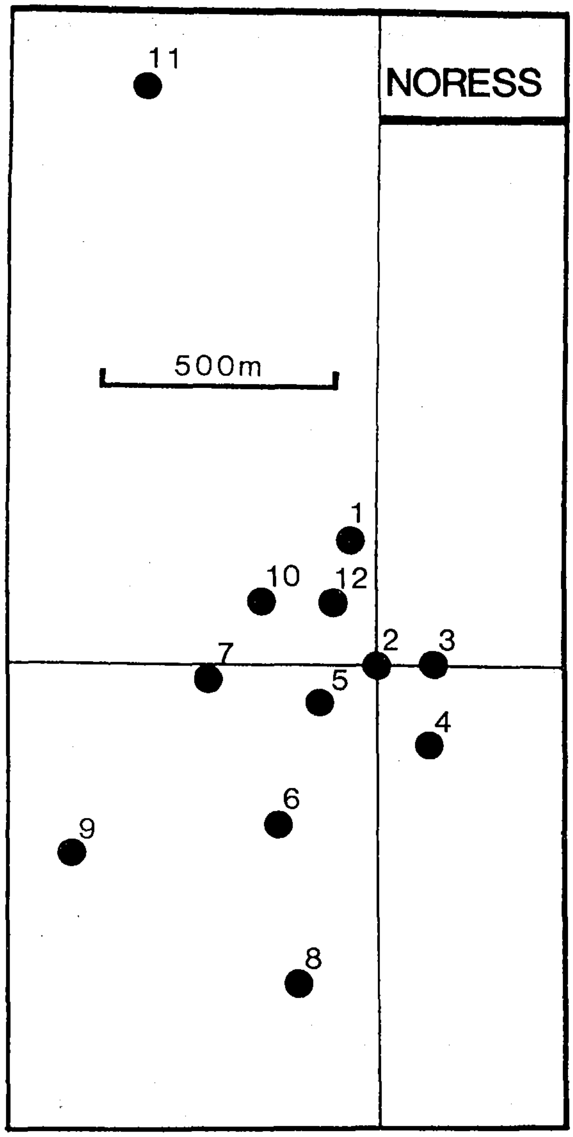
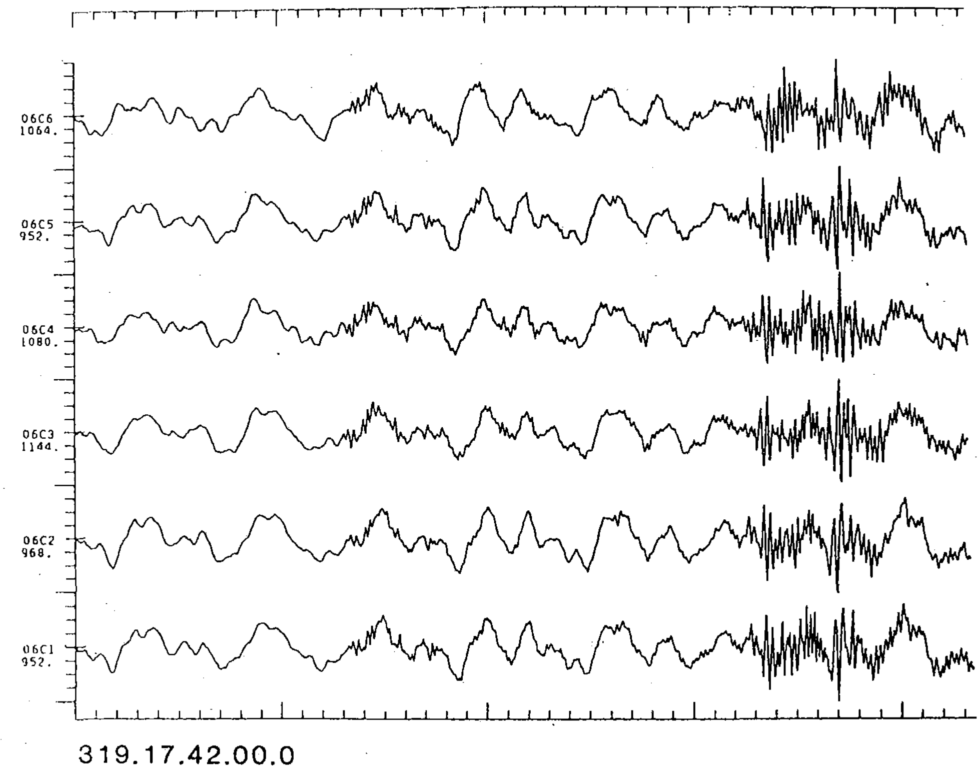


Fig. VI.1.1 NORESS geometry. The experiment described here is based on data from stations 1, 3, 8, 9, 10 and 11.



Detection record

Time											Per	Vel	Az	Pwr
1982	319	17	3	38	6	8	8	125.	0.82	3.09	1.20	3.07	312.5	36.7
1982	319	17	17	48	3	8	9	103.	1.00	3.07	3.00	1.86	42.0	11.7
1982	319	17	35	8	0	8	8	112.	0.93	3.09	1.00	5.30	212.0	37.4
1982	319	17	42	13	0	10	10	67.	0.22	5.55	4.50	6.57	156.8	33.9 ◀
1982	319	17	42	19	2	10	10	42.	0.25	4.32	3.90	6.06	166.0	26.0
1982	319	17	42	21	6	10	10	42.	0.25	3.25	3.90	6.20	187.1	22.1
1982	319	17	42	25	9	10	10	48.	0.25	3.16	4.00	4.04	166.0	24.4
1982	319	17	42	32	2	10	10	227.	0.26	4.80	3.80	4.14	155.6	44.0 ◀
1982	319	17	42	36	7	8	9	257.	0.32	4.16	3.00	4.64	158.2	42.6
1982	319	18	10	20	3	8	9	106.	1.01	3.15	3.00	2.93	20.6	12.6

Location record

```
****************
LG TYPE PHASE DETECTED AT     1982 319 17 42 25  9
ASSOCIATED WITH P ARRIVAL AT 1982 319 17 42 13  0
                EVENT LOCATED AT LAT= 59.947 LON= 12.212
****************
LG TYPE PHASE DETECTED AT     1982 319 17 42 32  2
ASSOCIATED WITH P ARRIVAL AT 1982 319 17 42 13  0
                OVERRIDING EARLIER SOLUTION,NOW LAT= 59.584 LON= 12.511
****************
LG TYPE PHASE DETECTED AT     1982 319 17 42 36  7
P PHASE FOUND AT              1982 319 17 42 13  0
                HAS ALREADY BEEN ASSOCIATED WITH STRONGER LG PHASE
****************
LG TYPE PHASE DETECTED AT     1982 319 18 10 20  3
ASSOCIATION ATTEMPT UNSUCCESFUL.NO P PHASE FOUND.
****************
```

Fig. VI.1.2 Extracts from RONAPP detection and location records with plot of relevant data.

VI.2 NORESS noise and signal characteristics

The analysis of seismic noise characteristics in Fennoscandia as documented in our previous Semiannual Report (Bungum, 1982) has continued through an extensive analysis of noise level variation at the NORESS stations, and with two purposes: to obtain estimates of the long term noise levels and to study possible day/night differences.

Three different time periods between day 76/1982 (17 March) and day 195/1982 (14 July) were analyzed, as shown in Table VI.2.1. Values are given for five frequencies (0.25, 0.5, 1.0, 2.0 and 4.0 Hz), and the day/night differences are calculated for the same frequencies. From the averages and the standard deviation at the bottom of Table VI.2.1 we see that the difference is significant only at 2.0 and 4.0 Hz (values above 4.0 Hz could not be obtained because of dynamic limitations). The difference is quite small, 1.5-2.0 dB, which is consistent with the results of Ringdal & Bungum (1977). It is noteworthy that the standard deviation of the daily variations increases for decreasing frequencies, which is due to variations in the levels of ocean-generated noise.

The results with respect to absolute noise level in Table VI.2.1 are consistent with one of the conclusions in Bungum (1982), namely, that the noise level falls off with about 20 dB/octave below 1-2 Hz, and with about 10 dB/octave above that frequency. The average noise level at 1 Hz is 3.3 dB, corresponding to about 2 nm^2/Hz.

In Fig. VI.2.1 the average NORESS noise levels are plotted on top of noise spectra for the SRO stations ANMO (Albuquerque, New Mexico), NWAO (Mundaring, Australia) and the ASRO station KONO (Kongsberg, Norway), as taken from Peterson (1980). While a certain variation occurs for lower frequencies, the levels are quite similar for 2 and 4 Hz. At around 10 Hz, however, the typical level for southeastern Norway is lower than for all of the SRO/ASRO sites analyzed by Peterson (1980).

The NORESS 40 Hz data are now also being used in analysis of signal spectra and signal-to-noise ratio at higher frequencies. In Figs. VI.2.2-VI.2.3 there are given two examples of local earthquakes (distance 3° and 5°), and it is obvious that the SNR just continues to increase at least up to 10 Hz for those events. This high-frequency predominance is of course not being preserved for the distances of 26° and 38° presented in Figs. VI.2.4-VI.2.5 (presumed nuclear explosions in the Caspian Sea area and in Eastern Kazakh). The peak in SNR now occurs around 2 Hz, but there is still (with the exception of the weakest of the E. Kazakh events) good SNR up to about 8 Hz.

H. Bungum

References

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Peterson, J. (1980): Preliminary observations of noise spectra at the SRO and ASRO stations. USGS Open File Report 80-992, Albuquerque, New Mexico.

Ringdal, F. & H. Bungum (1977): Noise level variation at NORSAR and its effect on detectability. Bull. Seism. Soc. Am. 67, 479-492.

DAY	HOUR	POWER DENSITY (DB REL TO 1 NM**2) .25	.50	1.0	2.0	4.0	POWER DENSITY DIFFERENCE(DB) .25	.50	1.0	2.0	4.0
76	1542	48	30	7	-12	-25					
77	0200	48	30	5	-14	-27	0	0	2	2	2
77	1606	48	28	3	-15	-27					
78	0200	48	27	1	-18	-28	0	1	2	3	1
80	1405	38	25	5	-17	-28					
81	0200	40	23	2	-17	-28	-2	2	3	0	0
83	1545	48	30	7	-13	-26					
84	0200	49	28	5	-15	-28	-1	2	2	2	2
84	1507	50	33	7	-13	-26					
85	0200	50	29	5	-15	-27	0	4	2	2	1
123	1400	58	34	9	-10	-23					
124	0200	57	33	9	-13	-27	1	1	0	3	4
124	1400	54	33	9	-10	-24					
125	0200	51	29	8	-14	-27	3	4	1	4	3
125	1400	52	31	7	-13	-25					
126	0200	52	30	4	-14	-27	0	1	3	1	2
127	1400	43	26	3	-14	-25					
128	0200	42	29	5	-14	-26	1	-3	-2	0	1
128	1400	43	29	5	-15	-27					
129	0200	42	27	3	-16	-27	1	2	2	1	0
129	1400	40	26	2	-16	-27					
130	0200	37	21	0	-18	-28	3	5	2	2	1
130	1400	38	20	0	-14	-25					
131	0200	36	20	0	-17	-27	2	0	0	3	2
186	1500	40	28	7	-13	-24					
187	0200	46	27	3	-15	-27	-6	1	4	2	3
187	1400	46	25	2	-15	-26					
188	0100	48	27	4	-17	-28	-2	-2	-2	2	2
188	1400	43	24	2	-15	-27					
189	0159	44	26	4	-16	-28	-1	-2	-2	1	1
189	1400	40	25	3	-14	-26					
190	0200	43	28	3	-17	-28	-3	-3	0	3	2
191	1440	42	25	3	-16	-27					
192	0200	45	26	2	-18	-29	-3	-1	1	2	2
192	1405	40	21	2	-17	-27					
193	0205	36	20	0	-18	-29	4	1	2	1	2
194	1400	40	27	0	-15	-26					
195	0205	37	26	0	-16	-28	3	1	0	1	2
AVERAGE		44.8	26.6	3.3	-15.9	-27.6					
ST. DEV		5.8	3.4	2.5	1.6	0.7					
AVERAGE DIFFERENCE (DB)							0.0	0.7	1.1	1.8	1.7
STANDARD DEVIATION (DB)							2.4	2.2	1.7	1.0	1.0

Table VI.2.1 NORESS (40 Hz data) noise power spectral density values at 5 frequencies separated by one octave, for a number of cases with measurements 12 hours apart. The day/night spectral differences are also given, together with average values and standard deviations both for the spectral levels and for the daily variations. The average values are plotted in Fig. VI.2.1.

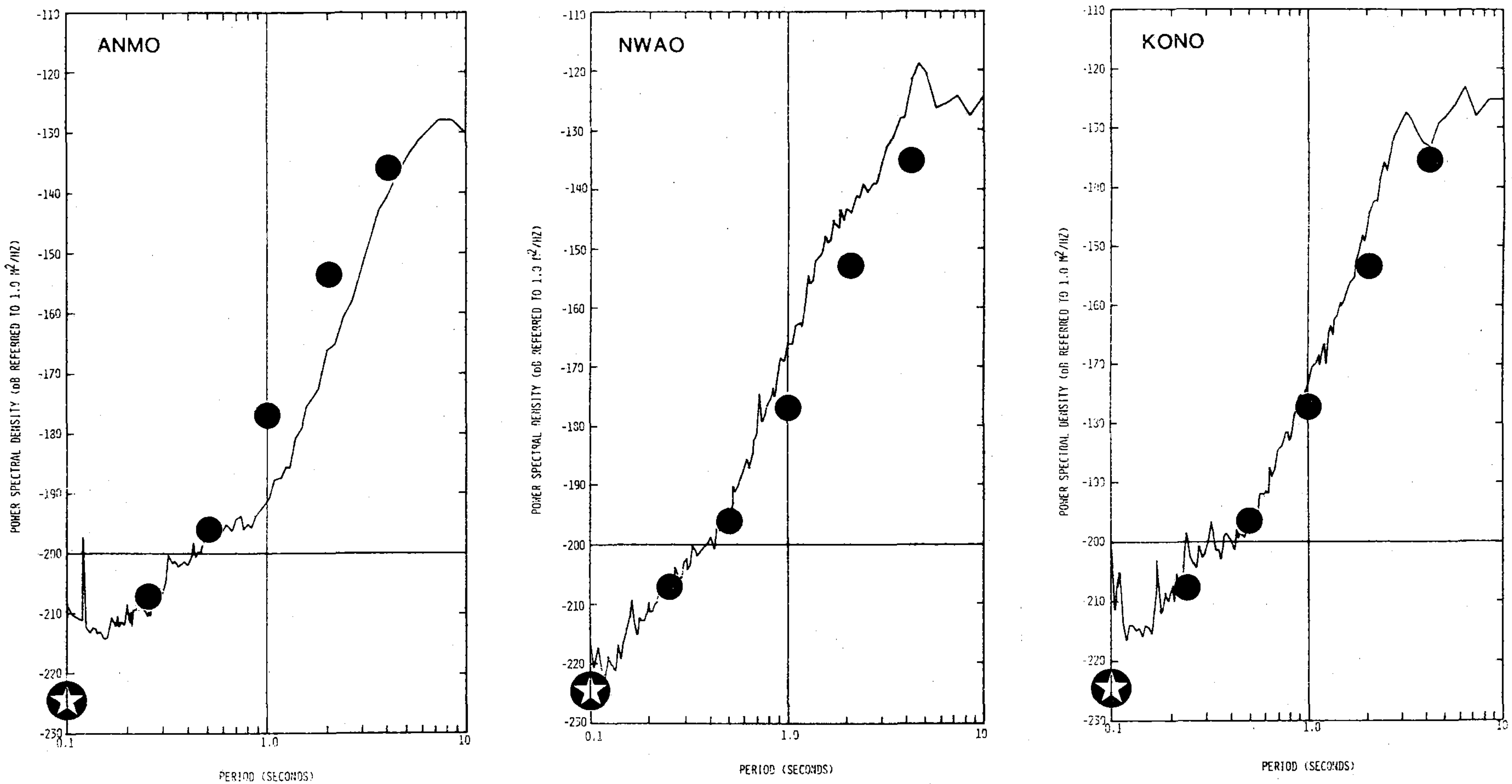


Fig. VI.2.1 Average NORESS noise level values from Table VI.2.1 (dots) plotted on top of SRO noise level curves (Peterson, 1980) for ANMO (New Mexico), NWAO (Australia) and KONO (Norway). The star indicates the typical 10 Hz noise level in southeastern Norway as recorded by independent field measurements.

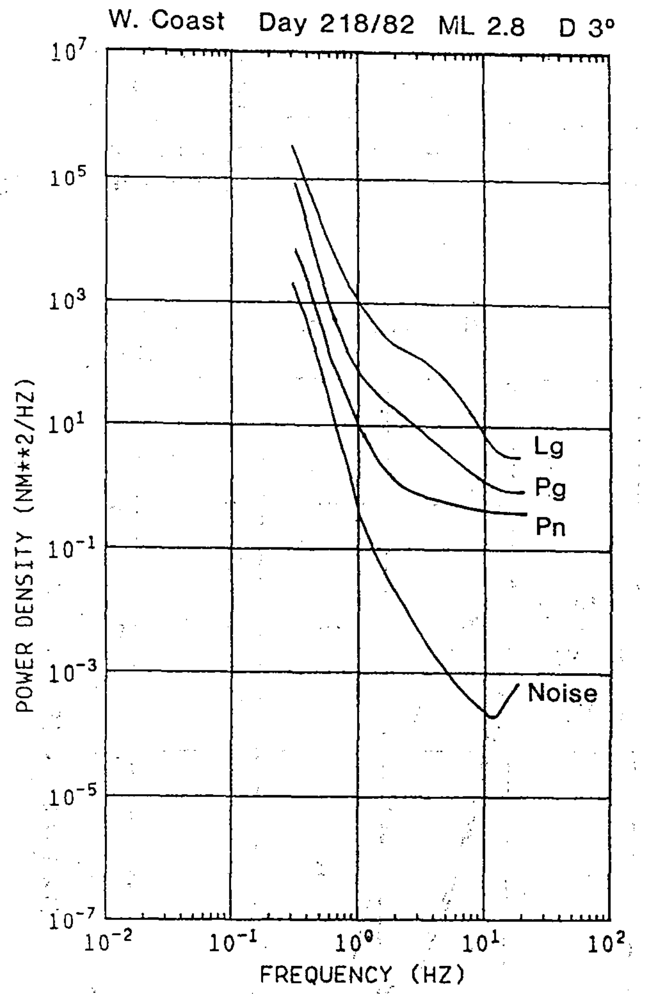


Fig. VI.2.2 NORESS (40 Hz) power spectral density values for a W. coast earthquake on day 218/82, ML=2.8, Δ=3°. The spectra for Pn, Pg and Lg are given, together with the spectrum for the preceding noise. Values above 6-8 Hz are biased upwards by system noise.

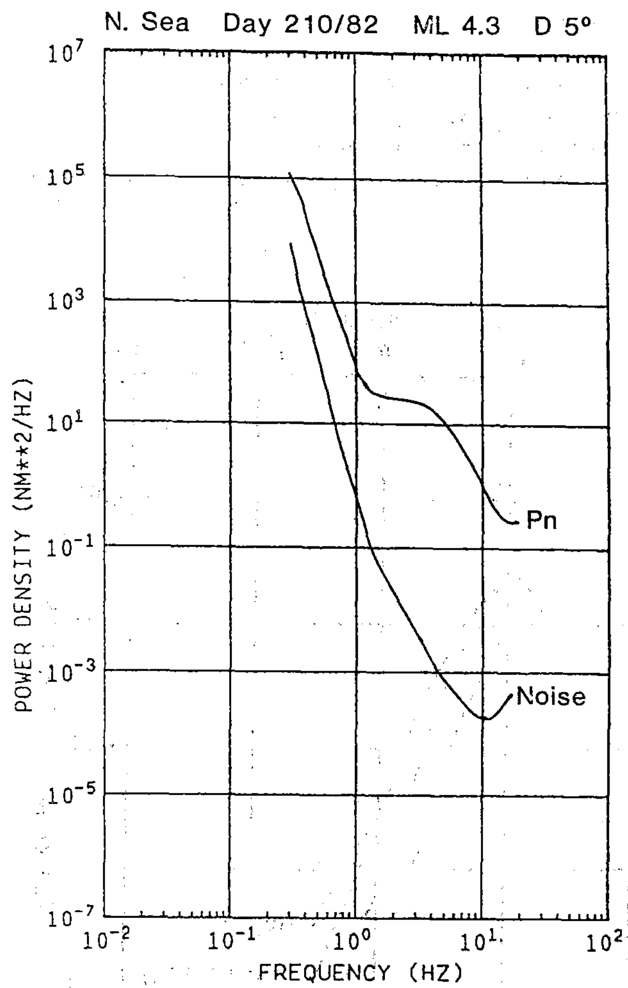


Fig. VI.2.3 Same as for Fig. VI.2.2, but for a N. Sea earthquake on day 210/82, ML=4.3, Δ=5°. The spectrum for Pn is given.

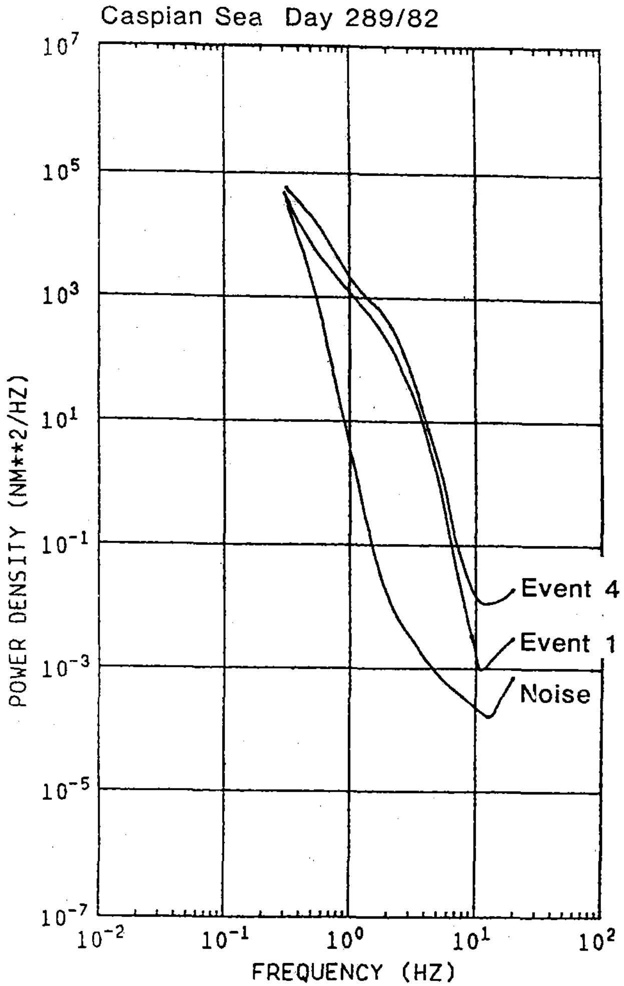


Fig. VI.2.4 Same as for Fig. VI.2.2, but for two Caspian Sea presumed explosions on day 289/82 (m_b 5.3 and 5.7). The two events are the first and last ones in a series of four. The epicentral distance is 26°.

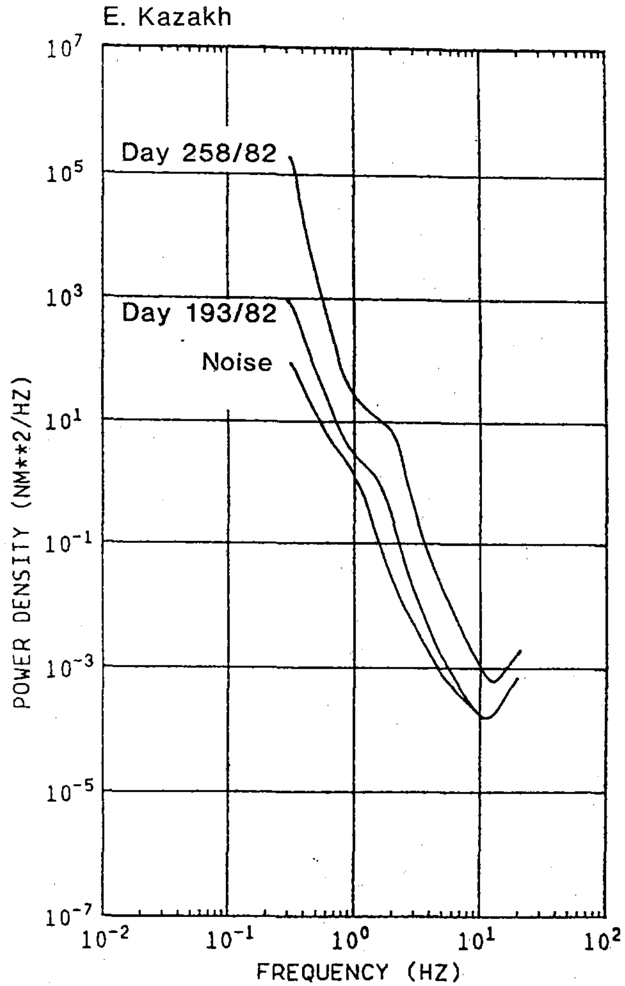


Fig. VI.2.5 Same as for Fig. VI.2.2, but for two E. Kazakh presumed explosions on day 193/82 (m_b=3.9) and 258/2 (m_b=4.2). The epicentral distance is 38°.

VI.3 P-wave coda amplitudes at NORSAR for Semipalatinsk events

This paper presents some preliminary results on the stability of P coda and Lg for magnitude estimates for events from the Eastern Kazakh test site. The significant variations of P-amplitudes across NORSAR is well known, and illustrated in Fig. VI.3.1. Typically, these amplitudes vary across NORSAR by an order of magnitude, and show that single site measurements of m_b have a large factor of uncertainty. The standard deviation of log amplitudes across NORSAR is about 0.28 m_b units for any given Semipalatinsk event.

Fig. VI.3.2 shows that the amplitude variations are greatly reduced a few minutes into the coda. This figure, which covers the Lg window, demonstrates that the variability across the array of Lg amplitudes and P coda preceding Lg are similar. The standard deviation is of the order of 0.08 m_b units (peak amplitudes) and can be reduced even further (to about 0.05 m_b units) by considering RMS amplitudes. Thus, averaging the amplitudes of all 42 NORSAR SP sensors should provide 'm_b' estimates with a precision of about 0.01 m_b units.

The near-receiver 'focusing effects' illustrated in Fig. VI.3.1 might be expected to have counterparts in near-source 'focusing'. An indication that such focusing takes place is given in Fig. VI.3.3, where 3 Semipalatinsk events of the same NEIS m_b (5.9) are shown for NORSAR sensor 01A06. Event 1 (Degelen mountains) has the lowest amplitudes at NORSAR (NORSAR m_b = 6.02), but also the difference between the two Shagan River events is significant (m_b = 6.26 and 6.56, respectively).

Fig. VI.3.4 shows that the coda decay at NORSAR is very different for these 3 events. The event with the highest NORSAR m_b shows the most rapid decay. (Note also that Degelen Mountain events have a pronounced PP phase not usually observed at NORSAR from Shagan River). Fig. VI.3.5 is similar to Fig. VI.3.4, but with all 3 events plotted in the same amplitude scale. Here, it is seen that the P coda amplitudes are about equally large for the three events after about 3 minutes. The same applies to Lg, although Lg has a low SNR. Thus, a hypothetical 'coda magnitude' (and also Lg magnitude) at NORSAR would be similar for the 3 events, consistent with the NEIS reportings.

In conclusion, P coda and Lg magnitudes show great promise both in reducing focusing effects near the receiver and near the source. Further investigations into this problem are planned.

F. Ringdal

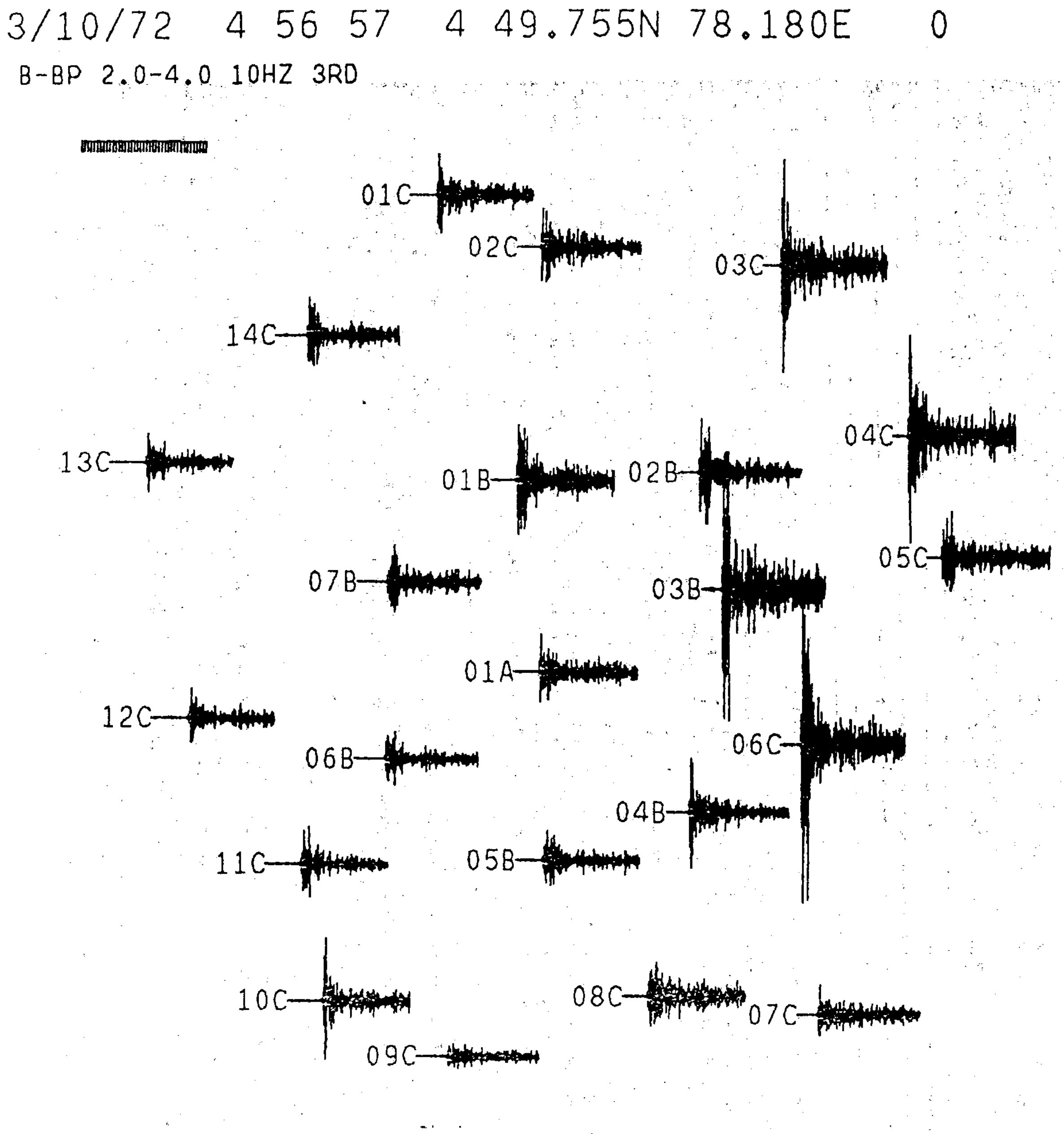


Fig. 1 . Typical P-wave amplitude distribution across NORSAR for Semipalatinsk events. Amplitudes vary by a factor of 10. Standard deviation of log amplitudes is 0.28.

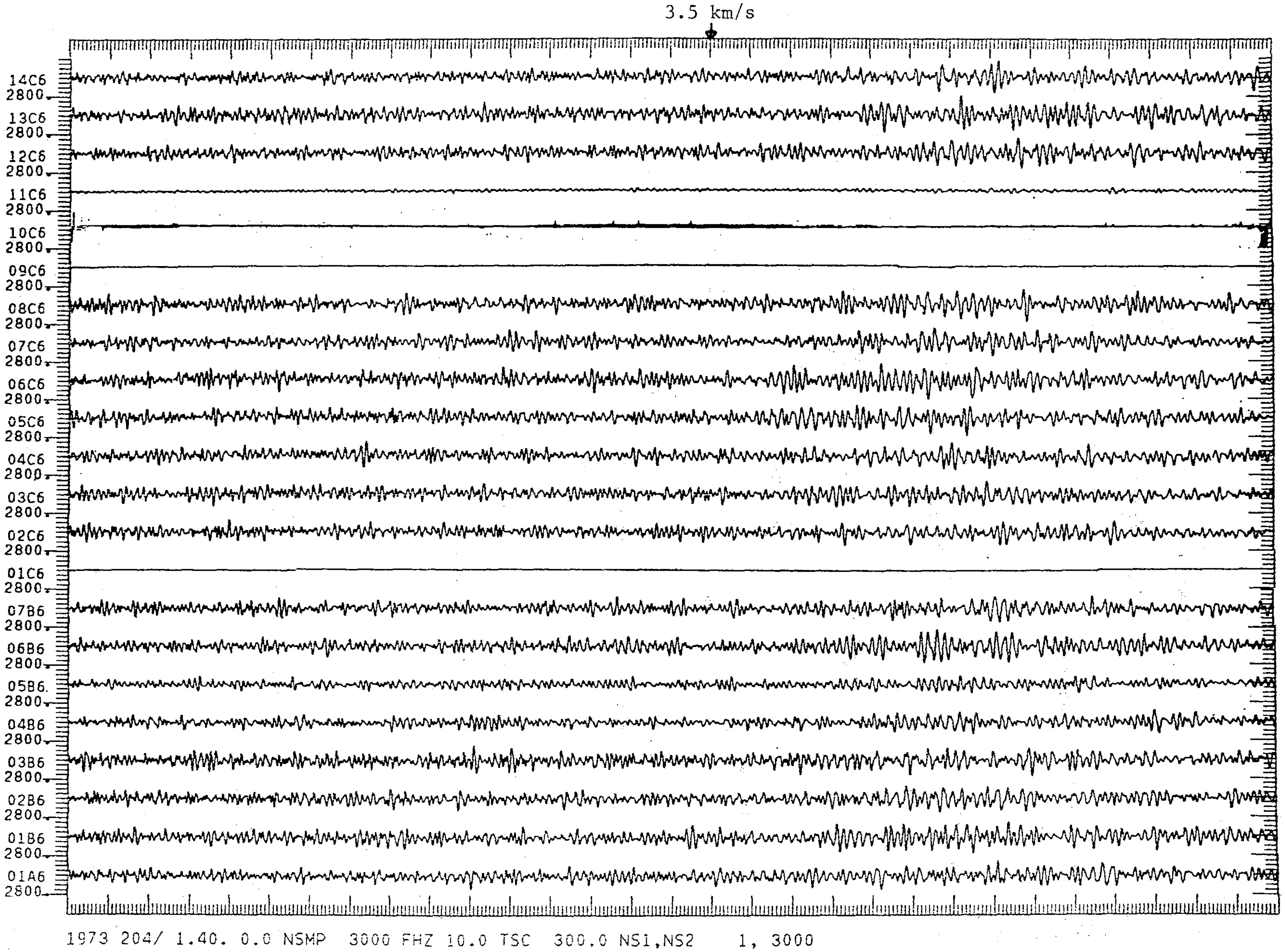
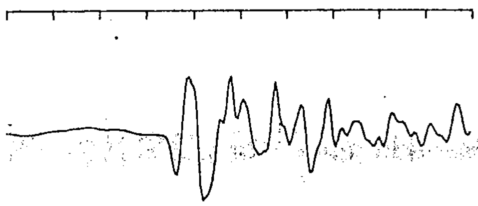


Fig. 2. P coda for NORSAR subarray center sensors plotted for a Semipalatinsk explosion. The plot covers 5 min, and Lg can be identified. The standard deviation across NORSAR of log amplitudes is 0.08 and 0.05 for peak and rms amlitudes, respectively.

Event 1 - Degelen Mountains

4/25/71 3 32 58 0 49.823N 78.092E 0 5.9 38.0

** FLTR = ALL PASS **

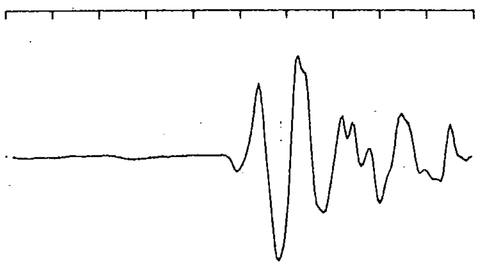


m_b (NORSAR)= 6.02

Event 2 - Shagan River

10/12/80 3 34 14 1 49.958N 79.085E 0 5.9 38.4

** FLTR = ALL PASS **

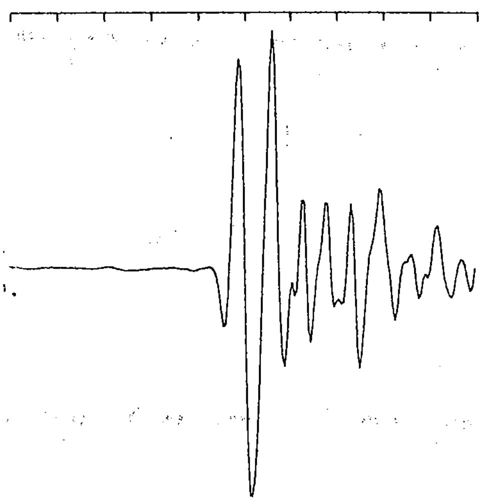


m_b (NORSAR)=6.26

Event 3 - Shagan River

4/22/81 1 17 11 4 49.901N 78.901E 0 5.9 38.4

** FLTR = ALL PASS **



m_b (NORSAR)=6.56

Fig. 3. NORSAR P-wave recordings of 3 Semipalatinsk explosions plotted to the same amplitude scale. All 3 events have NEIS m_b 5.9. Note the significant amplitude differences (instrument 01A06).

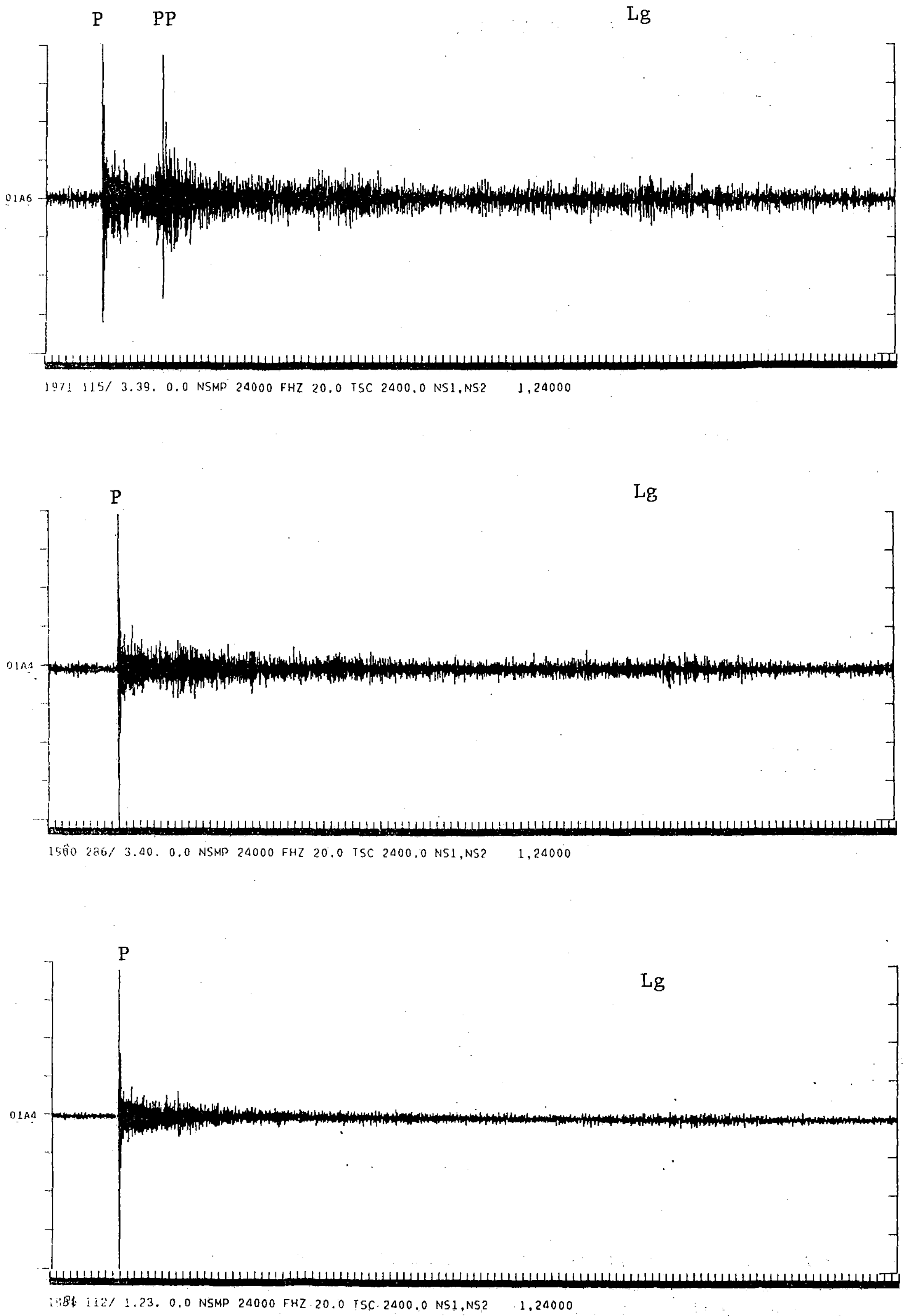


Fig. 4. 20 minutes recordings of the same three events as displayed in Figure 3. Nøte the much more rapid coda decay of event 3 (bottom).

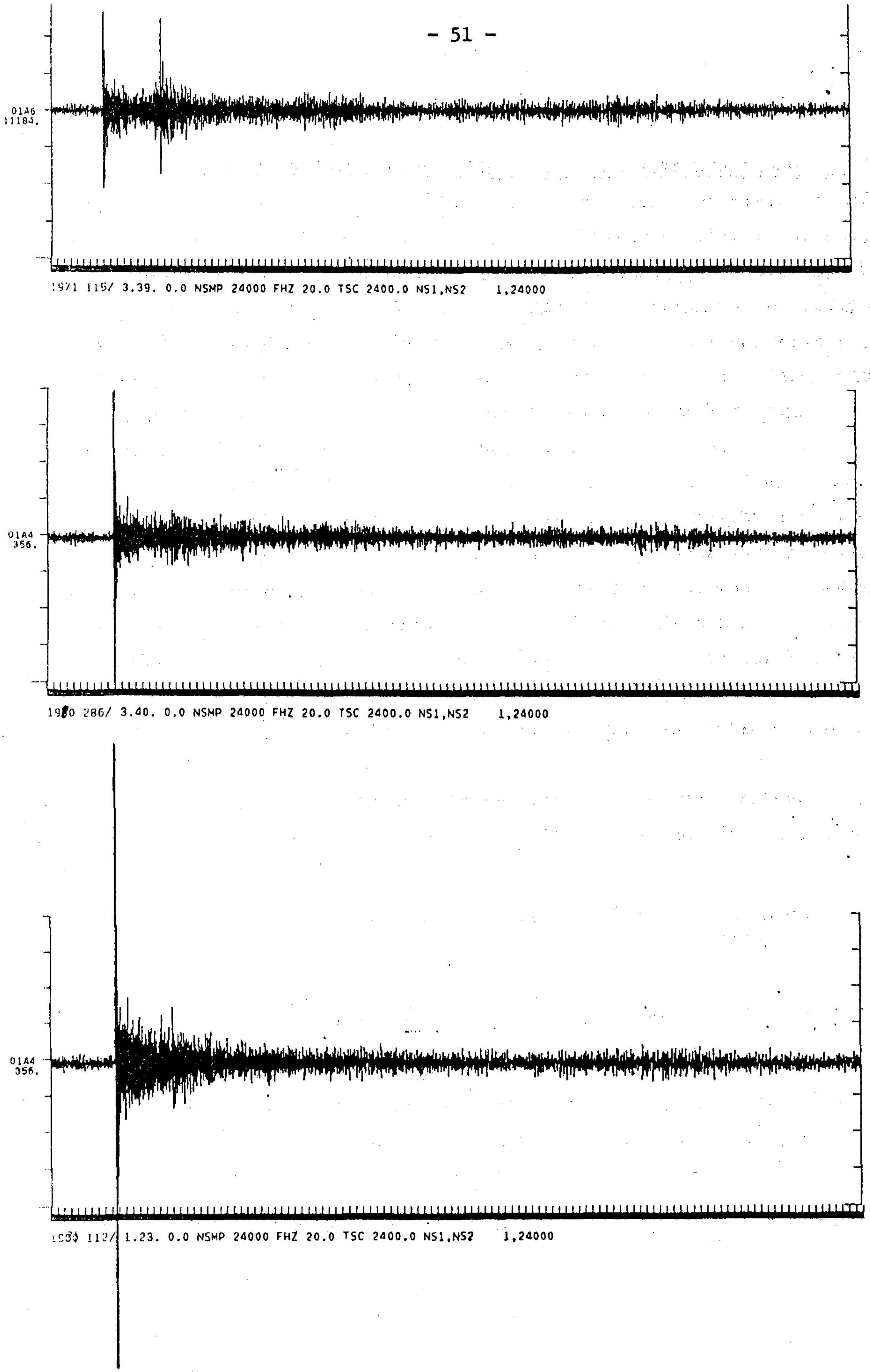


Fig 5. Same as Fig 4, but with all 3 traces plotted in the same amplitude scale. Note that the coda level (including Lg) is very similar after about 3 minutes, thus indicating that a coda magnitude would give relative magnitudes consistent with NEIS.

VI.4 Seismic energy and stress drop from moment tensor analysis

In the previous semiannual summary we discussed suitable ways of extrapolating low-frequency approximations of the source spectrum to higher frequencies. A typical low-frequency approximation is the source representation by moments of low degree, and a suitable extrapolation, at least for practical purposes, was suggested to be given by a Gaussian spectrum. The ω-square model was given as an alternative. It should be noted that each of these spectral source models provides an estimate of seismic energy and apparent stress, and the second degree moments in each model can be interpreted in terms of source dimensions from which an estimate of static stress drop may be inferred. A number of practical procedures for estimating the parameters in these source models is under development; at this stage the restriction is that the source be not too shallow. This is due to our present treatment of Green's functions in the inversion procedure. Here we summarize the procedure and give preliminary results for a deep event as an example. A more detailed treatment is given in Doornbos (1982).

For a bounded source function with zero degree moment tensor $\underline{\underline{M}}$, an expression for the total radiated seismic energy is

$$E_s = \frac{1}{16\pi^2\rho} \int_\Omega d\Omega \left[\alpha^{-5} B^2(\underline{\zeta}_p) E(\underline{\zeta}_p) (\gamma_j \gamma_k M_{jk})^2 \right.$$

$$\left. + \beta^{-5} B^2(\underline{\zeta}_s) E(\underline{\zeta}_s) \{ \gamma_j \gamma_k M_{j\ell} M_{k\ell} - (\gamma_j \gamma_k M_{jk})^2 \} \right] \qquad (1)$$

where α and β are P and S velocities, $\underline{\zeta}_p$ and $\underline{\zeta}_s$ are the associated slowness vectors, γ_i are direction cosines, and we have introduced the energy E and spectral bandwidth B of a pulse by

$$E(\underline{\zeta}) = \int_{-\infty}^{+\infty} \frac{d\omega}{2\pi} |F(\underline{\zeta},\omega)|^2 \, , \quad B^2(\underline{\zeta}) = \int_{-\infty}^{+\infty} \frac{d\omega}{2\pi} \omega^2 |F(\underline{\zeta},\omega)|^2 / E(\underline{\zeta}) \qquad (2)$$

For the Gaussian and ω-square models with second degree moment tensor $\hat{\underline{\underline{F}}}_{(2)}$:

$$B^2(\underline{\zeta})E(\underline{\zeta}) = \chi(\underline{\zeta}^T\hat{\underline{\underline{F}}}_{(2)}\underline{\zeta})^{-3/2} \qquad (2)$$

$$\chi = 1/4\ \pi^{-\frac{1}{2}} \qquad \text{(Gaussian)}$$

$$\chi = 1/\sqrt{2} \qquad \text{(ω-square)}$$

In general the integral over solid angle in equation (1) should be evaluated numerically. Only for a point source is there an analytic solution. It is more convenient to rewrite the quadratic form in equation (2) in the principal axes system of $\hat{F}_{\ell m}$, the spatial part of $\hat{\underline{\underline{F}}}_{(2)}$. Let $\underline{p}_i$ be the unit eigenvectors of $\hat{F}_{\ell m}$ and $\lambda_i{}^2$ the associated (positive) eigenvalues.
Then:

$$\underline{\zeta}^T\hat{\underline{\underline{F}}}_{(2)}\underline{\zeta} = \frac{\lambda_i{}^2}{c^2}(\underline{\gamma}\cdot\underline{p}_i)^2 + \frac{2}{c}\,\hat{F}_{p_1,\tau}(\underline{\gamma}\cdot\underline{p}_1) + \hat{F}_{\tau\tau} \qquad (3)$$

where c is the wave velocity, and rupture is supposed to extend along the major principal axis. An interpretation of the spatial moments $\lambda_i{}^2$ and temporal moment $\hat{F}_{\tau\tau}$ in terms of an equivalent uniform source region is

$$V_u = \frac{20}{3}\pi\ \lambda_1\lambda_2\lambda_3\ , \qquad S_u = 4\pi\ \lambda_1\lambda_2\ ,$$

$$T_u = 2\sqrt{3}\ \hat{F}_{\tau\tau}{}^{\frac{1}{2}} \qquad (4)$$

where V_u is a volume, S_u is a surface appropriate for a plane fault, and T_u is a time length. A stochastic interpretation of the moments leads to slightly different constants in the expressions for V and T.

If Green's functions are determined by only one asymptotic wave, an estimate of the 'travel time residual' for each station and phase, ΔT_i, can be obtained by standard travel time analysis, and determining the first degree moment tensor $\underline{F}_{(1)}$ from the linear system

$$\Delta T_i = \underline{\zeta}_i^T \underline{F}_{(1)} \qquad (5)$$

would then amount to the usual procedure of estimating source location. This will not be further pursued here. Simple Green's functions in the above sense can be decomposed, and the system of equations for determining the moments of degree zero and two becomes

$$U_i(\underline{x},\omega) = A_i G_i(\underline{\xi}_o,\underline{x},\omega) \exp(-\tfrac{1}{2}\omega^2 B_i - i\omega\tau_o) \qquad (6)$$

with

$$A_i = (s_j \zeta_k)_i M_{jk} \qquad (7)$$

$$B_i = \underline{\zeta}_i^T \hat{\underline{\underline{F}}}_{(2)} \underline{\zeta}_i \qquad (8)$$

where $\underline{s}$ is the unit displacement vector of the wave in the source reference point $\underline{\xi}_o$. Although equations (7) and (8) are both linear systems, it is recommended to estimate $\hat{\underline{\underline{F}}}_{(2)}$ by nonlinear inversion using equation (6) directly, and to use physically plausible constraints in the procedure.

As an example of the procedure, we have inverted long- and short-period SRO data from a deep-focus event. The observations are displayed in figure 1, and pertinent results for three cases (point source, circular source and general ellipsoidal source) are given in table 1. In the context of a shear dislocation model, the apparent stress $\eta\bar{\sigma}$ may be obtained from scalar moment M and seismic energy E_s, and the stress drop $\Delta\sigma$ may be obtained from scalar moment and fault shape and surface area (e.g., Aki, 1972). The stress drops listed in table 1 were simply for a circular fault shape. Despite the rather different constraints the results of cases (a) and (c) are reasonably close, suggesting that reasonable estimates of seismic energy and stress drop can be obtained without knowing the fault geometry and rupture history in detail. Nevertheless a number of practical problems remains and figure 2 serves to illustrate some of them, namely, the possible effects of limited bandwidth of the digital SRO system, and frequency dependence of Q. These problems were already identified previously.

D.J. Doornbos

References

Aki, K. (1972): Earthquake mechanism. Tectonophysics, 13, 423-446.

Doornbos, D.J. (1982): Seismic source spectra and moment tensors. Phys. Earth Planet. Int., in press.

	M	N	λ_1^2	λ_2^2	λ_3^2	$\lvert\hat{F}_{\ell\tau}\rvert$	$\hat{F}_{\tau\tau}$	RMS	
	(10^{25} dyne ·cm)			(km^2)		(km·s)	(s^2)	error	
(a)	1.92 (±0.06)	0.17 (±0.05)	16.8 (±0.9)	15.7 (±1.3)	1.5 (±3.5)	2.0 (±0.1)	0.45 (±0.06)	44	$E_s = 2.4 \times 10^{19}$ erg $S = 204$ km^2 $\Delta\sigma$=16 bar $\eta\bar{\sigma}$=1.5 bar
(b)	1.92 (±0.06)	0.17 (±0.05)	0	0	0	0	0.33 (±0.02)	148	E_s=4.4x10^{19}erg
(c)	1.92 (±0.06)	0.17 (±0.05)	9.4 (±1.2)	9.4 (±1.2)	0	0	0.25 (±0.02)	155	E_s=3.2 x 10^{19}erg S=118 km^2 $\Delta\sigma$=36 bar $\eta\bar{\sigma}$=2.0 bar

Table VI.4.1 Fiji Islands event with PDE origin time 1980, June 17, 8 hr, 42 m, 56.9 s, location 20.175°S, 178.443°W, depth 580 km, m_b 5.6. M and N are scalar moments of major and minor double couple, λ_i^2 are positive eigenvalues of the spatial moment tensor, $\hat{F}_{\tau\tau}$ is temporal moment. $\lvert\hat{F}_{\ell\tau}\rvert$ is length of spatial-temporal moment, E_s is total radiated seismic energy, S is fault surface area, $\Delta\sigma$ is stress drop, $\eta\bar{\sigma}$ is apparent stress. Standard deviations in parentheses. Results for (a) general model, (b) point source, (c) prescribed rupture on circular fault.

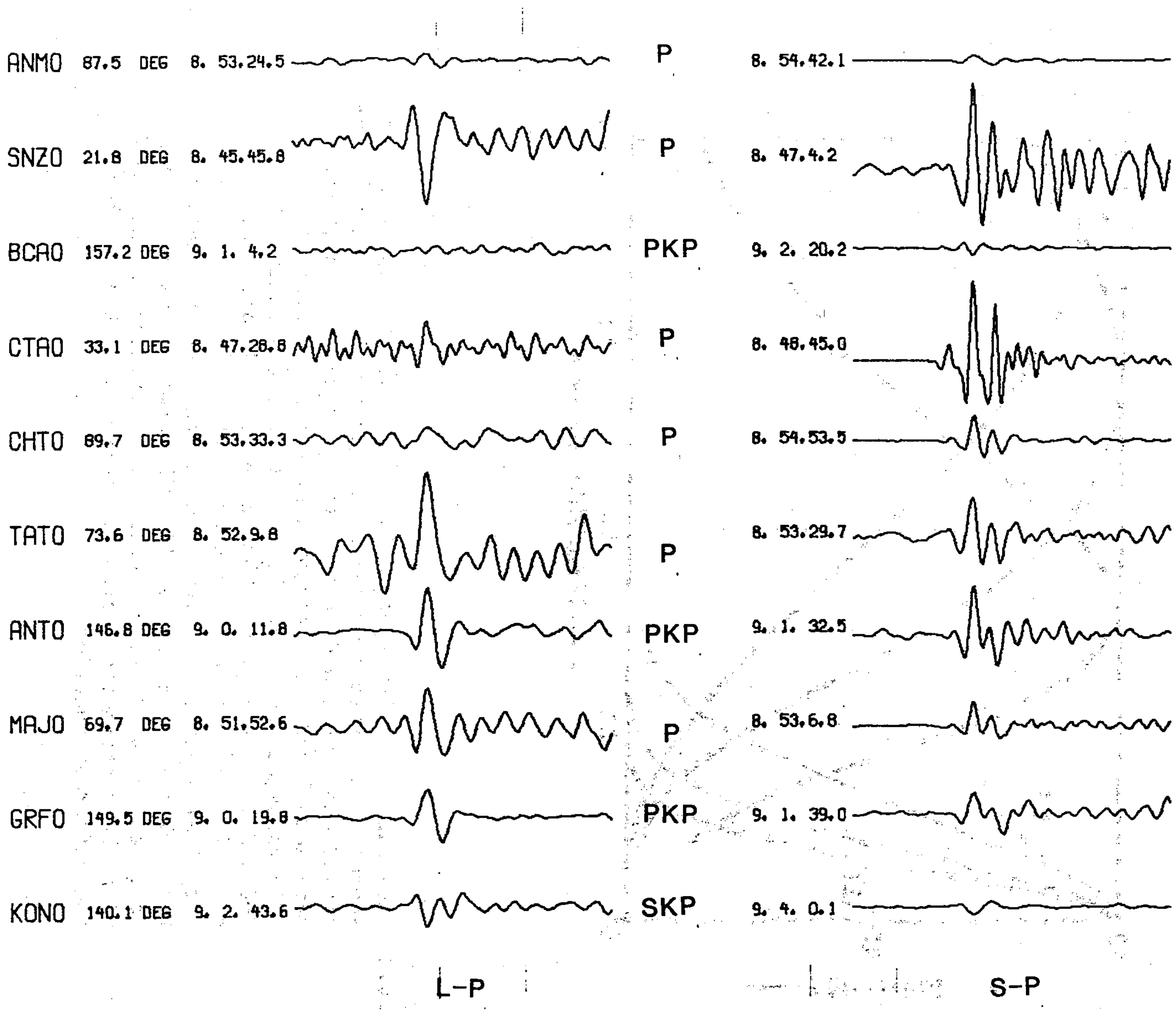


Fig. VI.4.1 SRO and ASRO records from Fiji Islands events (see Table VI.4.1 for details) with vertical components of P, PKP or SKP. Different amplitude scale for long- and short-period sections. Long-period record length is 4 minutes, short-period record length is 12 seconds.

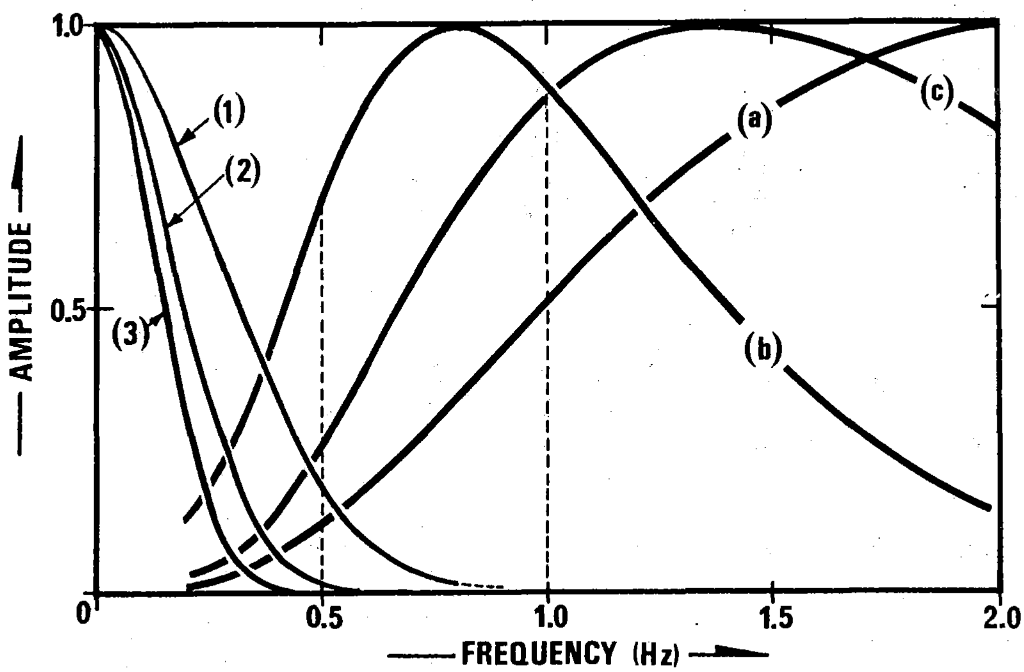


Fig. VI.4.2 Gaussian excitation spectra (1), (2), (3), for spatial point source with finite temporal moment obtained by fitting long-period amplitudes and short-period energy. (1): short-period bandwidth 0.5-2.0 Hz, temporal moment $F_{\tau\tau} = 0.33\ s^2$; (2): bandwidth 0-1.0 Hz, $F_{\tau\tau} = 0.82\ s^2$; (3) bandwidth 0-0.5 Hz, $F_{\tau\tau} = 1.47\ s^2$. The curve (a) indicates the digital short-period SRO response, (b) and (c) indicate a typical Green's function in a standard earth model, for P at teleseismic distance. (b) PREM Q-model (used with the long-period data), (c) Q-model from Archambeau et al (used with the short-period data). Different amplitude scales for the different functions.

VI.5 The Global Digital Seismograph Network software package

Introduction

The Global Digital Seismograph Network (GDSN) is now in full operation providing seismic waveform data from SRO, ASRO and DWWSSN stations. It is described in a number of articles including Peterson et al (1976) and Zibres and Buland (1981), and it is the subject of a new Newsletter published by the USGS.

A comprehensive software package is written and dispatched to various seismological agencies to read data tapes generated at the GDSN stations (Zibres and Buland, 1981). The aim of this report is to suggest new extensions to the package such that it can incorporate seismologists' requests directly and reduce the volume of unnecessary data tapes that should be dispatched to individual users.

The Zibres and Buland package, called the Network-Day Tape Software (NDTS), is thus modified into a new one called GDSN software package hereafter. The GDSN package is prepared to operate in much the same way as NDTS but to include many additional options not considered in the latter.

The GDSN software package is described in the next section where a flowchart diagram (Fig. VI.5.1) is used to demonstrate how it is linked to the NDTS. A useful option in the GDSN is its Help Manager, a subroutine which can be accessed by users and helps them to understand and operate the package. The Help Manager is given in Appendix VI.5.1. A practical GDSN users' guide mainly for the NORSAR installation is given in Appendix VI.5.2.

The GDSN software package

The aim of both NDTS and GDSN software packages is mainly to read the seismic waveform data from data tapes, reformat and copy to disk files for further processing. Therefore, most tasks require two steps: In the first step the waveform data are transformed from data tapes to disk files, and in the second step the disk files are used to process the retrieved data. Although both software packages are essentially written to do the first step, they provide options for the second step too.

The NDTS provides all necessary subroutines for using the GDSN data tapes, a complete collection of which is available only in a few places such as the USGS in the US and the NORSAR data processing center in Norway. The potential users normally require a large number of data tapes which must be sent to them, a slow and expensive process. An alternative is to provide the users with all waveform data they want and according to their specifications ideally on one or two tapes. The GDSN software package provides all the additional subroutines to do this service. It is therefore most useful in the main data centers with complete data tape libraries.

The GDSN package is based on the idea that by the time the data tapes are available at the main data centers, the hypocenter information is also available for the same data. To demonstrate the operation procedure of the GDSN software package, let us now consider a typical user request.

Long period P waveform data for all events that occurred within a certain time period (say 1975 to 1982), within a certain magnitude range (say 5.5 to 7.0) from all GDSN stations within a certain distance range (say 20 to 90°) are requested.

At a main data center first the USGS or ISC hypocenter information files are searched for all events that satisfy the above request, and an EVENT DATA file is assembled. Then the GDSN software package is asked to take this file, retrieve the waveform data and file on disk (or tape). The end result contains both hypocenter information and waveform data, can be put on one or two tapes for say 100 events at 30 stations each and dispatched to the users.

Steps in the GDSN software package for doing this or similar tasks are shown in the flowchart diagram in Fig. VI.5.1 and are described below

Step 0 - Initialize the GDSN software package by giving an event number from the EVENT DATA file to start with, the number of runs (i.e., number of events to do) and an initialization token.

Step 1 - Enter a program called MAKIN, and make an input file for the NDTS according to specified selection options decided by the user's request (MAKIN uses JB travel time tables to find approximate P wave arrival time for each event-station set up). If waveform data are not requested, this step will be bypassed.

Step 2 - Enter a program called GSET, decide a route in the NDTS corresponding to the given request, name disk output files and request the GDSN data tape for the current event to be mounted on the system. At this stage it is possible to enter the Help Manager and obtain information on the features of the GDSN software package.

Step 3 - Enter a program called GTAPE, and enter the correct subroutine in the NDTS according to the route decided in step 2.

Step 4 - If waveform data are retrieved, enter a program called CATLG and catalog the event number.

Step 5 - Enter a program called GDSNDP and plot the waveform data for all the stations for this event.

At this stage, one event is completed and the package loops for more events (if requested) and repeats steps 1-5. From this stage until the end of the run the package uses selection options and parameters decided in steps 1 and 2, and halts only to request for a new GDSN data tape to be mounted on the system.

At the end of the run all waveform data files for all of the event-station sets are completed and may be transferred to tapes and dispatched to the users.

The disk I/O routes are managed in an independent step in the GDSN package. A FORTRAN program reads an event from the EVENT DATA file and assembles files specifications from the origin time of the event. This naming scheme is applied only to those files that are to be used in every task, and all other files normally required by the NDTS are routed to a dummy file which is deleted at the end of the run. This is important in view of the fact that NDTS requires seven waveform data files and one identification file for each event, while in most practical tasks only a fraction of these files are actually used (only 2 files are needed to retrieve short period component waveform data).

It has to be emphasized that all original features of NDTS are preserved in the GDSN, and besides some installation-dependent modifications, the only other modification is to make the four main commands of NDTS (see Zibres and Buland, 1981) operate like subroutines.

An additional facility available in the GDSN package is a disk-oriented routine to analyze events after the waveform data is copied to disk files. It is a general purpose FORTRAN program that can be adapted to individual users' problems with little effort. It also operates through the user's EVENT DATA file and uses the same file specification manager as the main package.

In summary, the GDSN software package covers all the features of the NDTS but also includes the following new features:

a) It uses the entire NDTS in its original form except for the necessary modification required by the local installation. Thus, it can easily accommodate new and updated versions of the NDTS.

b) Since the exact waveform windows are calculated, considerable saving is achieved in the disk or tape space used by the waveform data files.

c) The hypocenter information is included in the identification file which is created for every event. Therefore, for the next stages of processing both waveform data and hypocentral data are available for every event.

d) Using an installation-independent disk I/O manager, the user need not do any bookkeeping on files, etc. An EVENT DATA file is all that is needed. To process each event after waveform data are copied to disk files, the user enters only the event number from his EVENT DATA file and starts processing.

e) The GDSN package is transportable and can be easily adapted to most computer installations.

It is hoped that these new and practical modifications encourage more use of the GDSN data, and that the suggested modifications be installed at the main data centers that distribute the GDSN data tapes.

I. Asudeh

<u>References</u>

Peterson, J., H.M. Butler, L.G. Holocomb & C.R. Hutt (1976): The seismic research observatory, Bull. Seism. Soc. Am. 66, 2049-2068.

Zibres, M. & R. Buland (1981): Network-Day Software Users Guide, USGS Open-File Report 81-666.

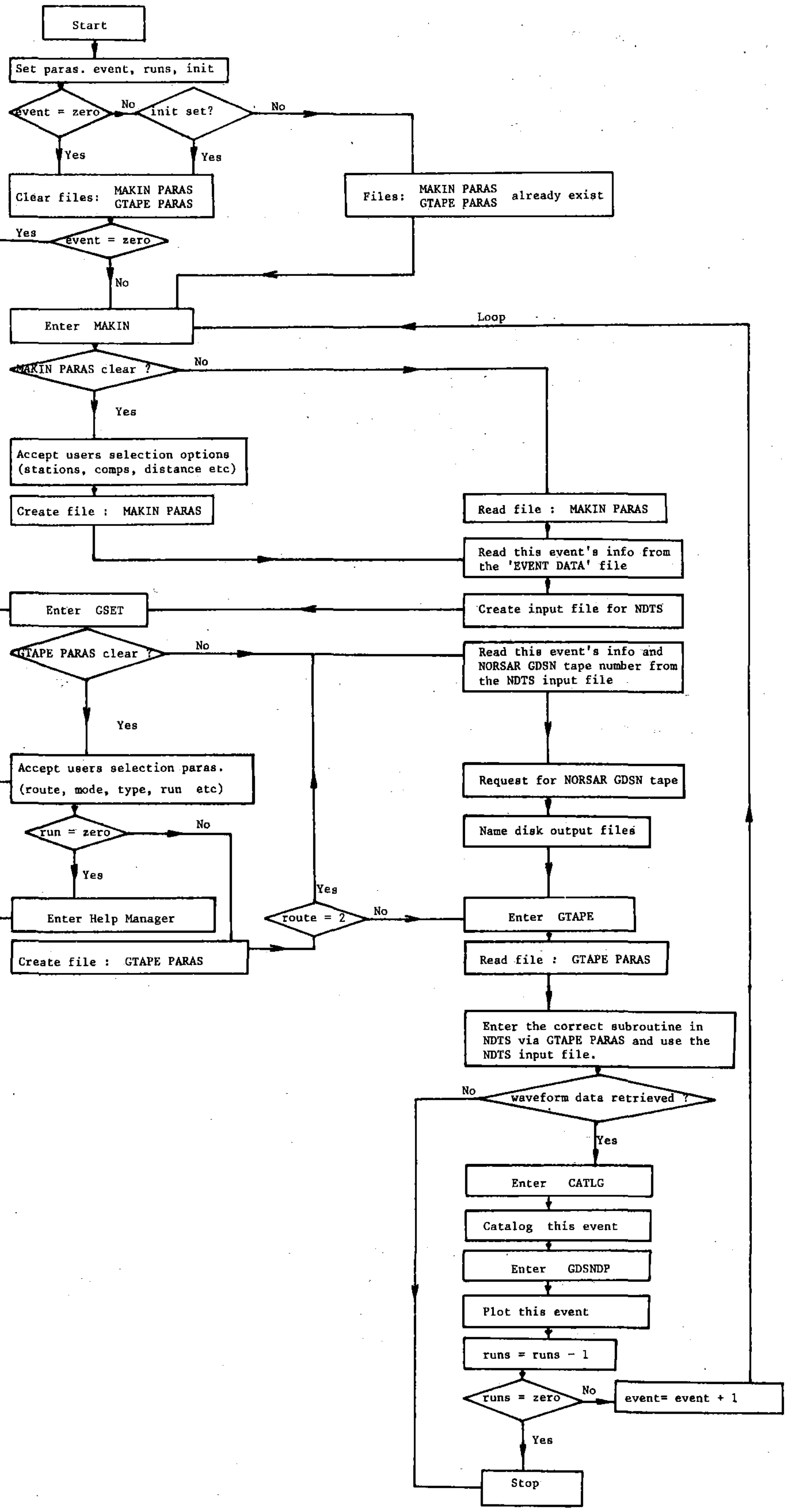

Start
Set paras. event, runs, init
event = zero
No
init set?
No
Yes
Yes
Clear files: MAKIN PARAS GTAPE PARAS
Files: MAKIN PARAS GTAPE PARAS already exist
Yes
event = zero
No
Enter MAKIN
Loop
MAKIN PARAS clear ?
No
Yes
Accept users selection options (stations, comps, distance etc)
Create file : MAKIN PARAS
Read file : MAKIN PARAS
Read this event's info from the 'EVENT DATA' file
Enter GSET
Create input file for NDTS
GTAPE PARAS clear ?
No
Read this event's info and NORSAR GDSN tape number from the NDTS input file
Yes
Accept users selection paras. (route, mode, type, run etc)
Request for NORSAR GDSN tape
run = zero
No
Name disk output files
Yes
Yes
Enter Help Manager
route = 2
No
Enter GTAPE
Create file : GTAPE PARAS
Read file : GTAPE PARAS
Enter the correct subroutine in NDTS via GTAPE PARAS and use the NDTS input file.
No
waveform data retrieved ?
Yes
Enter CATLG
Catalog this event
Enter GDSNDP
Plot this event
runs = runs - 1
runs = zero
No
event= event + 1
Yes
Stop

Fig. VI.5.1

Appendix VI.5.1 - The GDSN Help Manager

At the initial step of the GDSN software package, the user receives help to tailor an initialization set up for his task. Furthermore, the user may also enter the GDSN Help Manager to get additional information on all aspects of the GDSN. Once entered the Help Manager, part or all of the following information will be displayed at the user's terminal:

```
I CAN HELP YOU ON THE FOLLOWING ITEMS:
GDSN               What is GDSN ?
ROUTe              Want data log summaries or waveform data ?
MODE               Is your data tape recorded after 1.1.1980 ?
TYPE               Do you have Network-Day or Single tape ?
RUN                How do you run the package ?
TAPEs              What is a GDSN tape ?
FILEs              How do you name your Disk output files ?
INTEractive run    If you are BEGINNER !
PRODuction run     If you want the package to do it for you.
EXECs              How is the package executed ?
ALL                If you want all of the above.
QUIT               If you want to get out of HELP.

SELECT ONE:
```

If you select ALL, all information in the Help Manager shown below will be displayed at your terminal.

```
   GDSN                                      HELP MANAGER

   Global Digital Seismograph Network (GDSN) Help Manager

  A comprehensive software package is developed by USGS to
read the data tapes produced at SRO, ASRO and DWWSSN stations.
This packages reads both Signle station and Network-Day tapes
and is called Network-Day Tape Software (NTDS).
(see Zibres and Buland, USGS open file report 81-666.)
  The NORSAR adaptation of NDTS is called GDSN software package
and this Help Manager provides a quick guide for using it.
It explains the package switches ROUTE, MODE, TYPE and RUN
as well as TAPE and FILE formats and suggested procedures
for running the package.
  Additional documentation on GDSN package is given in the file
GDSN MEMO.

P.S. You entered GTAPE at your terminal to run the package!
```

ROUTe HELP MANAGER

The ROUTE switch directs the GDSN package into two main routes. ROUTE can be either 1 or 2.
If ROUTE is 1, the package reads and files out the data log summaries from a GDSN tape without actually retrieving waveform data. This route is useful when you want to know just what is on the tape, e.g. which stations are present and their data coverage etc. Only one output file called GTAPE OUTPUT is created.
If ROUTE is 2, the package retrieves waveform data from a GDSN tape, and many output files are created (see FILEs).

MODE HELP MANAGER

The MODE switch informs the package of the data tape mode. It is either 1 or 2 depending on the data recording date.
MODE is 1 for GDSN tapes containing data originally recorded before 1.1.1980.
MODE is 2 for GDSN tapes containing data originally recorded after 1.1.1980.

TYPE HELP MANAGER

The TYPE switch indicates the type of data tape being read. It is either 1 or 2.
TYPE is 1 for data tapes made from continuous running of a Single station (e.g. Bergen DWWSSN data tapes coming direct from Bergen).
TYPE is 2 for the Network-Day tapes coming from the U.S.

RUN HELP MANAGER

The RUN switch controles the way the package is run.
It can be 1, 2 or 0.
If RUN is 1 the request lines for data retrievals are read from the terminal and the user decides names for waveform data files, this mode of the run is called INTERACTIVE RUN option.

*** INTERACTIVE RUN OPTION IS USEFUL FOR BEGINNERS !***

If RUN is 2 the request lines for data retrievals are read from a file called GTAPE INPUT A which is usually made by program MAKIN. In this case the waveform data files are named by the package, this mode of run is called PRODUCTION RUN option.
(see also FILES in this Help Manager).
N.B. If RUN is 0 this Help Manager is called.

The GDSN package reads commands and instructions from Unit 5 and writes the standard output file to Unit 6. If waveform data are retrieved, 7 extra output files are also generated. These are as follows:

Filename	Filetype	Filemode	Unit	Comments
?******	SZ****	?	1	SPZ component
?******	LZ****	?	2	LPZ component
?******	LN****	?	3	LPN component
?******	LE****	?	4	LPE component
?******	IZ****	?	7	IPZ component
?******	IN****	?	8	IPN component
?******	IE****	?	9	IPE component

where the fixed Filetype prefixes (SZ, LZ, ...) are used to indicate different components, the (?) show the position of the Filename prefix and Filemode determined by the user. The rest of the file specifications (denoted by *) are determined either by the user (INTERACTIVE RUN) or by the package (PRODUCTION RUN). So the user is free to choose any name to replace the (*) if he is in the INTERACTIVE RUN, for example a file like XTEST LNTEST A is acceptable.

But if the user is in the PRODUCTION RUN mode, the package will fill the (*) in the file specification with Origin time of the event for which data retrieval is attempted. So, the Origin time of the event in question must be given as input to the package. This is done by starting with a program called MAKIN. MAKIN will ask the user what stations he wants and what type of waveform should be read, etc. Then it makes input lines which are 160 characters long. The first 80 characters are standard request lines and the next 80 contain ISC hypocentral information as well as distance and azimuth to each station and the NORSAR tape number. In PRODUCTION RUN an example of a waveform data file is S811224 LZ2236 B, which is LPZ component for an event origin time of 1981 Dec. 24 at 22:36 GMT, and belongs to project S, and is on disk B.

Note that some of these 7 files are not actually used in most runs though they should be defined as shown above. So, they are all assigned to a file called GTAPE DUMMY A and are deleted at the end of each run.

The way the package operates require a few steps in the EXEC command and some DUMMY files are used to link various steps. It is advisable not to change any of the file names in the EXEC unless you are familiar with the package.

TAPEs HELP MANAGER

A GDSN data tape contains digitally recorded seismic data from SRO, ASRO and DWWSSN stations.
The GDSN package is designed to read such tapes. If you are running the package in the INTERACTIVE mode your data tape should be mounted by now (or mount it just now!).
In the PRODUCTION RUN mode provided you use program MAKIN to make your input file, the package will tell you which NORSAR tape to mount before starting the run.

INTEractive run HELP MANAGER

A useful policy in running GDSN package is to run it in INTERACTIVE RUN first to get used to its functions. This option is explained below.

STEPS IN RUNNING GDSN PACKAGE IN INTERACTIVE RUN OPTION

a) Choose your GDSN tape and load it on the IBM.

b) Enter the following line at your terminal:
GTAPE
The package will assume an INTERACTIVE RUN mode, so remember to set the RUN switch to 1 when you are asked.

PRODuction run HELP MANAGER

Once you are familiar with the GDSN package by practicing a few INTERACTIVE RUNs, you may wish to retrieve your waveform data using the PRODUCTION RUN option as suggested below.

STEPS IN RUNNING GDSN PACKAGE IN PRODUCTION RUN OPTION

a) Make an EVENT DATA file (at NORSAR this is done by running the package MERGE).
b) This EVENT DATA file is essential for the next step and the index of each event on this file (i.e. the line number of each event) is used to identify each event.

c) Enter the following line at your terminal :
GTAPE EVENT RUNS INIT
in which EVENT is the event index, RUNS is the number of events to do starting from EVENT, and INIT is a switch indicating you are at the start of the run.

The main EXEC command which operates the GDSN package is GTAPE

GTAPE has the following forms:

```
a)    GTAPE                          for INTERACTIVE RUN mode
b)    GTAPE  event runs init         for PRODUCTION RUN mode
c)    GTAPE  event runs              for PRODUCTION RUN mode
where :
      event          is the event number to start with
      runs           is the number of events to read
      init           to indicate you are starting the run.
```

Appendix VI.5.2 - A practical users' guide to the GDSN software package

This section is intended for NORSAR only and it is assumed that the users are familiar with the NORSAR IBM 370 installation.

Note that GDSN needs at least 2M storage and uses VSLIB. So, set the storage to 2M and take the following steps:

1. Link to user 'GDSN SRO', and take a copy of the following files:

   GTAPEE EXEC
   GPLOTE EXEC
   GDISKE EXEC
   GDSN EXEC
   DATA EXEC
   DATAR EXEC
   GDISK FORTRAN
   GDSNDR FORTRAN

   Rename the first three files for your own use as follows:

   GTAPE EXEC
   GPLOT EXEC
   GDISK EXEC

   but keep the last five files in their original names.

2. Enter the following line at your terminal:

   GTAPE

   and enter the Help Manager if you wish. Make yourself familiar with the package features. Then exit the package in any way you can.

3. Prepare a list of events for which you seek waveform data. This list must contain hypocentral information for your events in the following (self-explanatory) format:

   1981 SEP 2 NAO 92452.0 36.800N 140.600E 33 5.5

   and must be called 'EVENT DATA'.

4. Decide a one letter code called Filename prefix to identify your project, etc., and also decide a one letter code called Filemode for your virtual disk intended for waveform data. Say 'X' for the former and 'A' for the latter. Remember you can write on other users' files if the codes you select have already been used.

5. Suppose you wish to do 5 events starting from the first event on the EVENT DATA file. Enter the following line at your terminal:

   GTAPE 1 5 init

   and respond to package questions for your initialization set up. The package will then ask you to mount the first data tape by giving the NORSAR tape number. Your waveform data for the first event will be retrieved and plotted before you are asked for the next data tape and so on.

   Note that the key 'init' in the above command is for the initial run only. So, if you wish to do another 10 events starting from event 6, you only need to enter the following line:

   GTAPE 6 10

   and your original initialization set up is preserved for you.

6. You may use command GPLOT to make another set of plots for your waveform data. If you want to replot event 1, your Filename prefix is 'X', your Filemode identifier is 'A' and you have already retrieved LP data, then enter the following line at your terminal:

   GPLOT 1 X A LP

7. You may use command GDISK instead of GPLOT to use the program GDISK which you may wish to modify for your own use. The syntax of this command for the same example as in (6) above is:

   GDISK 1 X A LP

The FORTRAN programs GDISK and GDSNDR are the only ones you may need to modify for your own use. You will have to modify GDISK to branch to your own subroutines for data processing but modify GDSNDR only if you need instrument response information as well. Both GDSNDR and GDISK are well commented.