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ESTABLISHMENT OF DATA BASE OF REGIONAL SEISMIC RECORDINGS FROM EARTHQUAKES, CHEMICAL EXPLOSIONS AND NUCLEAR EXPLOSIONS IN THE FORMER SOVIET UNION

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R E P O R T

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ANNOTATION.

In this report results of work on establishment of a data base of regional seismic recordings from earthquakes, chemical explosions and nuclear explosions in the former Soviet Union are described. This work was carried out in the Complex Seismological Expedition (CSE) of the Joint Institute of Physics of the Earth (JIPE) of the Russian Academy of Sciences according to an agreement between the JIPE and Lawrence Livermore National Laboratory (University of California, USA).

The recording system, methods of investigations and primary data processing are described in detail.

The largest number of digital records was received by the permanent seismic station Talgar, situated in the northern Tien Shan, 20 km to the east of Almaty city. More than half of the records are seismograms of underground nuclear explosions and chemical explosions. The nuclear explosions were recorded mainly from the Semipalatinsk test site. In addition, records of the explosions from the Chinese test site Lop Nor and industrial nuclear explosions from the West Siberia region were obtained.

Four records of strong chemical explosions were picked out (two of them have been produced at the Semipalatinsk test site and two - in Uzbekistan). We also obtained 16 records of crustal earthquakes, mainly from the Altai region, close to the Semipalatinsk test site, and also from the West China region, close to the Lop Nor test site. In

addition, a small number of records of earthquakes and underground nuclear explosions, received by arrays of temporary stations, that have been working in the southern Kazakhstan region are included in this report.

Parameters of the digital seismograms and file structure are described.

In the end of the report possible directions of future work on the digitizing of an unique data archive, which have been accumulated in the CSE, are discussed.

CONTENTS

INTRODUCTION.

The Talgar subdivision of the Complex Seismological Expedition (CSE) of the Joint Institute of Physics of the Earth (JIPE) of the Russian Academy of Sciences was organized in 1960. The main focus of the CSE work was the study of local seismicity, including induced seismicity, investigations of the Earth structure, development of methods for detailed seismic zoning and mineral prospecting, study of the nature of seismic wave fields, and finally, the monitoring of nuclear explosions.

Special networks of seismic stations were installed to carry out this geophysical research. The most important results were obtained during the monitoring of the underground nuclear explosions that occured in the CSE since 1969. Until 1991 the CSE installed more than one hundred highly-sensitive seismic stations in various regions of the former Soviet Union. These stations were set up as part of a special project to identify uniquely sensitive locations for the monitoring nuclear explosions. Most of these were temporary stations - not part of the regular national seismic network. Most of these stations consisted of 1 3-component short-period set from 1 to 10 Hz and 1 vertical high-magnification channel centered at 1 Hz. Narrow-band channels had very high gain - in some cases more than 1 million. Recording was usually with a pen-ink system. Most stations operated for 1 to 2 years.

In the CSE an apparatus of magnetic recording (analog and digital) was also used, although to a much smaller extent. Also, investigations with temporary small-aperture arrays have been carried out in some regions.

Because of the use of highly sensitive seismic stations a huge amount of experimental material has been accumulated, allowing the solution of various geophysical problems.

It is necessary to note that the seismograms are kept in Talgar in an analog form - either on photographic and usual paper, or on magnetic tapes. Due to this there is an urgent need to preserve this material and convert it to a digital form. For this reason Lawrence Livermore National Laboratory (University of California, USA) concluded this contract with the JIPE.

A major goal of this work is the establishment of a data base of regional seismic recordings from earthquakes, chemical, and nuclear explosions in the former Soviet Union.

This report details the results of the work to convert into digital form a relatively small part of the seismogram archives of the CSE, which have been kept on magnetic tapes.

The report consists of an introduction, 3 main parts, and conclusions. In the first part of the report we describe the apparatus used. In the second part we consider observation systems, including the seismic station Talgar, from which the largest volume of data has been obtained, and also small seismic arrays, which have been installed in southern Kazakhstan. The third part is devoted to a description of the digital data archives, which are appended to this report.

Floppy-disks which contain the text of the report in English and digital seismograms are included with the report.

The report is 108 pages, including 40 pages of text, 57 figures and 11 tables.

The following CSE employees took part in this work:

Kopnichev Yu.F.-professor and director of the CSE.

Kunakov V.G.- senior scientist.

Rakhmatullin M.Kh.-leading scientist.

Sokolova I.N.-junior scientist.

Vybornyy Zh.I.-engineer.

Ermolenko N.A.-engineer.

Kunakova O.K.-engineer.

Zhernokleva T.A., Linnik V.V. and Starchenko S.G. took part in the production of this report.

1. APPARATUS, METHODS OF INVESTIGATION AND PRIMARY PROCESSING.

In this report results of the work on the creation of the digital data base, obtained by a magnetic recording system are described. Below we will consider mainly the data recorded by the Talgar station, which is located in the northern Tien Shan region 20 km to the east of Almaty city, and also a small volume of data recorded by arrays of temporary stations that have been installed in the Muyunkum desert and in the Ili river area (both - in southern Kazakhstan, see Fig.1.1).

1.1. Apparatus used.

Recording of the seismic data, presented in this report, has been carried out by the following standart sets of devices:

1) By apparatus consisting of stations of the magnetic recording system ASS-6/12 or ASS-3/12, playback system VSS-6 and seismic information input system AVSI, or playback system VSS-3/6.

2) By the set of telemetered stations RTSS, consisting of 12 field units, sending the information through radiochannels or wires, and recording center on magnetic tapes (stations ASS-6/12).

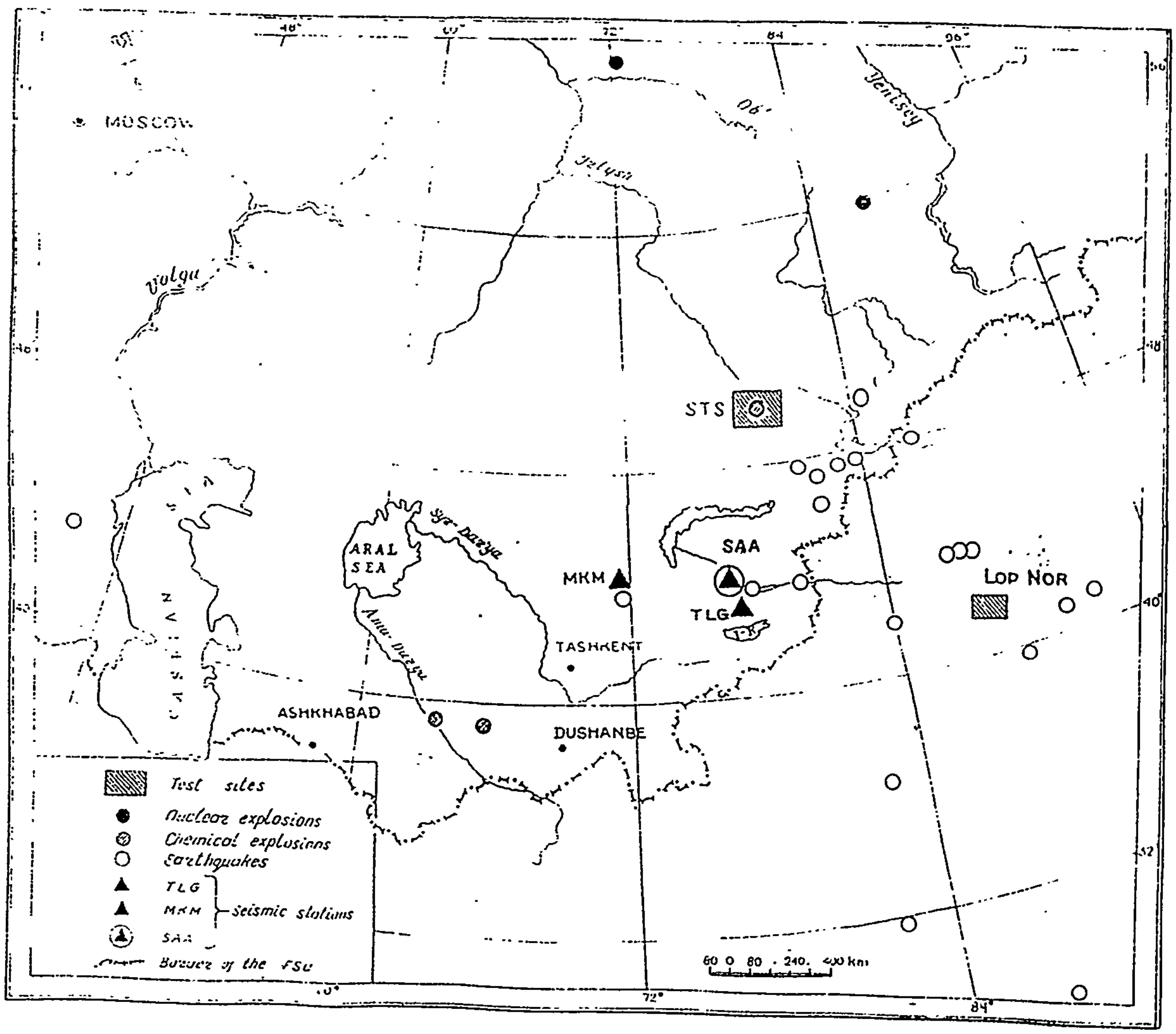


Fig. 1.1. Location of the stations, epicenters of underground nuclear explosions, chemical explosions and earthquakes.

Our experience with this work has shown that these stations have technical parameters that are stable in time, easy to use and mobile and reliable in operating. This allows quick installation of seismic arrays and obtaining high-quality digital records when carrying out the field observations.

3) By the software operated seismic system PUSK-2, functioning in a triggered regime. An original algorithm of the information receiving is used in this set, which allows the dynamic range of the signals recorded to be enlarged considerably.

Below the main characteristics of the devices used are described.

1.2. Magnetic Recording System.

1.2.1. Magnetic recording station ASS-6/12.

The automated seismic station ASS-6/12 [Brulev et al., 1980] is intended for long-term permanent recording the seismic information together with time code on magnetic tape. The mode of information recording is a direct analog record with a high-frequency bias. The usual number of channels of the magnetic record is 16. The station permits two regimes of the recording: for 6 seismic channels (when recording at two amplitude levels, which gives a dynamic range of 70 dB) or for 12 channels (when recording at a dynamic range of 40 dB). The station allows recording at one of three speeds of tape movement: 0.5, 1 and 2 mm/sec , which permits a frequency range of the seismic channels (0.5-16) Hz, (0.5-32) Hz and (0.5-64) Hz respectively. Power is provided by 12 V rechargable batteries.

The station consists of a tape recorder unit, an amplifier unit, a control unit and seismometers. The amplifier unit includes 12 idenfical amplifiers for the seismic record and an attenuation circuit for the input signal and a choice of a recording regime (if necessary). The magnetic tape recorder unit includes the tape drive mechanism, quartz clocks, a former of the bias signal and a calibration oscillator (2 Hz sinusoidal signal, which is fed three times a day into the auxiliary coils of the seismometers). The control unit, intended for real-time verification of the station operation, consists of a reference quartz clock, a control circuit and direction of the clocks of the recording station and a circuit of the verification of the seismic and auxiliary channel operation. Note that the reference quartz clocks are started by timing signals and allows estimation of the accuracy of the quartz clocks at the recording station to within 0.001 sec.

Each recording station includes SM-3 (three-component) seismometers with a natural period of 2.0 sec.

During station operation, seismic signals from the seismometers go to amplifiers inputs through the attenuator. From the amplifier output, signals go to the 12 magnetic heads of the magnetic recording unit in such a manner that seismic signals of one amplitude level or signals from channels from 1 to 6 (in the regime of 12-channel recording) are recorded using one unit. The seismic signals of a second amplitude level or signals from channels 7 to 12 (in the regime of 12-channel recording) are recorded using the 6 magnetic heads of the second unit. The time code and reference frequency are recorded on the last 4 channels of the head unit.

1.2.2. Playback system VSS-6.

The VSS-6 system is the laboratory part of the instrument set. It is intended for transformation of the information recorded on the magnetic tapes by the ASS-6/12 stations into oscillograms (on photographic paper) or into the digital form using the AVSI-6 device.

The playback system includes a tape-recorder, a processing rack, and a light-based oscillograph. During playback the signals recorded on the tape with one of the magnetic head units (6 seismic and 2 auxiliary channels) are reproduced simultaneously. Thus, station VSS-6 carries out the successive signal reproduction: first one amplitude level, then the other or first channels 1 to 6, then 7 to 12, when operating in the 12-channel recording regime. Seismic signals selected in such a manner go from the tape recorder to inputs of six amplifiers at the processing rack. From the amplifier outputs for each of the signals are branched to the inputs of three filters of upper and lower frequencies and one final amplifier. The last circuit forms a broad-band (without filtering) channel. From the filter, output signals also go to the final amplifiers and later to galvanometers of the oscillograph for recording on photographic paper. From the final amplifiers the signals also go to inputs of an analog-to-digital converter (DTD) of the apparatus AVSI-6. It is possible to obtain seismic information from the output of the VSS-6 device either in broad-band, or after filtering.

Signals of timing frequency (10 KHz) are also obtained from the processing rack. A divisor of the timing frequency (to 2, 4, 8 and 16 times) is part of in circuit. This ensures a choice of an optimal sampling frequency. The next modification of the playback system VSS-3/6 has such the characteristics. Through amplitude-frequency characteristics of the signals presented are shown in Fig. 1.2. Curve 1 corresponds to the signals of the ASS in the period of 1982-1984, and curve 2, to the signals in the period of 1986-1988.

1.2.3. Seismic information input system AVSI-6.

The seismic information input system AVSI-6 is intended for transformation of information coming from the station VSS-6 into digital form in ES format and for recording of the digital signal on a standard magnetic tape storage (NML) in automated regime. The AVSI-6 system consists of an analog-to-digital converter (UTP) and data-formating device UFIN-1024 for recording on the NML. When reproducing the

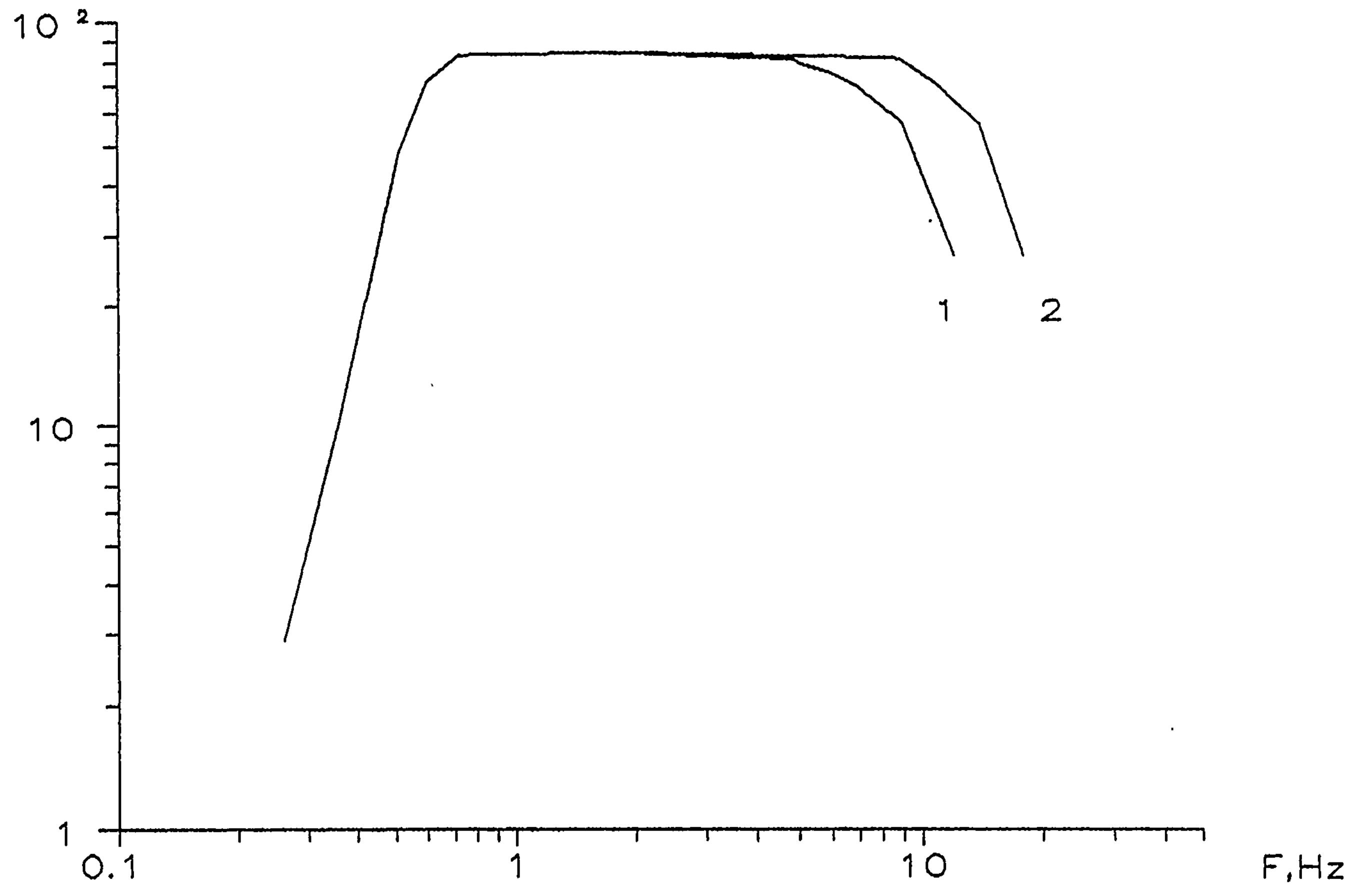


Fig. 1.2 Frequency responces of the stations ASS 6/12 (1) and ASS 3/12 (2).

seismic information an analog-digital signal transformation up to 9 ranks for 6 channels is carried out. The result of the transformation, together with auxiliary information, is stored in the memory of the UTP. To control the conversion the data are read from an operative memory device (OZU).

The data are then transformed into analog form and can be seen on an oscilloscope screen. The system receives the information stored in the memory and sends it to the device UFIN-1024 through an interface line. Here 1 Kbyte segments with byte word length are formed; the seismic information is then recorded in the NML. The auxiliary information is recorded by a separate segment with 1 Kbyte length. The OZU permits recording and reading of 8 Kbytes of 2-byte numbers for each channel.

Special attention was paid to the quality of the digital data. When recording on the NML the time code information is written to the least-significant bit of the most significant byte. In subsequent computer processing an analysis of this time code is carried out and also the stability of the reference-frequency and the accuracy of the start time of the digital record can be estimated .

The structure of an archived digital tape created with the AVSI-6 system is described below.

For processing convenience an 80-bytes segment in ASCII format is written at the beginning of the each file. Information is input from a keyboard of the device UFIN-1024; it includes data on a position of switches "attenuation" of the playback system VSS-6, data from earthquake catalogs, some auxiliary information. After this 1-Kbyte segment from OZU UTP, including data on the time of the beginning of the digitization(year, month, day, hour, minute, second), and also information on the data recording rate and playback, the sampling frequency and on which channels (1-6 or 7-12) were recorded.

The digital signal is recorded successively in 1-Kbyte segments (6 seismic channels and 8 Kbytes numbers for the each channel). Each file is ended by EOF. Later the digital records are introduced into the IBM PC (through the computer ES-1040). Part of the information was digitized on the device VSS-3/6 , which is a modified version of the complex VSS-6-AVSI. At the station VSS-3/6 the records after digitization are input directly to the IBM PC.

1.3. Telemetered station RTS-AN.

Telemetered system RTS-AN [Radiotelemetric..., 1990] is intended for continuous recording seismic data. The system consists of two parts: twelve 3-component field units and a central recording station (CRP). Communication between the field units and the central station is accomplished through radiochannels operating in the UHF - range, or through wires at short distances. The information is gathered in analog form permanently on the magnetic tape (standard tape recorders of the ASS-6/12 system).

Thus, in this case the seismic data is quite similar to the records obtained by the ASS system.

The following are the general technical characteristics of the RTS-AN system:

1. Number of field points (FP).......................12
2. Mode of the seismic information transformation - frequency modulation (FM).
3. Mode of radio-telemetry transmission...........FM-FM
4. Number of radiochannels transmitted from each FP to CRP...1
5. Number of seismic channels at each FP...........1-3
6. Number of seismic channels of CRP system.........36
7. Mode of the data collection - continuously in analog form on magnetic tape by ASS-6/12 recorders.
8. Speed of the magnetic tape drive.........2.0 mm/sec.
9. Dynamic range of the seismic channels:
   without magnetic recording..........at least 54 dB
   with magnetic recording.............at least 42 dB
10. Noise level at input .... not more than 1 µV
11. Frequency range of the seismic channels
    at the 1 dB level.......................0.5-32 Hz
12. Range of operating temperature FP......-30^{o}±50^{o} C
13. For timing reference clocks, mounted in the magnetic recorder units of the ASS-6/12 system are used.
14. Timing error for 10 days is not more than 100 msec.
15. Power, consumed by device FP
    without transmitter................less than 1.2 W,
    with transmitter...................less than 2.0 W,
16. Data recorded can be reproduced either on

oscillograph, or in digital form. For this purpose the playback system VSS-6 is used.

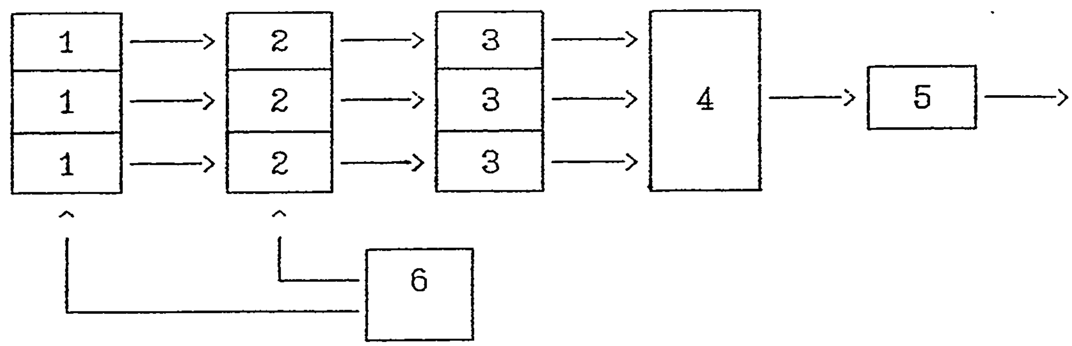
A functional circuit of the RTS-AN system is shown in Fig. 1.3. A field point (FP) includes one or three SM-3 seismometers (1), whose output signals go to amplifiers (2). The amplified signals are modulated in frequency by the carrier frequency generators (3). Carrier frequencies are set at 1550 Hz, 2335 Hz, and 3100 Hz. Later signals of carrier frequencies are multiplexed by an arithmetic summation circuit(4). From the output of the summation circuit the signal goes to the low-frequency input of the transmitter (5). There is an automatic calibration unit in the field system (6). This unit sends a calibration signal into the auxiliary coil of the seismometer, once each eight hours.

The field unit can be also connected with the central recording point by wire line.

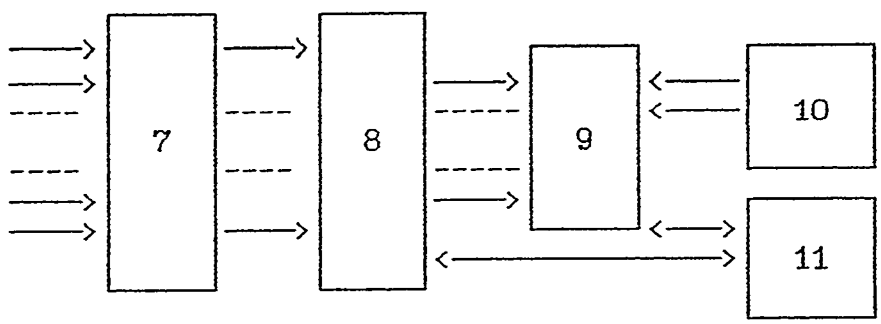
The central recording point is intended for continuous receiving of data from the field units, which is transformed into a seismic signal and recorded on magnetic tape .

The signals from the field units, received either by a receiver unit (7) or through a wire line, go to a discriminator unit (8). In this unit (8) seismic signals are separated, which are then recorded by the ASS-6/12 recording system (9) on magnetic tape.

The time "tag" of the information, recorded on the magnetic tape, is obtained from by the reference clocks (10), which are forming the time code and the reference



Remote Unit.



Data collection center.

1. Seismometers, 2. Amplifiers, 3. Modulators, 4. Summator, 5. Transmitter, 6. Calibrator, 7. Receivers unit, 8. Discriminators unit, 9. Tape recorders, 10. Master clock, 11. Control unit.

Fig. 1.3 Circuit function of the RTS-AN.

frequency.

These signals are recorded on the magnetic tape simultaneously with recording the seismic signals.

Control and regulation of groups of the central recording point is carried out with a control unit (11).

As the radiochannels the RSS1.2-01 receiver and transmitter PSS 4.1 were used.

The general specifications of devices are as follows:

RECEIVER:

Sensitivity:...................................0.5 µV

Unstability of the frequency responce.......... 1.5 dB

Typical current............................... 2.0 mA

TRANSMITTER:

Output power.................................. 0.4 W

Coefficient of nonlinear distortion.............. 3.0%

Deviation of frequency........................ 4 KHz

Typical current................................120 mA

Voltage of radiochannels....................... 12 V

1.4. Seismic station PUSK-2.

The program-controlled complex PUSK-2 is intended for measurement and recording of seismic and other geophysical signals in digital form over a broad dynamic and frequency range [Aranovich et al., 1987].

The general technical specifications of the system:

1) The number of connected seismic channels.........1-9
2) Frequency range of attenuated
   input signals, Hz.............................0.1-10

A block diagram of general units of complex PUSK-2 is shown in Fig.1.4.

The block diagram consists of:

computer "Electronica-60" (6);

magnetic tape storage - SM5300.01 (8,9);

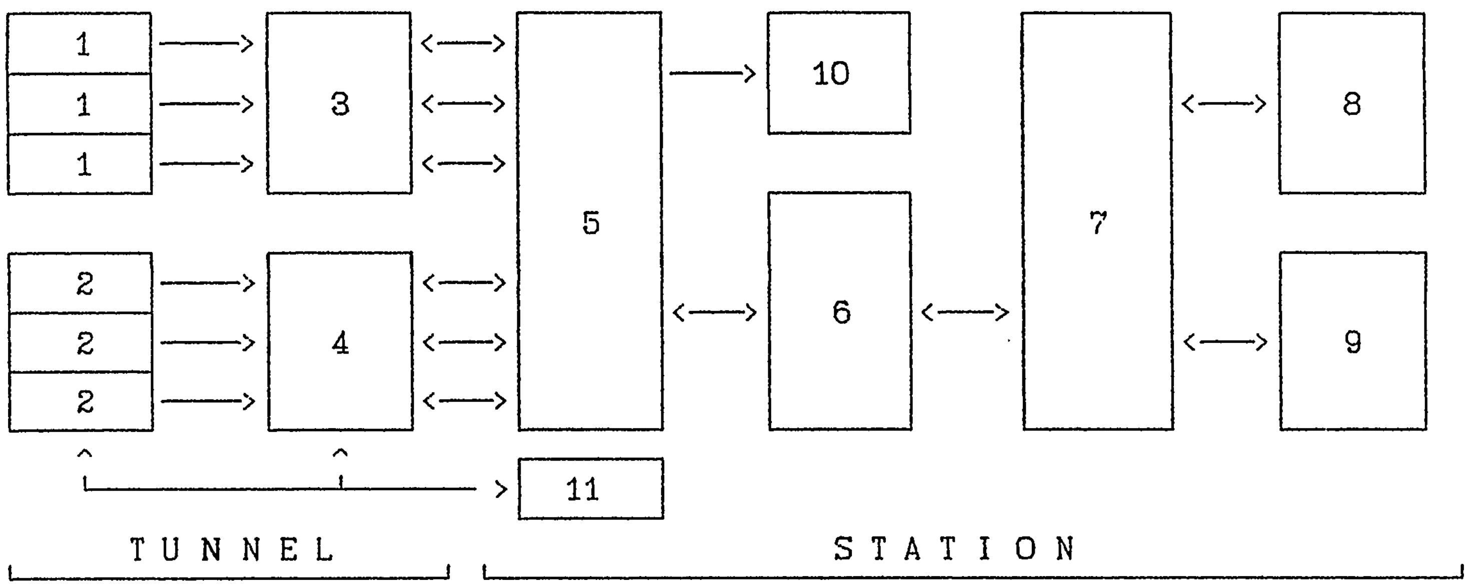
three S-5-S seismographs with high-resistance coil (2);

three SM-3 seismographs with high-resistance coil (1);

two units forming the characteristics, BFHD.01 and BFHD.02 (3,4) ;

an oscillograph measurement unit UZI-1 (5,10).

Three short-period channels with a bandwidth of 0.5-10 Hz (Fig.1.5) are used with the SM-3 seismometer, whereas three intermediate-period channels with bandwidth of 0.1-10 Hz (Fig.1.6.) are used with the S-5-S seismometer and unit BFHD.02. Both represent the velocity response. The PUSK-2 system operated in a triggered mode. The unit UZI [Digital device ..,1986] (before the beginning of the event) receives and converts continuous signals of microseismic noise , but it does not output the digital data to the PC. The data obtained are continuously analyzed. Depending on the input signal amplitude, the PC determines the coefficient of amplification of the UZI-1; this coefficient is multiplied by a number, given simultaneously by AZP and the result received is written to the core memory [Negrebetzkiy,



1. Seismometers SM-3 (short-period), 2. Seismometers S-5-S (middle-period), 3. Filter 0.5 - 10 Hz, 4. Filter 0.1 - 10 Hz, 5. MUX + A/D converter, 6. Computer (PC), 7. Controller, 8. Tape recorder 1, 9. Tape recorder 2, 10. Pen recorder, 11. Calibrator unit.

Fig. 1.4 Circuit function of the PUSK-2.

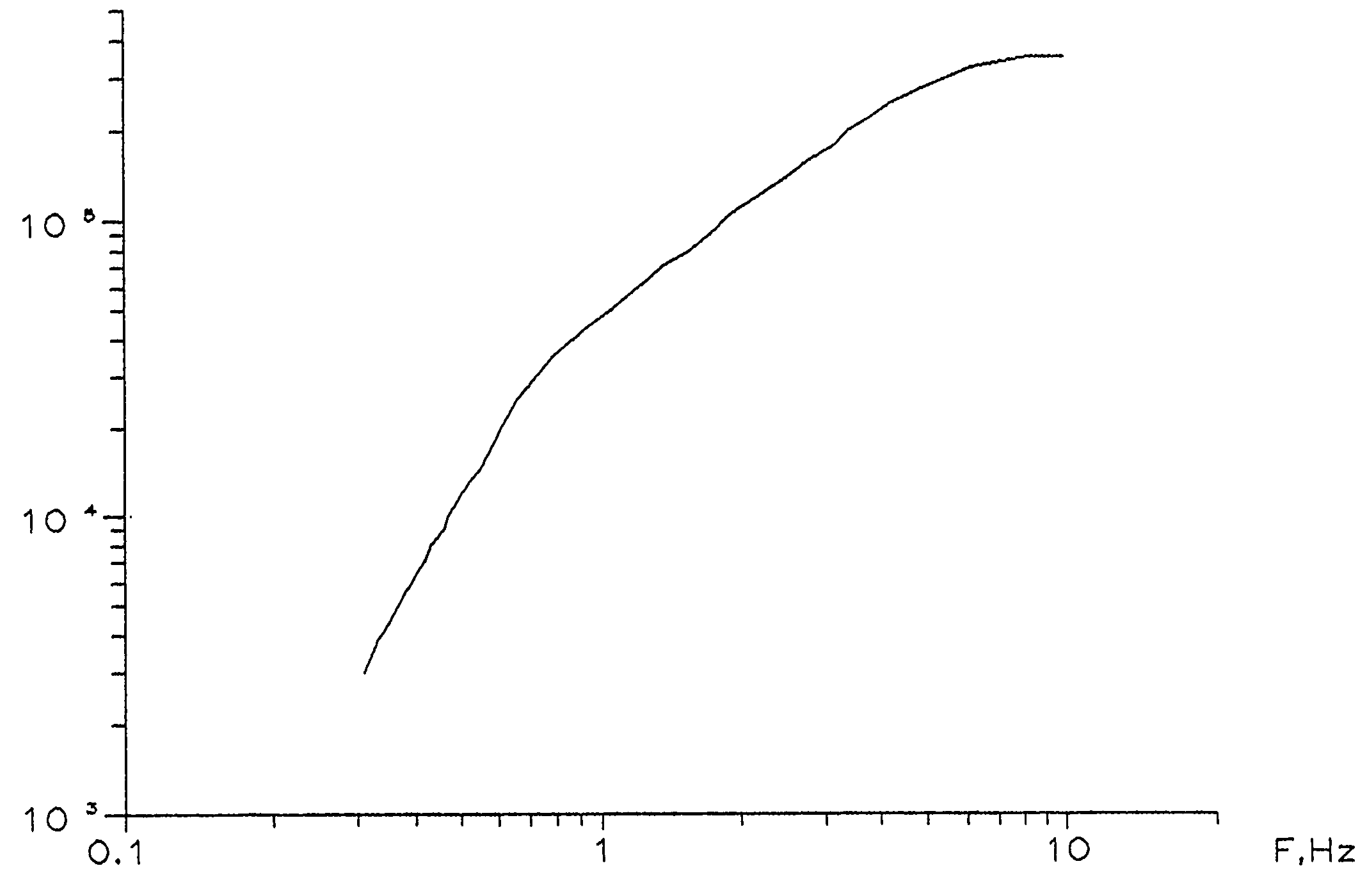


Fig. 1.5 Frequency responce of the station PUSK-2, CH 1-3.

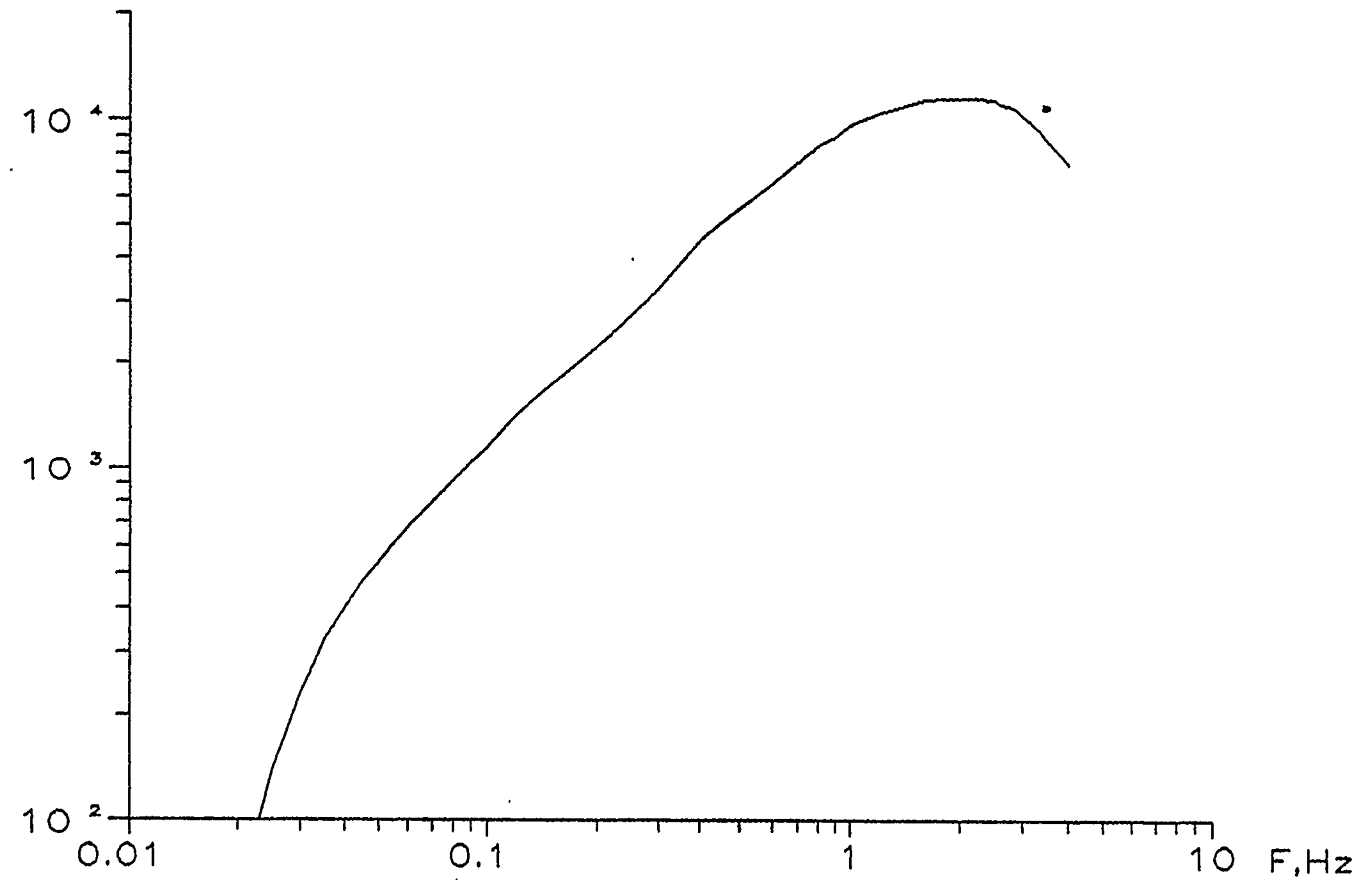


Fig. 1.6 Frequency responce of the station
PUSK—2, CH 4—6.

Turetzkiy,...1980]. Four different coefficients of amplification can be used for each station: 1/16, 1, 16, and 256.

Note that this algorithm operates independently from the existence of a seismic event. The information is delivered into a PC, and subsequently recorded on the NML, when the signal energy exceeds a certain velocity. For this purpose a circuit is applied which raises the value of the input voltage to the second power: at a frequency of 1 Hz for detection of distant events and at frequency of 10 Hz for local events. The voltage at the output of an electromagnetic seismometer (for example, SM-3-BVX and S55-BVX), is proportional to the velocity of ground movement. If this voltage value is raised to the second power, the resulting voltage will be proportional to the acceleration of the ground. In the device PUSK-2 the principle described above is used for detection of seismic signals. In the signal detector circuit the measures are provided for protection from a false trigger due to electrical impulses.

Transformation of the seismic signal into digital form is carried out using a maximum sampling frequency of 100 Hz per channel. For time synhronization of the seismic data an internal timing system is built into the unit UZI-1. For a control of the whole path of the digital transformation an output of an analog signal to the recording system RVZ-3 is provided (after reconstructing it from the digital code). Calibration pulses can be automatically sent to the seismometer coil. The polarity of the calibration impulse can be switched by hand.

Parameters of the calibration pulses :

Amplitude - 10±0.5 V

Duration - 5±0.15 msec

Files containing information on the calibration results have special marks.

Time of the signal transformation -1 msec.

1.4.1. Working cycle of the station PUSK-2.

During the work the PUSK-2 system is in waiting regime and the vertical component of microseismic noise is continuosly analyzed and transferred to the input of the system from vertical channel (channels 1,4), until the impulse signal that turns on the recording system is activated.

As soon as the required command impulse is given, the UTI-1 unit organizes the data output to a micro-PC channel and then to the record on magnetic tape.

Event recording takes place on variable-length files. The file size depends on the magnitude and duration of the event. When starting from the first (short-period) channel, the record duration is 5-7 minutes, from the fourth (intermediate-period) channel, 15 minutes or more.

The current information goes into the operative memory with the old data being continuosly replaced by the new. The memory capacity is 20-23 sec, which allows about 15-17 sec of pre-event recording.

When the system turned on to record, the NML, which is in a regime of the control from the PC, records the event file with a time mark indicating the date and time of the event. After the recording is finished, the system returns to the waiting regime.

1.5. Calibration of the seismic apparatus of the CSE.

Practical experience with the magnetic recording stations under field conditions had shown a necessity to continuously control the condition of the seismic channels. A few such methods of control exist: for example, sending a signal of constant amplitude (MGPA) or sinusoidal signals, from a signal generator and also various calibration pulses to a seismometer coil. The pulse calibration is the preferable one, because besides determining the amplitude-frequency characteristics it allows determination of the phase-frequency characteristics as well, which is necessary for accurate correction of the seismic records. In the CSE all types of calibration are used, depending on the seismometer type.

For example, the PUSK-2 system is calibrated by a delta-impulse, recording system by shake-tables and also using short pulses; and photo- and pen-ink recording systems are controlled by signals of the constant amplitude signal generator (MGPA).

2. OBSERVATION SYSTEMS.

2.1. Organizing the observation points.

The observation points were equipped taking into account the existing experience. At the Talgar seismic station, the seismometers were installed on a concret pedestal in especially prepared places in a tunnel. In field areas the seismometers were installed mainly on bedrock, in small holes with a tubbing arrangement. The bottom of a hole was fixed with a small volume of cement for better contact of the seismometer's base with the ground. After installation the hole was filled with soil, which provided a necessary stable temperature regime and protection from wind noise.

Seismometer installation was carried out using a compass orienting the three-component device along the cardinal directions. A seismometer period was established with a stop-watch. Horizontality was checked with a level.

The field telemetry site or magnetic recorder with batteries were installed 10-15 meters from the seismometers, together with the antenna.

2.2. Station and seismic arrays.

The data base was created mainly using data received at the Talgar seismic station. In addition, seismograms obtained at a station installed in the area of the

"Amangel'dy" gas deposit in the Muynkum desert in 1984 and by the small-aperture array in the area of the Ili river in 1987 (both in southern Kazakhstan) were digitized.

Seismic data recording was carried out by the ASS-6/12 magnetic recording system; these arrays have operated for periods of 1-2 months.

2.3. Seismic station Talgar.

The station is situated in 7 km to the south from the city of Talgar in the foothills of Zailiyskiy Alatau ridge (Fig.1.1). The station coordinates are 43.23° N, 77.22° E. The seismometers are installed in a 120-meter-long tunnel, driven directly into the Paleozoic-age crystalline rocks, which are exposed at the surface. The altitude is about 1200 meters above the sea level.

The station is removed from various artificial sources of microseismic noise, thus conditions for seismic observations are rather favourable here. The only shortcoming is the proximity of the Talgar River, which slightly lowers a sensitivity of the station.

The Talgar station has operated since 1961 and during this time has carryied out continuous monitoring of seismicity. The station is a regional one; it is equipped with a whole set seismic recording systems. Until 1991 the station took part in the Real-time Service, in the Service of Urgent Reports (in the former USSR). At present urgent reports are not sent.

Initially the station was equipped with one 100 meter-long tunnel (Fig.2.1.). The tunnel has 8 lateral offshoots, in which seismometers have been installed on especially equipped piers.

The construction of the tunnel was completed using a special technology that minimized the breakage of the surrounding bedrock. The tunnel is oriented in the N-S direction.

From 1978 through 1980 a large volume of work on a reconstruction and modernization of the station has been carried out. As a result a new laboratory building and tunnel have been constructed (Fig.2.1), cable lines have been completely replaced, and the recording system has been considerably renewed. In the new tunnel geophysical observation systems have been installed. Since 1980 two new strainmeters with different modes of signal transformation have been working including both capacitive and inductive devices as well as an oscillographic recorder. The strainmeters are oriented in directions SW-NE, and SE-NW. In separately equipped compartments 3-meter-long bending strainmeters with an inductive transformer are installed. Since 1985 an apparatus for radon emission recording with a measurement frequency 2 times per a day have been working. It is worth noting that at the Talgar station practically all new developments of the Special design office of the JIPE RAS, including geophysical apparatus, strainmeters, gravimeters, and tiltmeters have been tested in field conditions. Thus, the seismic station Talgar is one of the

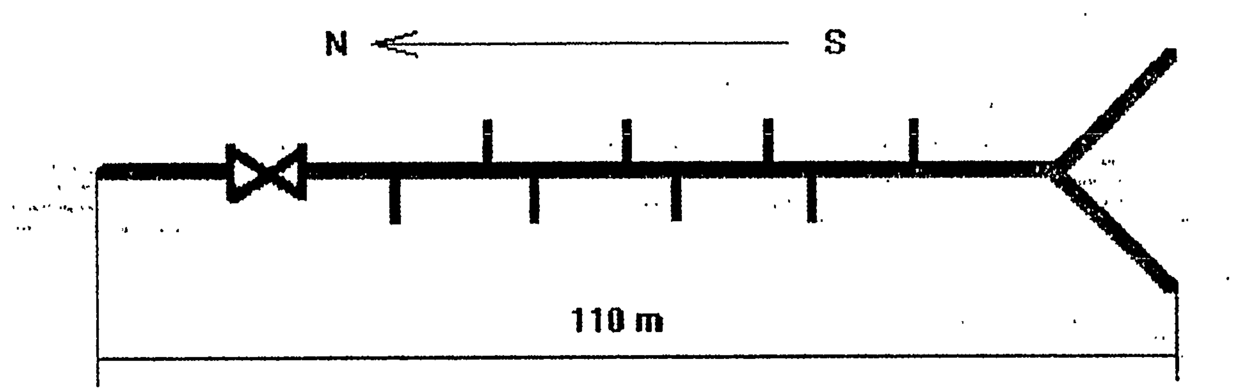


Fig. 2.1 Tunnel 1.

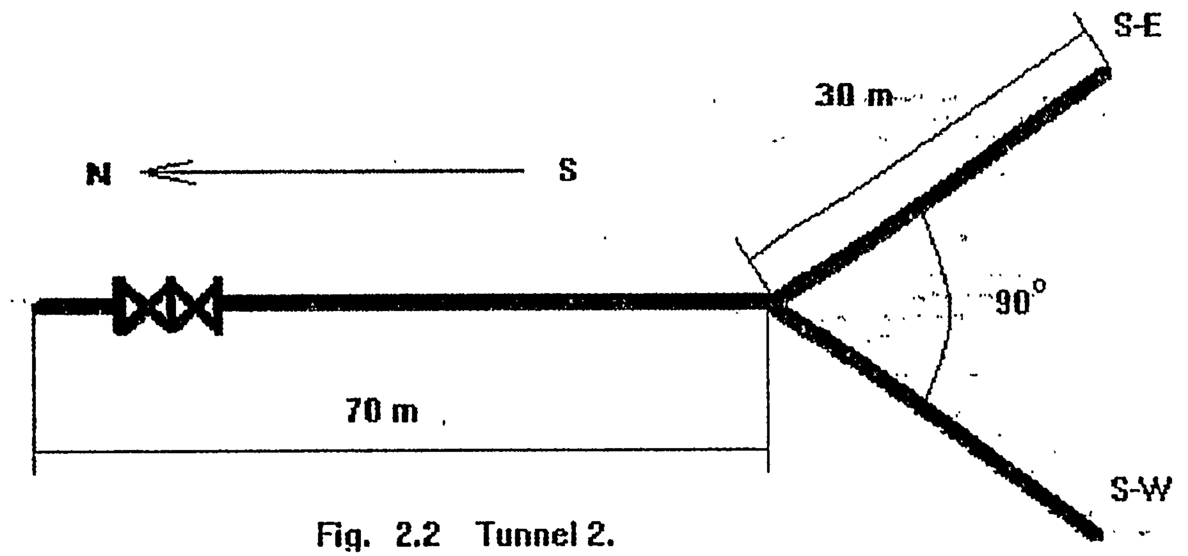


Fig. 2.2 Tunnel 2.

best equipped sites to conduct joint seismic and geophysical observations within the former Soviet Union.

2.4. System of observations at the gas deposit in the Muynkum sands.

To study patterns of seismic wave fields above the gas bed, the Complex Seismological Expedition of the JIPE has carried out investigations at the Amangel'dy gas deposit in southern Kazakhstan (Fig.2.3). A study area is located in the central, and most difficult part of the Muyunkum desert. The sands have a complicated uneven relief, with barkhan dunes reaching 400 meters absolute elevation and relative elevations reaching about 40-60 meters. From the lithologic and stratigraphic composition of rocks and the velocity parameters of the upper part of the section and the thickness of the low-velocity zone the study area is divided into a few zones. A zone of development of an eolian sand deposits of early and middle quaternary age, with a thickness of 40-70 meters has the widest distribution. It consists of dry sands (layer velocities V_{st}=1100-1400 m/sec). These deposits are underlain by poorly consolidated sandstones, wet sands and clays (V_{st}=1700-2000 m/sec).

The system of observations and contours of the deposit are shown in Fig.2.4. Recording was carried out by ten ASS-6/12 magnetic recording stations with three-component seismometers SM-3 and S-5-S continuosly for one month (with a magnification of about 1.5 million in the frequency range

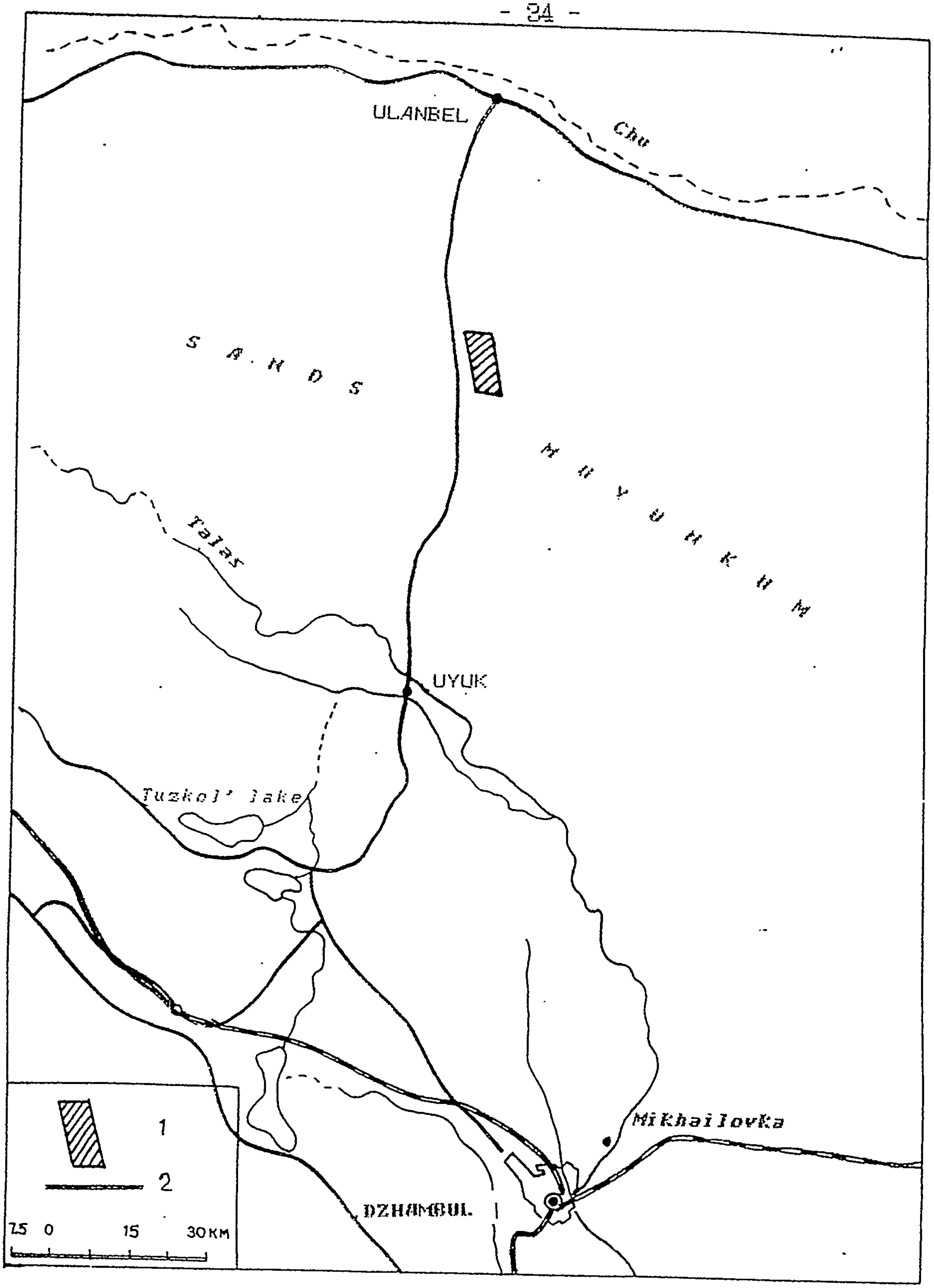


Fig. 2.3 Area of field works with the seismic array above the gas deposit. 1 - area of the works, 2 - main roads.

0.5-16 Hz). For control, recording by the oscillographic record was also conducted. The seismic information was recorded by the ASS-6/12 stations at two levels: high- and low-gain coarse, attenuated relative to the high-gain by 30 dB. The magnetic recording stations were installed as a linear and cross-shaped system. Places of the seismometers installation are shown in Fig.2.3 , by a triangle with a station number. We can see from Fig.2.3, that eight observation points were installed directly above the deposit and two outside it. Distances between the observation points are less in the central part of the deposit. The stations were installed mainly close to boreholes, which increased the accuracy of determination of coordinates. The distances between the stations were determined using a theodolite. As a result, a linear profile from eight stations was created, which coinsides with a seismographic profile 14A-74, for which a geophysical cross-section has been obtained.

In the field the stations were installed in metal boxes together with batteries. The seismometers were installed in concrete at a depth of about 40 centimetres. Horizontality of the seismometers was controlled by a level, and orientation of horizontal devices by compass. Then the boxes with the stations and seismometers were filled with a 10 cm-thick soil layer. Distances between stations and seismometers were at least 10 meters. Such an installation provides a good thermal isolation and protects from unfavorable influence of external conditions. Stations were working in rough conditions (daily temperature difference

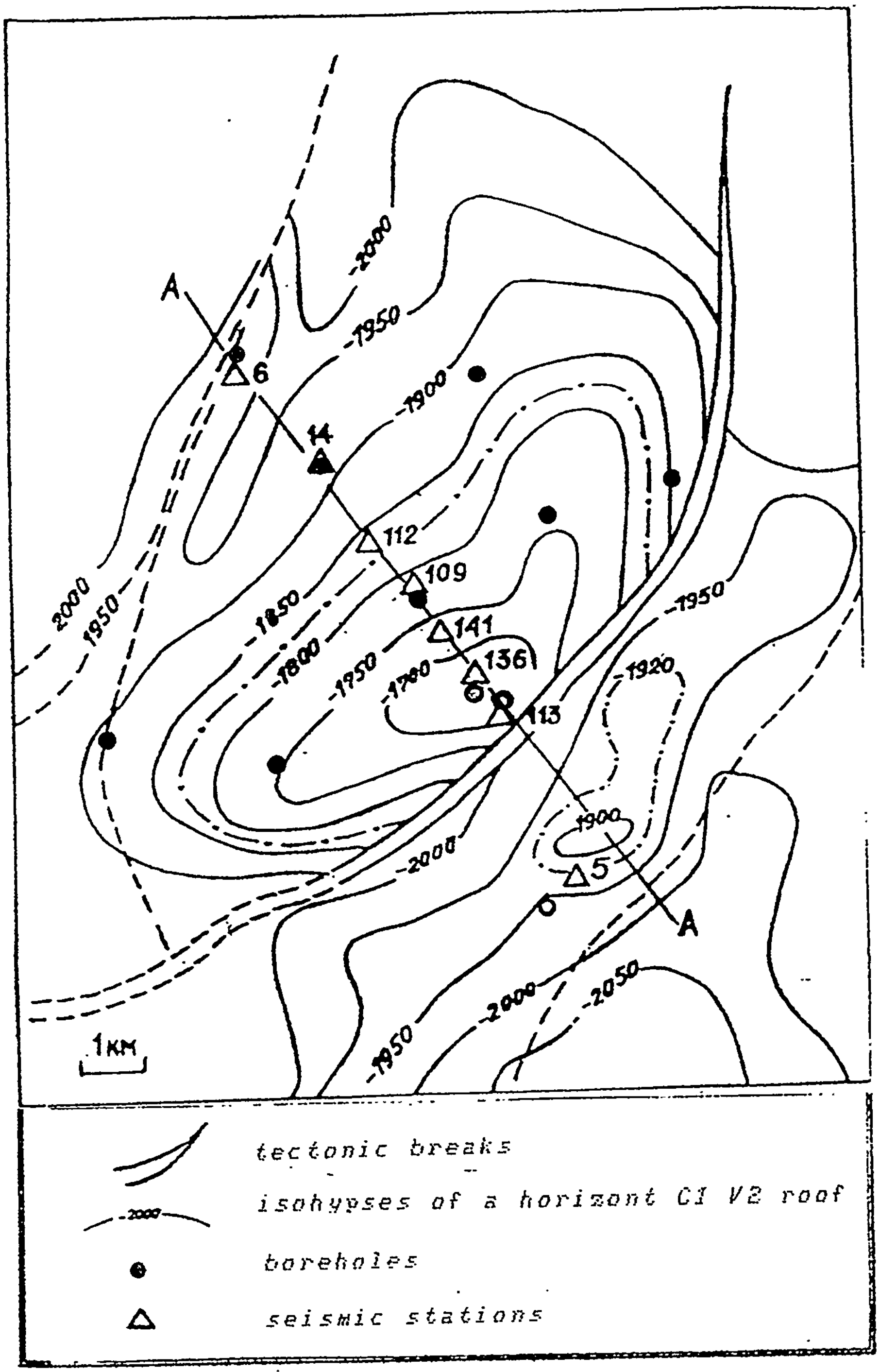


Fig. 2.4 System of investigation and a countor of the gas deposit "Amangel'dy".

reached 30° C, and strong winds and dust storms occured); for this reason the station operation was verified regularly. Station clocks correction were measured with an accuracy of 0.001 sec. The quality of the tape-drive mechanism work was checked (the speed of the tape drive was 0.5 mm/sec). The natural periods of the seismometers and levels of coil installation in the magnetic system of seismometers were also checked. Observations with the array were conducted from August 14 through September 27, 1984. During the work 2 underground nuclear explosions were recorded. In the data archives the records of one seismic station (number 109) are included (Fig.2.3). The station coordinates are: latitude - 44.38° N, longitude - 71.35° E.

More detailed information on the seismic array, methods of data processing and results obtained is appended in an article [Nersesov et al.,1990].

2.5. System of observations at the small-aperture array.

To study fine structure of the seismic wave fields the CSE organized in 1987 a temporary small-aperture array at a base 2×2 kilometers, consisting of 16 observation points.

The array was installed in 120 kilometers to the north from the city of Almaty, near the Malaisary ridge on the northern bank of the Ili river. The area is in the central part of the Eurasian continent, far from the sources of natural and artificial microseisms. Geological conditions are favorable for seismological investigations in this area. Bedrock of upper Paleozoic (Pz_3) are overlain by a thin layer of crushed rock and sandy deposits. Directly in the study area bedrock of the Malaisary Suite are represented by tuff-argillites and volcanic tuffs of dacitic-liparitic porphyrites. Outcrops of the rocks are found at the some sections of erosive cuts and along steep banks of the Ili river.

For the seismic information recording the RTS-AN system with analog recording on two stations of the ASS-6/12 magnetic recording system was used. 12 vertical seismometers were connected with one station (number 141), 4 sets of three-component devices with a second station (number 113). The recording was at one amplitude level. SM-3 seismometers with a natural period of 2.0 sec were used. The devices were installed mainly on a bedrock, in small tightly closed holes, which provided protection from the direct influence of wind and temperature variations. Seismometers were installed in cement. Horizontality of the devices instalation was verified by a level. The data was sent from the seismometers to the recording stations, placed in the center of the array, through wires.

A schematic of the arrangement of equipment in 15 observation points is shown in Fig.2.5. As seen in this figure, three-component seismometers were installed along a grid 0.15×0.15 kilometers, within a group of vertical devices (points 1-12) in order that the two arrays complemented each other. It was possible to use all the

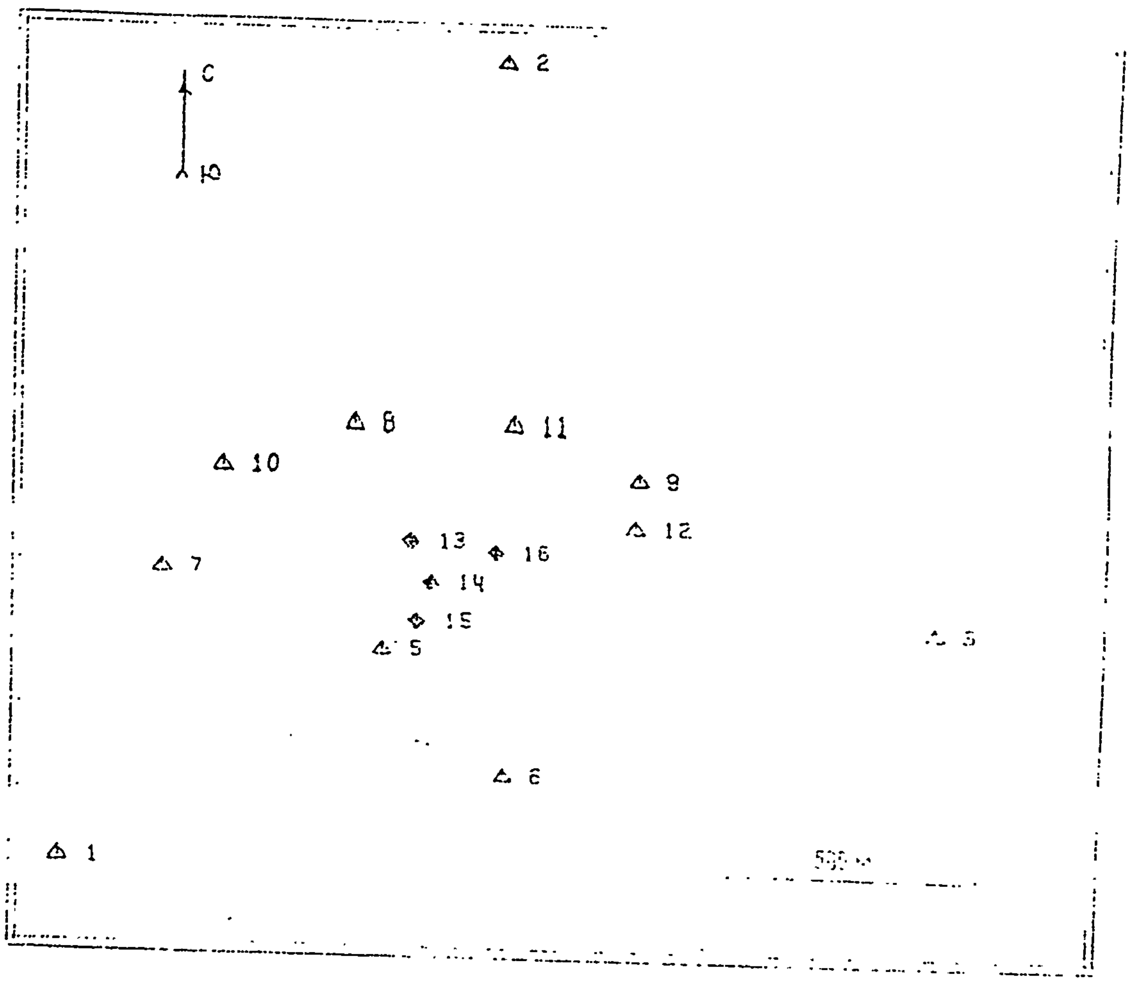


Fig. 2.5 Scheme of disposition of the seismometers during work of the small-aperture array. Points/1-12 -vertical instruments. 13-16 - three component instruments.

records in common processing of the data from the whole array. To control data quality, one three-component station and one vertical device were installed at the same point (observation point number 14).

Requirements to an accuracy of determining the relative coordinates of the observation points are rather high. For this reason the coordinates were determined with a T-50 theodolite using special methods. The accuracy obtained was about 1 meter at distant recording points. The coordinates of the observation points in meters relative to the recording stations in the central part of the array are shown in Table 2.1. Coordinates of the center of the array are as follows: latitude 44.4° N , longitude 76.77° E.

Recording the seismic information was carried out at a tape speed of 2 mm/sec with a magnification about 1.5 million in the frequency range 0.5-16 Hz. The maximum possible tape drive speed was chosen with the purpose of diminishing possible distortion, which can lead to large errors in data processing. In order to increase the accuracy of time determination at stations, we carried out a daily test of the quartz clocks for each station and restarted them based on precise timing signals using the reference clocks of the control unit.

The small-aperture array has been in operation from October 6 through October 31, 1987.

The data obtained by the array in an analog form were digitized by the AVSI-6 apparatus on the digital magnetic tape with subsequent creation of archives on floppy-disks.

Table 2.1

Relative coordinates of the observation points (meters).

Obs. point	1	2	3	4	5	6
X	-768.8	86.9	957.5	-46.0	-142.1	102.6
Y	-573.4	1009.6	-81.3	1.5	-135.1	-393.9
Z	-25.6	-51.7	-55.8	-3.5	-1.6	-9.3
Obs. point	7	8	9	10	11	12
X	-578.3	-205.7	370.3	-463.9	114.9	364.0
Y	23.6	310.1	-217.2	234.0	312.5	124.4
Z	-36.0	-36.0	-20.0	-36.1	-31.0	-23.8
Obs. point	13	14	15			
X	-88.7	-73.1	82.5			
Y	90.1	-72.6	66.8			
Z	-8.3	-5.5	-10.6			

3. ARCHIVES OF THE DIGITAL DATA.

A major amount of the digital seismograms were received for the Talgar station (ASS-6/12 and PUSK-2), and a considerably smaller number for the temporary seismic arrays.

3.1. Digital data obtained by the Talgar station.

Organization of the primary seismic data processing. Archival tapes prepared on AVSI-6 with the digital data were processed using the ES-1040 computer. The large volume of experimental material obtained and the possibility of repeated digitization of the seismic data (when necessary) allowed us to select high-quality digital records. For this purpose a program system has been developed which allows estimation of the digitizing quality (stability of the sampling frequency, overflow of the UTP and non-linear distortion) and to reject records which do not correspond to pre-selected parameters. The rejected seismograms were subjected to repeated digitization and testing. In the case of favorable test results the records were included in the archives.

3.1.1. Seismograms recorded by apparatus ASS.

Table 3.1 presents a list of the digital seismograms

List of the digital seismograms
(station Talgar, ASS)

Table 3.1

N	Date	t_o	t_p^*	φ	λ	h,km	m_b	M_s	M_L	Source type	Region
1.	20.03.1982	11-17-40	11-19-29.7	47.90N	86.80E		4.5		4.6	earthquake	Altai
2.	25.04.1982	03-23-05.5	03-24-48.1	49.87N	78.92E	0	6.1	4.6		UNE	STS ** borehole, Balapan
3.	25.12.1982	04-23-05.5	04-24-46.3	49.83N	78.12E	0	4.8			UNE	STS tunnel, Degelen
4.	26.12.1982	03-35-14.4	03-36-59.6	50.06N	79.05E	0	5.7			UNE	STS borehole, Balapan
5.	30.03.1983	04-17-07.7	04-18-49	49.87N	78.12E	0	4.9			UNE	STS tunnel, Degelen
6.	12.04.1983	03-41-05.6	03-42-46.5	49.86N	78.18E	0	4.9			UNE	STS tunnel, Degelen
7.	14.04.1983	19-05-00.1	19-18-42.4	37.10N	116.00W	0	5.7			UNE	NTS***

N	Date	t_o	t_p	φ	λ	h, km	m_b	M_s	M_L	Source type	Region
8.	19.04.1983	18-52-58.7	19-12-32.2	21.81S	138.95W	0	5.6			UNE	Tuamotu
9.	16.05.1983	12-07-49.3	12-10-41.2	39.28N	64.25E	10	4.7			chemical explosion	near Bukhara, Uzbekistan
10.	16.05.1983	16-30-02	16-31-49.7	43.66N	87.37E	9	4.8			earthquake	southern Xijiang
11.	25.05.1983	17-30-58.6	17-50-32.6	21.85S	138.90W	0	5.9			UNE	Tuamotu
12.	26.05.1983	12-18-14.2	12-20-30.7	39.16N	65.49E	33	4.7			chemical explosion	south-Eastern Uzbekistan
13.	30.05.1983	03-33-44.8	03-35-24.4	49.74N	78.19E	0	5.5	3.6		UNE	STS tunnel, Degelen
14.	01.06.1983	11-17-00	11-19-45	43.85N	88.60E	37	5.1			earthquake	southern Xijiang

N	Date	t_o	t_p	φ	λ	h,km	m_b	M_S	M_L	Source type	Region
15.	09.06.1983	06-25-16	06-27-44	39.70N	90.00E		4.4			earthquake	southern Xijiang
16.	12.06.1983	02-36-43.7	02-38-26.6	49.90N	78.97E	0	6.1	4.8		UNE	STS borehole, Balapan
17.	18.06.1983	12-06-21	12-07	47.30N	81.60E				3.6	earthquake	Altai
18.	24.06.1983	02-56-11.2	02-57-50.5	49.82N	78.12E	0	4.7			UNE	STS tunnel, Degelen
19.	28.06.1983	17-45-59	18-05	21.70S	138.94W	0	5.4			UNE	Tuamotu
20.	30.06.1983	21-39-58.5	21-47-27.5	43.32N	45.70E	16	4.6			earthquake	Caucasus
21.	19.02.1984	03-57-03.5	03-58-45.9	49.86N	78.80E	0	5.9	4.7		UNE	STS borehole, Balapan

N	Date	t_o	t_p	φ	λ	h,km	m_b	M_s	M_L	Source type	Region
22.	07.03.1984	02-39-06.4	02-41-02.1	50.00N	78.99E	0	5.7	4.1		UNE	STS borehole, Balapan
23.	29.03.1984	05-19-08.3	05-21-14	49.87N	78.97E	0	5.9			UNE	STS borehole, Balapan
24.	15.04.1984	03-17-09.3	03-18-49.3	49.69N	78.14E	0	5.7	4.5		UNE	STS tunnel, Degelen
25.	15.04.1984	04-56-42	04-59-57.8	31.70N	82.20E		5.0			earthquake	Tibet
26.	25.04.1984	01-09-03.7	01-10-47.1	49.90N	78.90E	0	6.0	4.8		UNE	STS borehole, Balapan
27.	01.05.1984	19-05-00	19-18-43.3	37.10N	116.00W	0	5.3	4.2		UNE	NTS
28.	26.05.1984	03-13-12.5	03-14-56.1	49.90N	79.00E	0	6.1	5.8		UNE	STS borehole, Balapan

N	Date	t_o	t_p	φ	λ	h, km	m_b	M_S	M_L	Source type	Region
29.	31.05.1984	13-04-00.1	13-17-42.4	37.10N	116.00W	0	5.8	4.1		UNE	NTS
30.	23.06.1984	02-57								chemical explosion	STS
31.	25.08.1984	18-59-58.7	19-04-18.3	61.88N	72.10E	0	5.3	3.7		UNE	western Siberia
32.	28.08.1984	02-49-02	02-50-58.5	47.70N	83.70E				3.2	earthquake	Altai
33.	30.08.1984	16-08-50.6	16-25-03	49.61N	85.23E				3.3	earthquake	Altai
34.	04.09.1984	05-23-30	05-26-21.1	41.14N	93.14E	13	4.9			earthquake	southen Xijiang
35.	09.09.1984	02-59-06.5	03-00-47.2	49.87N	78.21E	0	5.0			UNE	STS tunnel, Degelen

N	Date	t_o	t_p	φ	λ	h, km	m_b	M_S	M_L	Source type	Region
36.	15.09.1984	06-15-07	06-16-50.4	49.91N	78.91E	0	4.6			chemical explosion	STS
37.	17.09.1984	20-59-57.4	21-03-19.5	55.84N	87.41E	0	5.0			UNE	western Siberia
38.	03.10.1984	05-59-58	06-02	41.50N	88.67E	0	5.4			UNE	southen Xijiang
39.	18.10.1984	01-11-46	01-13-01.1	47.30N	81.70E				3.7	earthquake	Altai
40.	18.10.1984	04-57-06	04-58-46.1	49.80N	78.16E	0	4.5			UNE	STS tunnel, Degelen
41.	17.07.1986	21-00-00	21-13-42.5	37.30N	16.40W	0	5.7			UNE	NTS
42.	24.07.1986	05-02-40	05-04-29.2	43.75N	87.45E	26	4.4			earthquake	northern Xijiang

N	Date	t_o	t_p	φ	λ	h,km	m_b	M_s	M_L	Source type	Region
43.	24.08.1986	00-27-16	00-29-49.6	41.02E	91.50E			4.3		earthquake	southern Xijiang
44.	16.09.1986	10-36-27	10-37-42.7	47.40N	82.60E				3.9	earthquake	Altai
45.	19.11.1986	12-50-06	12-51-17.8	47.81N	80.85E				3.9	earthquake	Altai
46.	20.11.1986	02-40-24.3	02-41-45.1	41.95N	84.10E	33	4.6			earthquake	southern Xijiang
47.	26.02.1987	04-58-22	05-00-03.7	49.80N	78.10E	0	5.4			UNE	STS tunnel, Degelen
48.	14.09.1988	03-59-57.6	04-01-39.5	49.80N	78.80E	0	6.1	4.8		UNE	STS borehole, Balapan
49.	13.10.1988	14-00-00	14-13-43	37.09N	16.50W	0	5.9	4.4		UNE	NTS

* t_p - time of P-wave arrival
** STS - Semipalatinsk test site.
*** NTS - Nevada test site.

recorded using the ASS system, installed at the Talgar station (see also Fig.1.1.). In all, 49 records of earthquakes, chemical explosions, and nuclear explosions were digitized. According to the contract, the majority of the records are the seismograms of underground nuclear explosions at regional distances. 18 seismograms of underground nuclear explosions from the Semipalatinsk test site (9 from the Balapan area and 9 from the Degelen area), one seismogram of an underground nuclear explosion from the Chinese test site Lop Nor and one seismogram of an industrial nuclear explosion from West Siberia were digitized. In addition, 4 records of chemical explosions were obtained (2 from the Semipalatinsk test site area and 2 from the Uzbekistan region). 6 seismograms of earthquakes from the Altai region with epicenters close to the Semipalatinsk test site were also digitized. There are 8 earthquake records from West China region, close to the Lop Nor test site and also 2 records of earthquakes from other regions of Eurasia (Tibet and Caucasus) in the our data archives. Finally, 7 seismograms of underground nuclear explosions from the other test sites (4 from the Nevada test site and 3 from the French test site in the Pacific ocean) were digitized.

All seismograms are 3-component (N-S, E-W, Z), and were digitized with a frequency of 25 Hz (for the period 1982-1984) and 20 Hz (1986-1988). The record length varies from 330 to 410 sec. In pages 58-104 the records of all events obtained at regional distances are shown.

Fig.1.2 shows frequency characteristics of the channels. For the events N 1-40 (Table 3.1.) the frequency response was constant over the frequency range 0.5-8 Hz, for the events N 41-49, over the range 0.5-16 Hz. The magnification was about 430000.

File structure. All the data are described in the two first lines of the header. In the first line, information on an event recorded is indicated, which includes the following data: station name; t_p - time of P-wave arrival; event coordinates; hypocentral depth and magnitude.

In the second line, information on the seismogram is indicated: date and time of the first data point (the first 6 numbers are following: year, month, day, hour, minute, and second). Then station number follows (non-essential information); then the magnification of the record in dB when digitizing; V_{rd}, V_{wr} - non-essential information; then the sampling rate in Hz; number of channel (from 1 to 12, non-essential information); in the last position, seismometer type (horizontal or vertical).

For example: the file name 02260459.109; here 02 is the month, 26 the day, 04 is the hour, 59 is the minute, 109 is the station number.

The title of this file is the following:
Station: Talgar t_o=04-58-22 t_p=05-00-03.7 49.80N 78.10E h=0
M_b=5.4 87 2 26 4 59 55 109 63dB V_{rd}=50 V_{wr}=.5 20.00Hz
channel- 7 (E-W).

The station name - Talgar, origin time t_o=04-58-22, time of P-wave arrival- t_p=05-00-03.7, explosion coordinates

- 49.80N, 78.10E, the depth h=0 km, magnitude m_b=5.4.

The date and time of the first data point: 1900+87=1987(year), 2 is the month, 26 is the day, 04 is the hour, 59 is the minute, 55 is the second, 109 is the station number, the attenuation - 63 dB (it is necessary to multiply all numbers before an interpretation by $10^{(63/20)}$), 20.00 Hz is the digitization frequency, E-W the seismometer azimuth.

The second line of the title is appended before the data for a given channel in file.

The same file structure corresponds to the digital seismograms obtained by the seismic arrays (see below).

3.1.2. Seismograms recorded by the apparatus PUSK-2.

In Table 3.2. a list of digital seismograms, obtained by the apparatus PUSK-2 is indicated.

In all, 4 earthquakes and 3 underground nuclear explosions records were picked out. 2 nuclear explosions originated from the Semipalatinsk test site (the Balapan area), and one at the Lop Nor test site. Records of earthquakes from Borokhoro ridge (eastern Kazakhstan), southern Xinjiang, and Tibet were also picked out.

The seismograms are three-component, but in some cases due to an instrument fault the records of one of the horizontal channels are absent. The digitization frequency in all cases was 100 Hz.

File structure. In the first line of the header

List of the digital seismograms
(station Talgar, PUSK-2)

Table 3.2

N	Date	t_o	t_p	φ	λ	h, km	m_b	M_s	M_L	Source type	Region
1.	06.08.1988	04-58-02	04-58-28.0	44.60N	78.60E	0			3.4	earthquake	Borokhoro ridge
2.	29.09.1988	07-00-02	07-02-09.5	41.52N	88.15E	0	4.6			UNE	Lop Nor
3.	04.04.1989	13-29-51	13-30-41.7	44.40N	80.60E	0			3.4	earthquake	Borokhoro ridge
4.	02.09.1989	04-16-57	04-18-41.0	50.03N	79.02E	0	5.1	4.1		UNE	STS** borehole, Balapan
5.	08.10.1989	15-49-29	15-51-28.3	36.35N	82.68E	10	5.1	4.7		earthquake	southern Xinjiang
6.	19.10.1989	09-49-57	09-51-39.8	49.90N	78.97E	0	5.9	5.0		UNE	STS borehole, Balapan
7.	09.01.1990	02-29-21	02-33-24.5	28.15N	88.11E	35	5.7	4.3		earthquake	Tibet

* t_p - time of P-wave arrival
** STS - Semipalatinsk test site.

following information is indicated: station name, origin time t_o, P-wave arrival time t_p, epicentral coordinates (latitude and longitude), hypocentral depth and magnitude.

In the second line of the title the information for the channels (Z, E-W or N-S) is indicated.

The following data are indicated: year, month, hour, minute, second; the name of the digital station, the digitization frequency; length of the record; the channel number; and the seismometer type.

3.2. Seismograms obtained by the station installed in the Muyunkum desert area.

Two records of two underground nuclear explosions, one from the Semipalatinsk test site and an industrial explosion (from the West Siberia region), and also one record of an earthquake from the northern Tien Shan region were picked out (Table 3.3). It is interesting that both explosions indicated have also been recorded by the Talgar station (ASS), see Table 3.1.

The seismograms are three-component, and the digitization frequency is 25 Hz.

3.3. Seismograms recorded by the small-aperture array.

Unfortunately, during the time of operation of the small-aperture array, neither nuclear explosions nor

List of the digital seismograms
(station Muynkum)

Table 3.3

N	Date	t_o	t_p*	φ	λ	h,km	m_b	M_s	M_L	Source type	Region
1.	21.08.1984	14-08-32.6	14-09-46.5	44.10N	71.61E		4.4			earthquake	Tien Shan
2.	09.09.1984	02-59-06.5	03-00	49.87N	78.21E		5.0			UNE	STS** tunnel, Degelen
3.	17.09.1984	20-59-57.4	21-03-38.0	55.84N	87.41E		5.0			UNE	western Siberia

* t_p - time of P-wave arrival
** STS - Semipalatinsk test site.

chemical explosions were recorded. Seismograms of three earthquakes from the West China, the Chatkal Range (Uzbekistan) and the Hindu Kush regions were picked out (Table 2.4).

The earthquake records can be used for analyzing the fine structure of the seismic wave fields in the Central Asia region and for solving some other problems.

The earthquakes were recorded simultaneously by 15 stations of the array (vertical components only). The digitization frequency is 40 Hz.

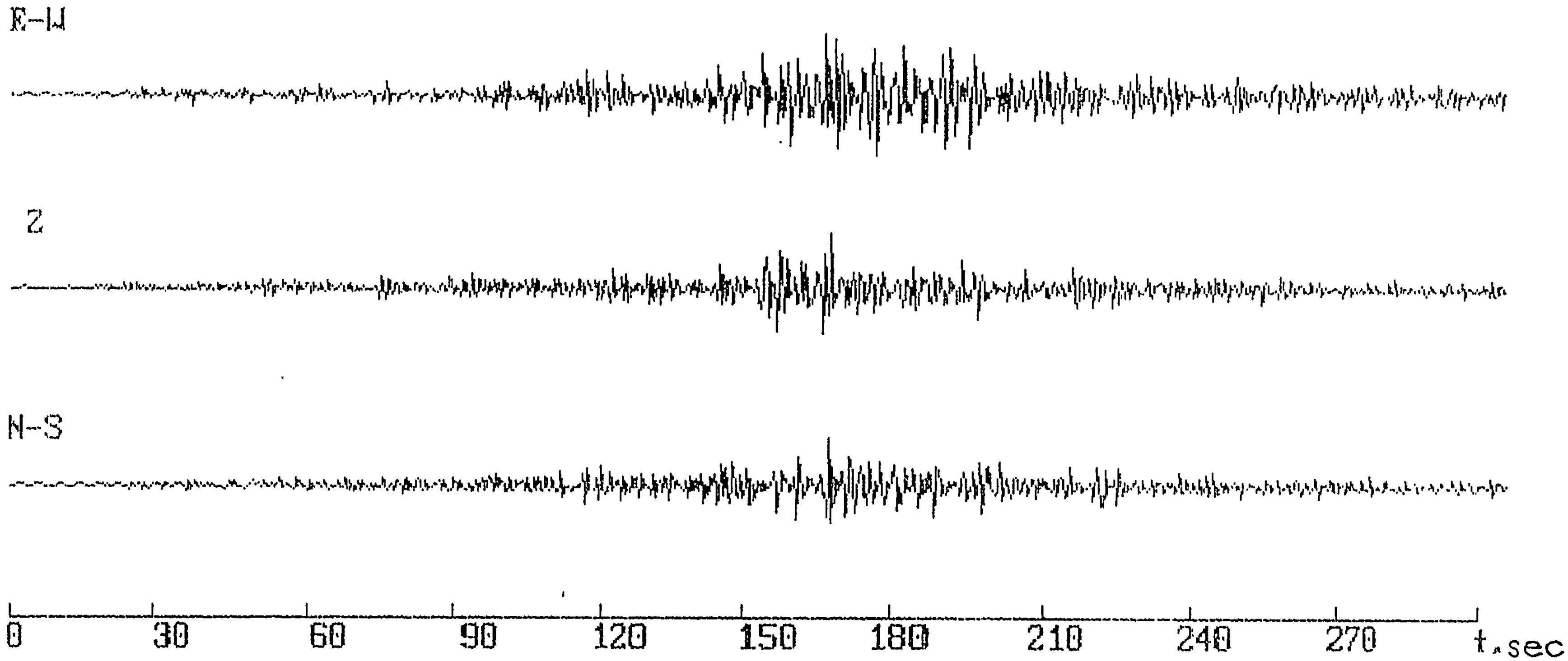
List of the digital seismograms
(small-aperture array)

Table 3.4

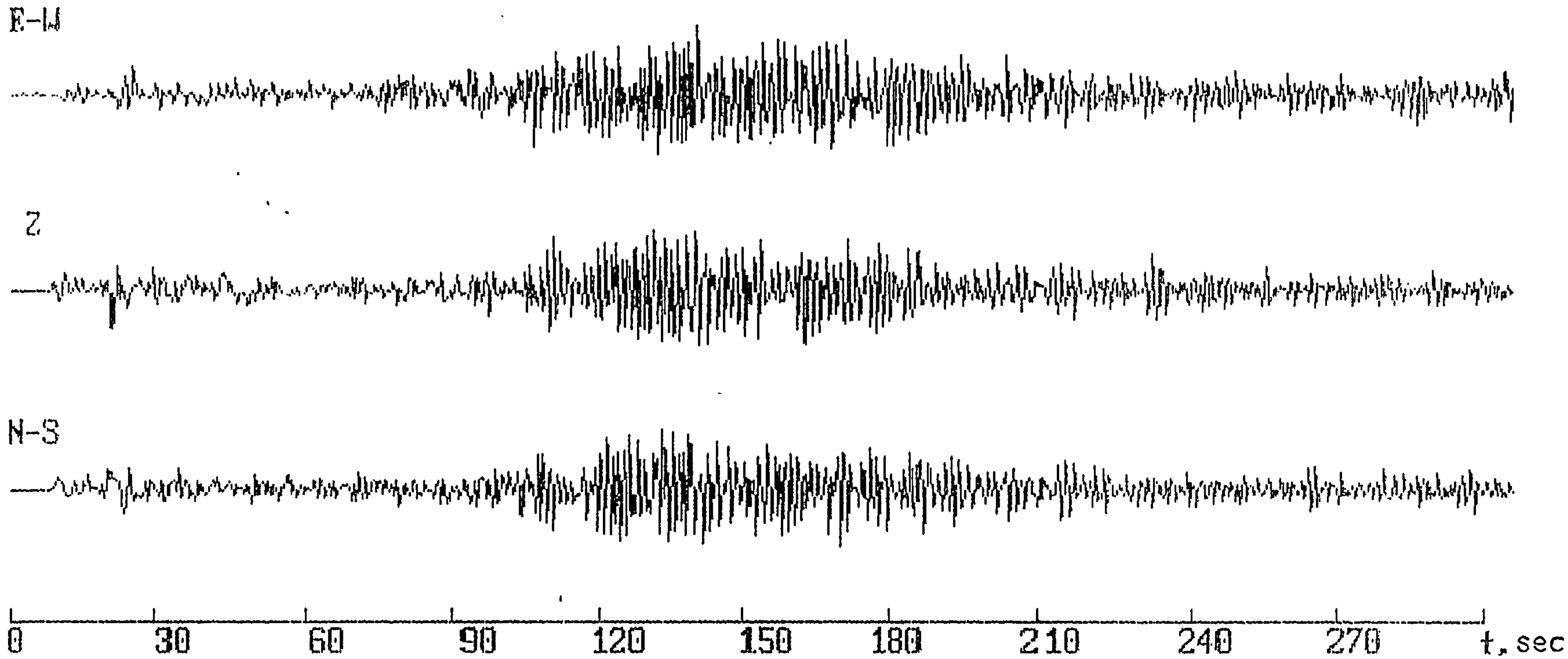
N	Date	t_o	t_p*	φ	λ	h,km	m_b	M_s	M_L	Source type	Region
1.	16.10.1987	18-30-45.7		44.19N	82.72E	3	4.6			earthquake	China
2.	18.10.1987	03-13-46.4		36.24N	69.58E	3	5.1			earthquake	Hindu Kush
3.	18.10-1987	07-01-14.0		42.30N	69.90E		4.1			earthquake	Chatcal

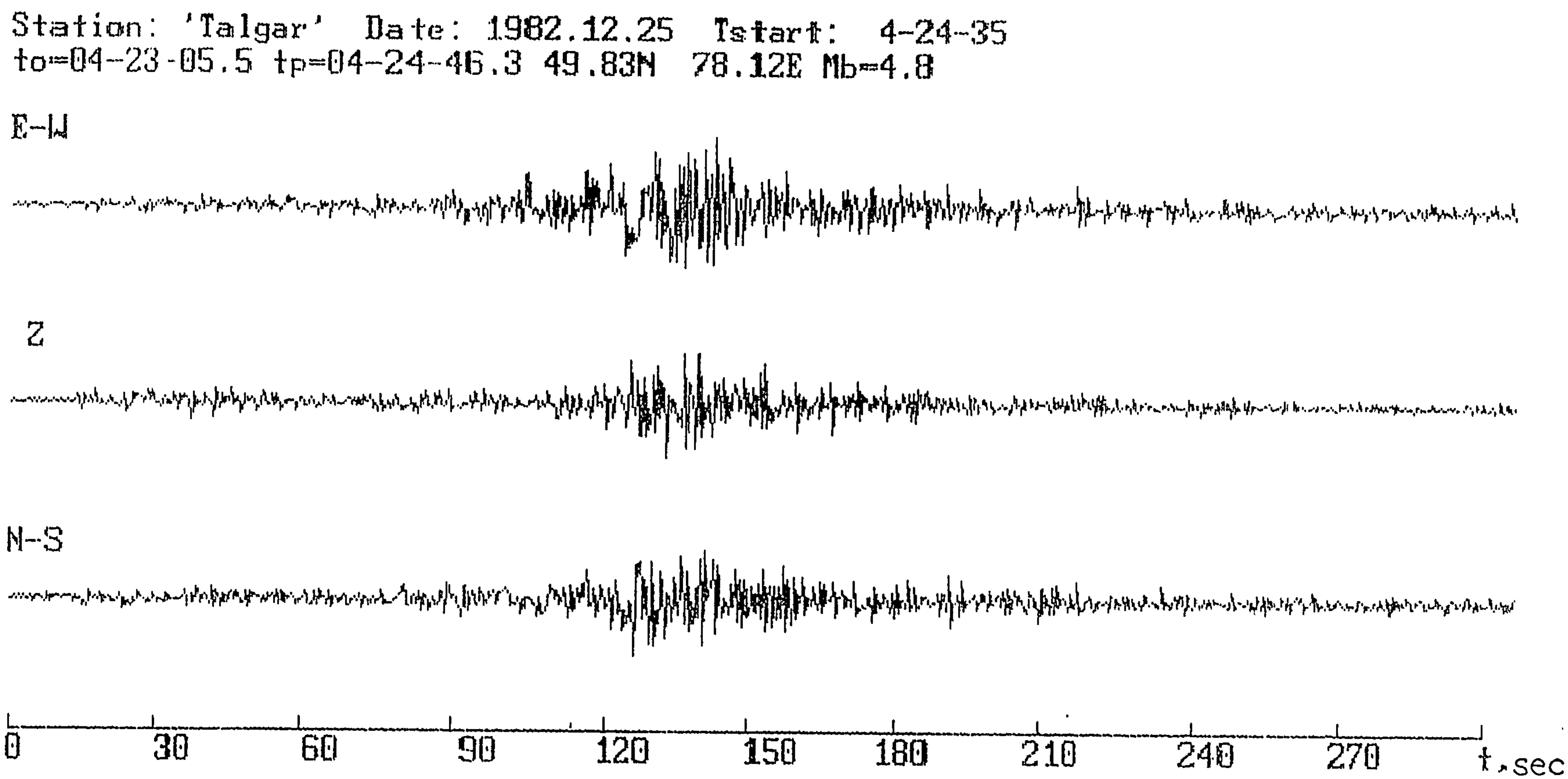
* t_p - time of P-wave arrival

Station: 'Talgar' Date: 1982. 3.20 Tstart: 11-19-20
to=11-17-40 tp=11-19-29.7 47.90N 86.80E M=4.5 K=12.2



Station: 'Talgar' Date: 1982. 4.25 Tstart: 3-24-40
to=03-23-05.5 tp=03-24-48.1 49.87N 78.92E M=6.1




Station: 'Talgar' Date: 1982.12.25 Tstart: 4-24-35
to=04-23-05.5 tp=04-24-46.3 49.83N 78.12E Mb=4.8
E-W
Z
N-S
0
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60
90
120
150
180
210
240
270
t,sec

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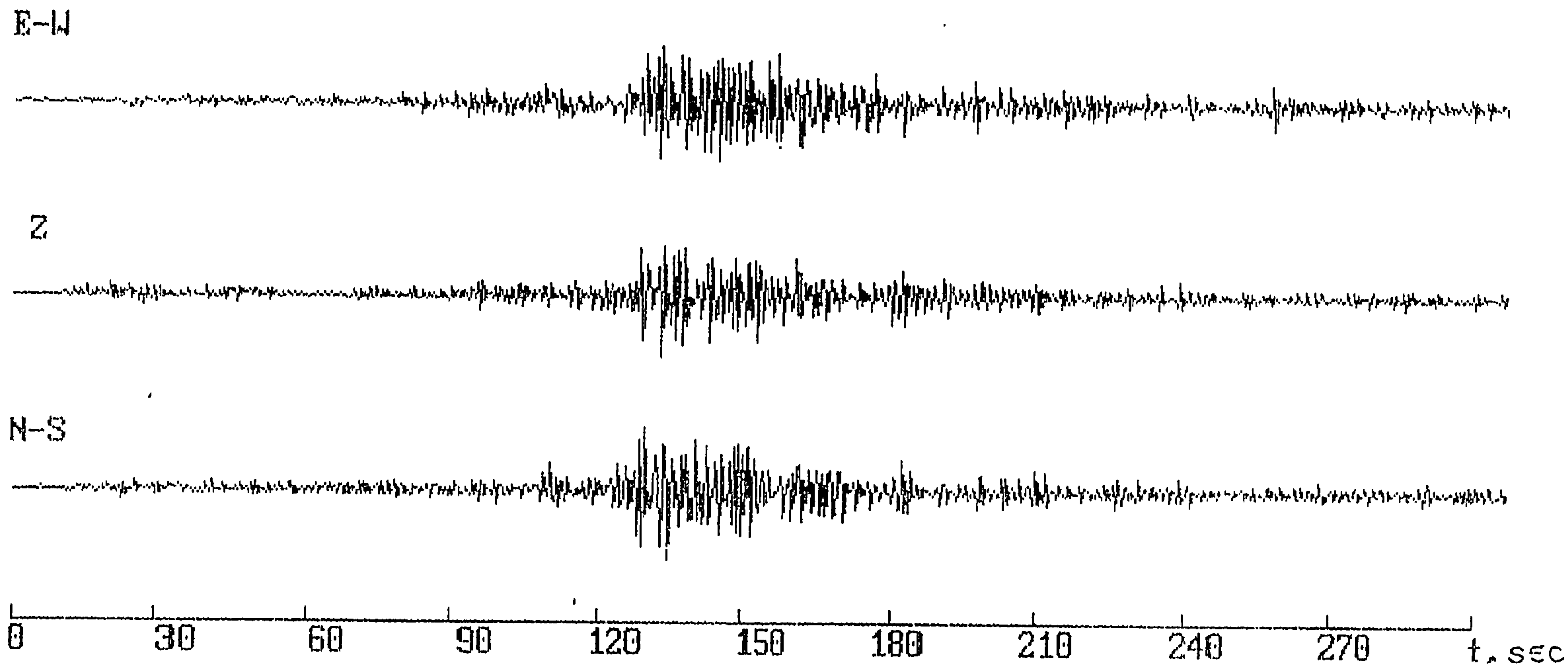
to=03-35-14.4 tp=03-36-59.6 50.06N 79.05E Mb=5.7



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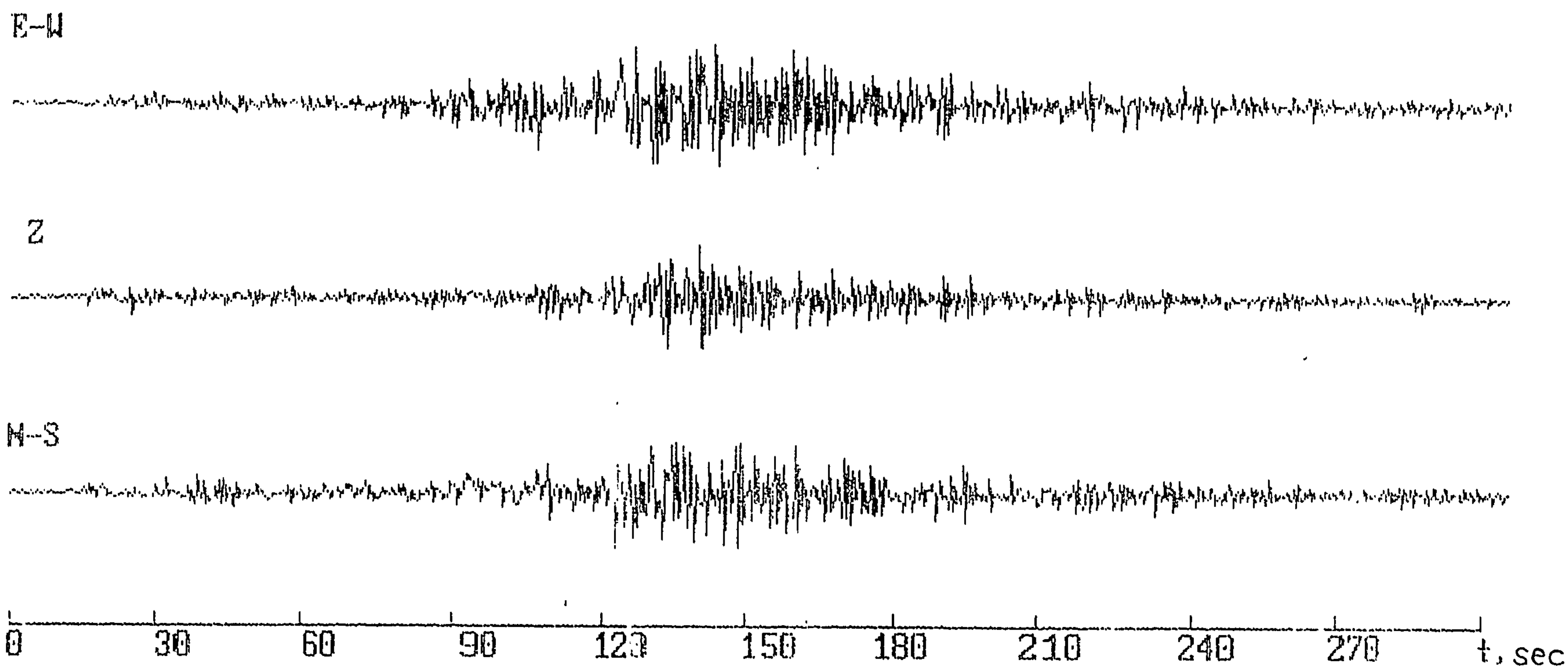
to=04-17-07.7 tp=04-18-49.0 49.87N 78.12E Mb=4.9



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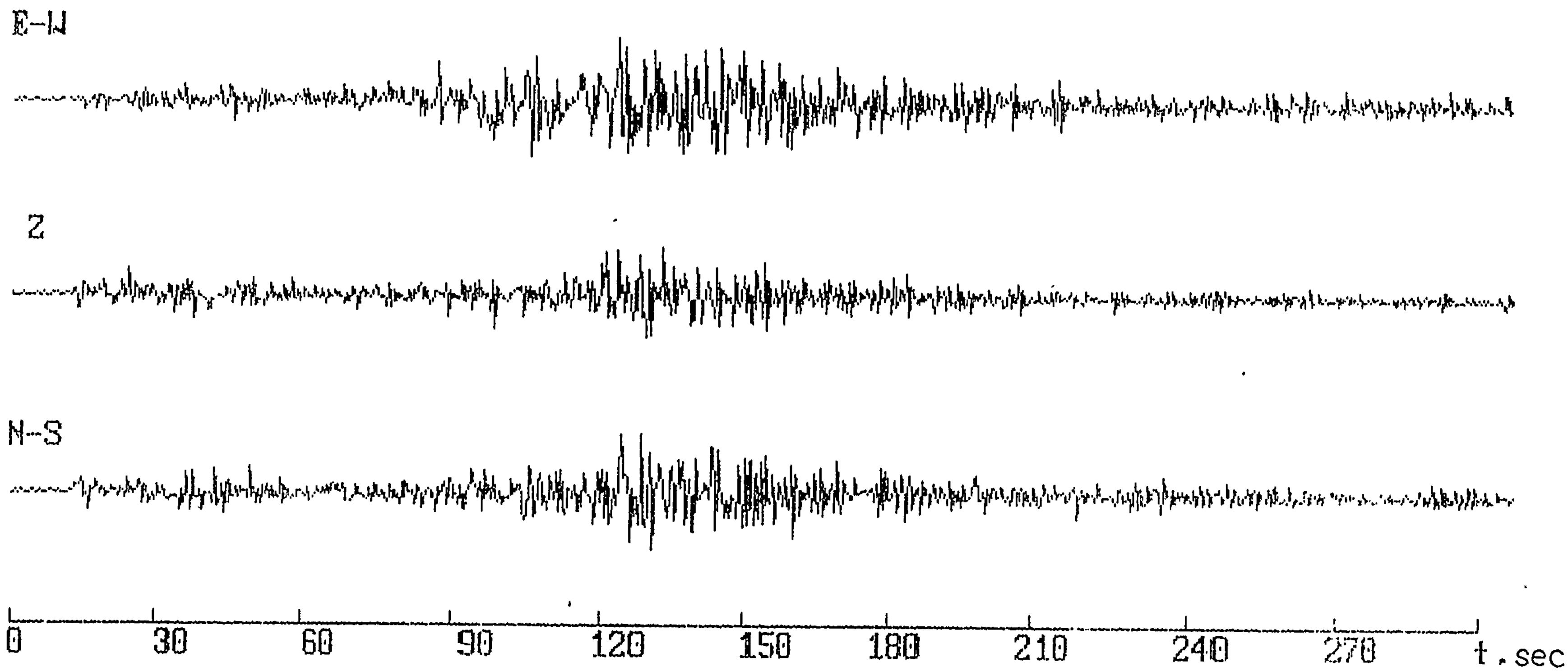

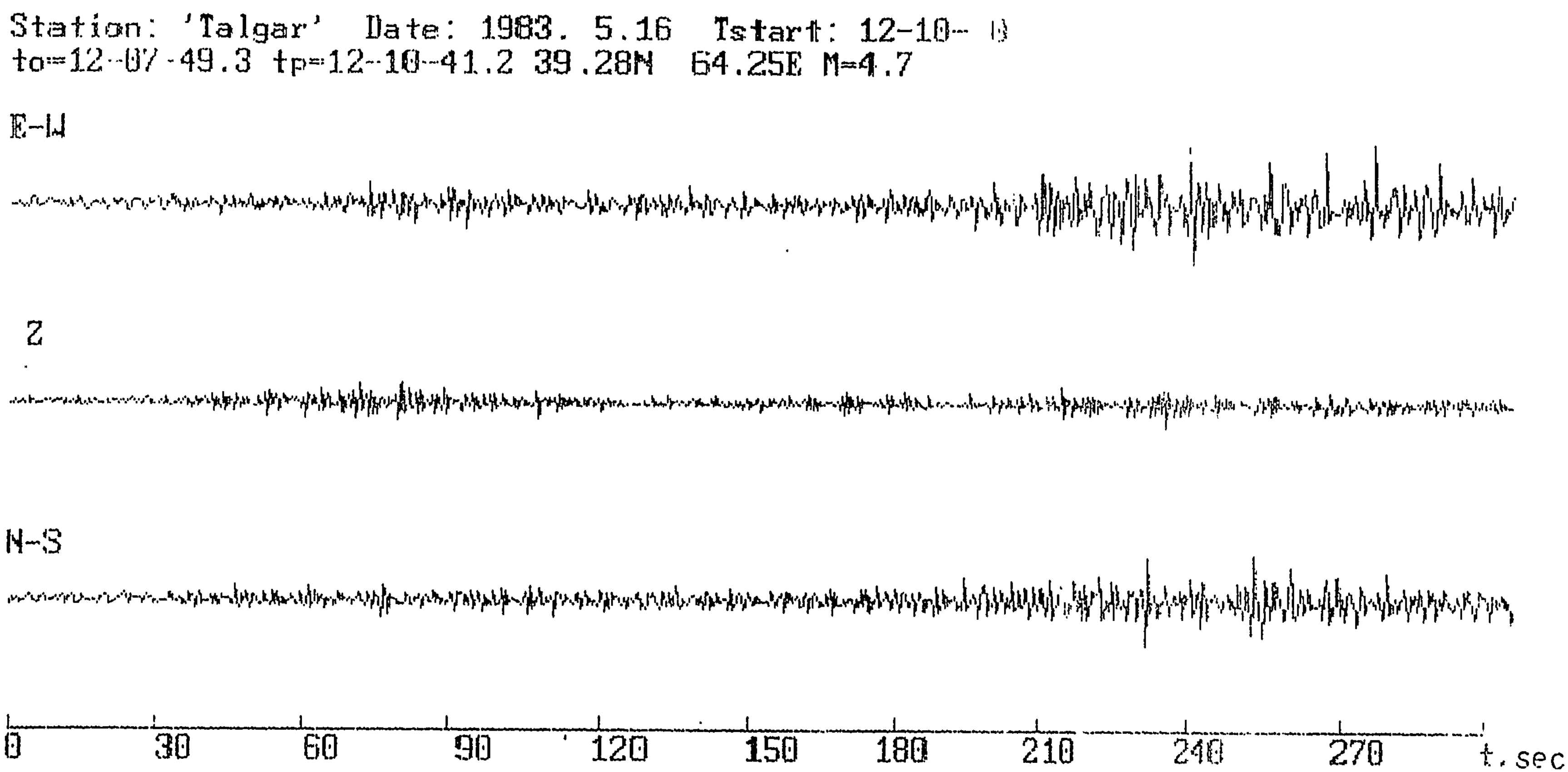
Station: 'Talgar' Date: 1983. 5.16 Tstart: 12-10- 0
to=12-07-49.3 tp=12-10-41.2 39.28N 64.25E M=4.7
E-W
Z
N-S
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240
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t, sec

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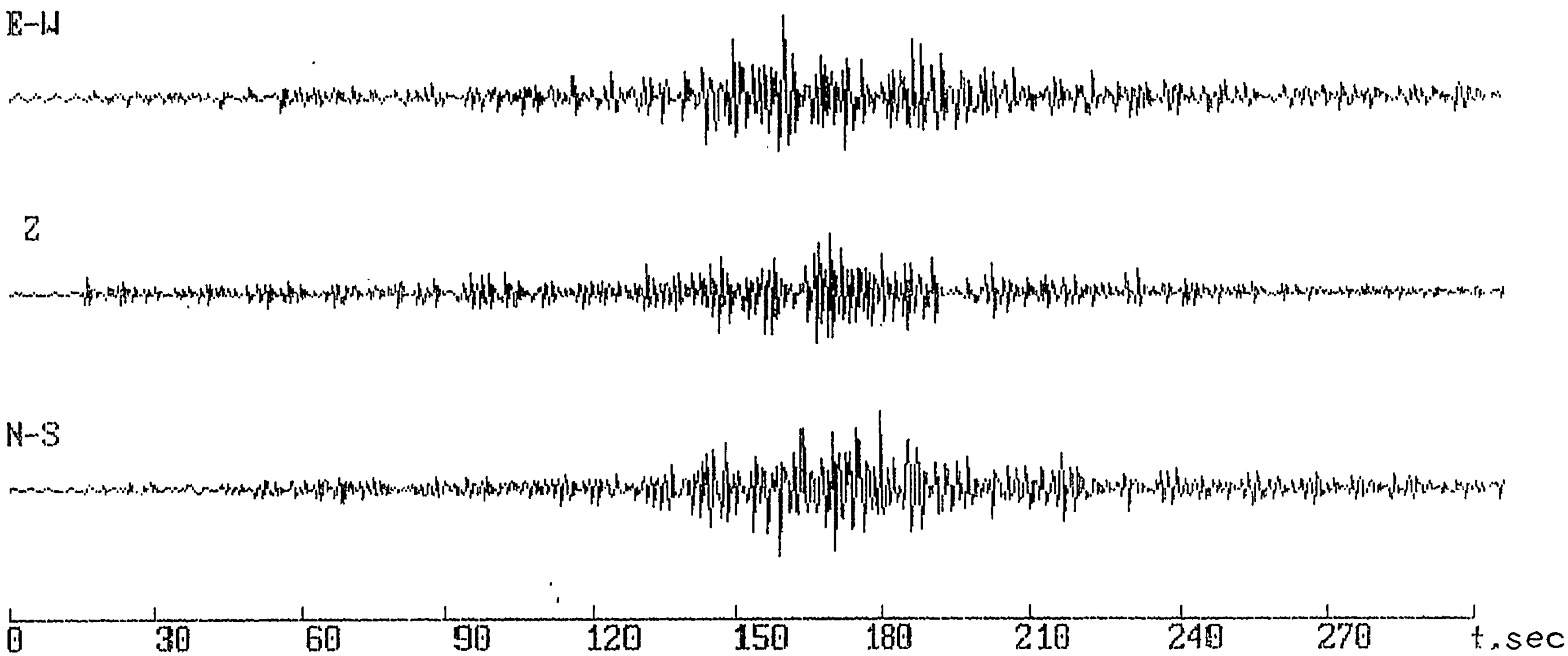

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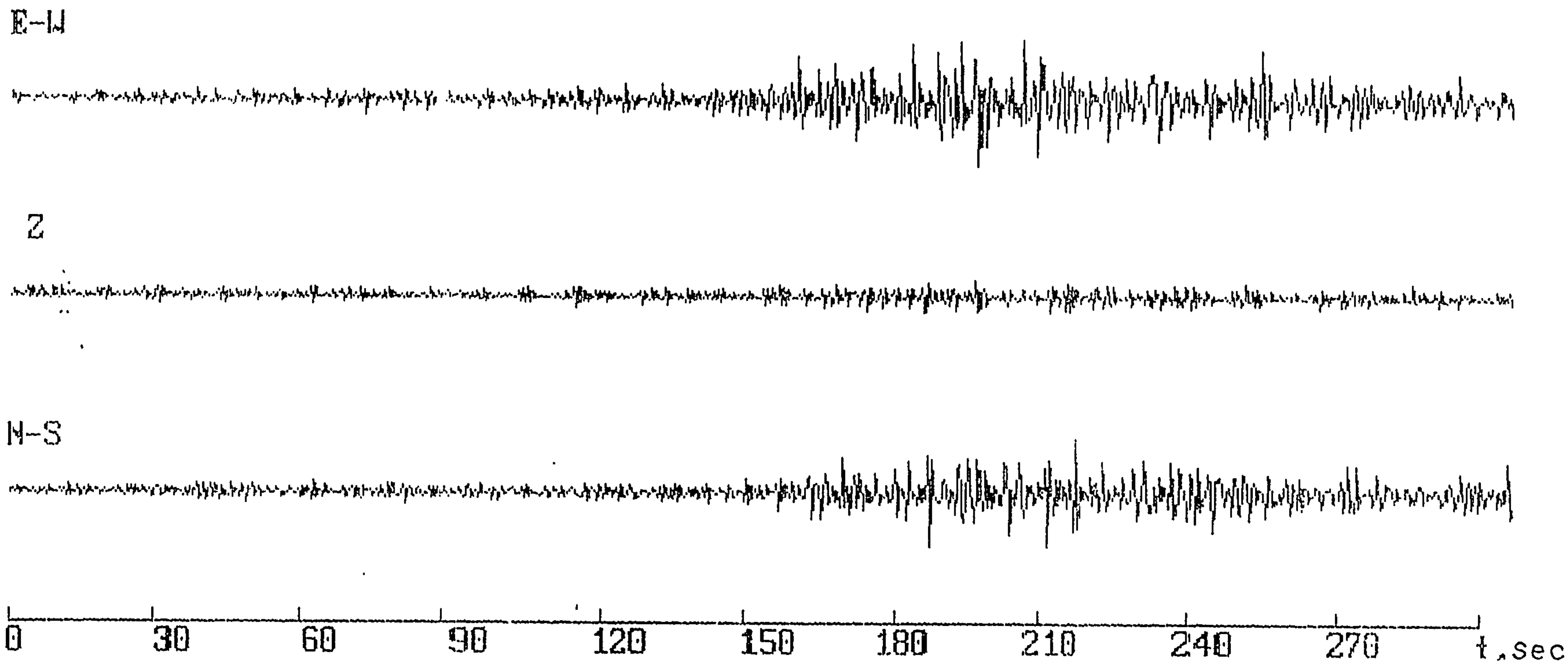

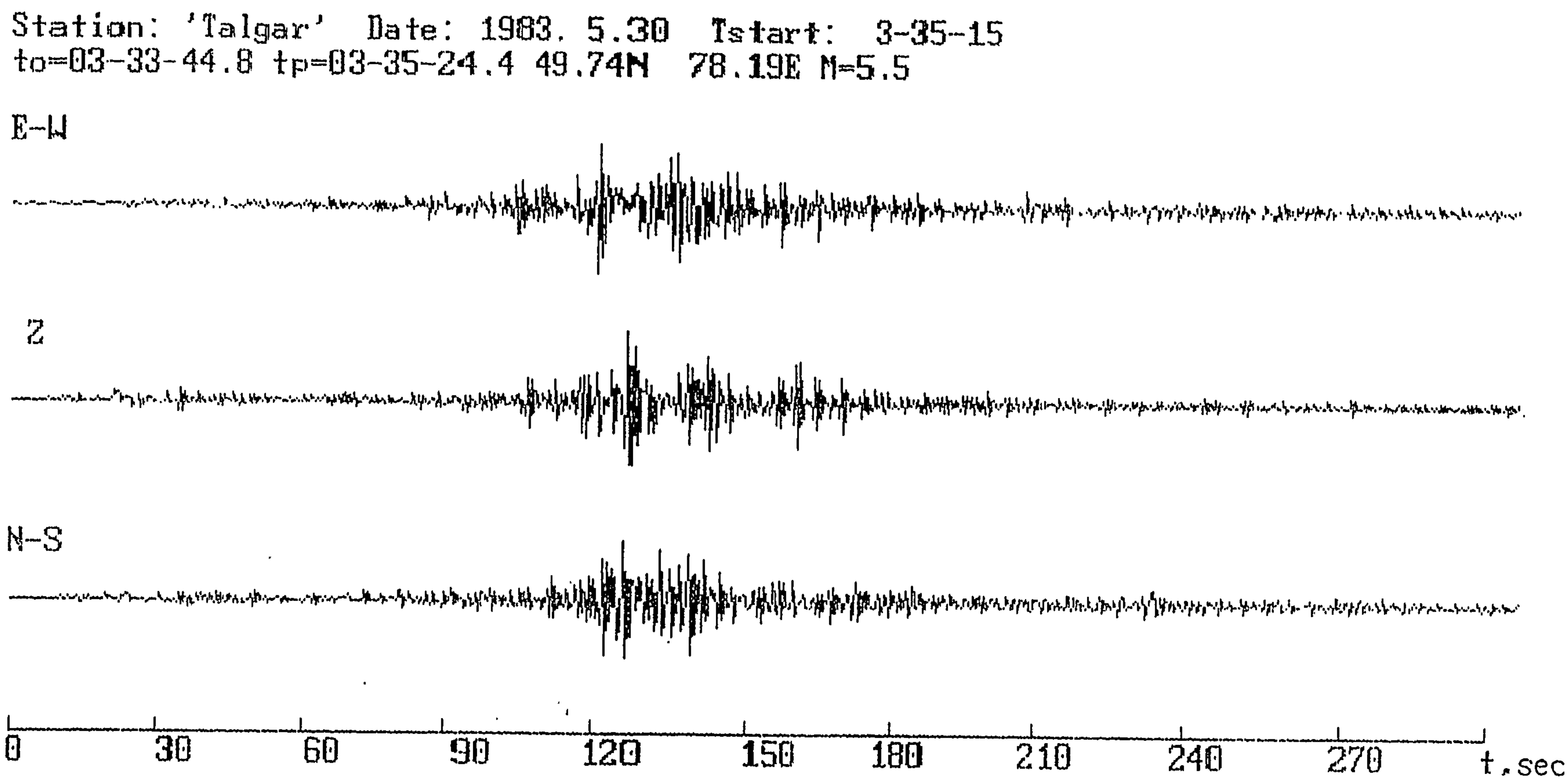
Station: 'Talgar' Date: 1983. 5.30 Tstart: 3-35-15
to=03-33-44.8 tp=03-35-24.4 49.74N 78.19E M=5.5
E-W
Z
N-S
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150
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210
240
270
t,sec

Station: 'Talgar' Date: 1983. 6. 9 Tstart: 6-27-35
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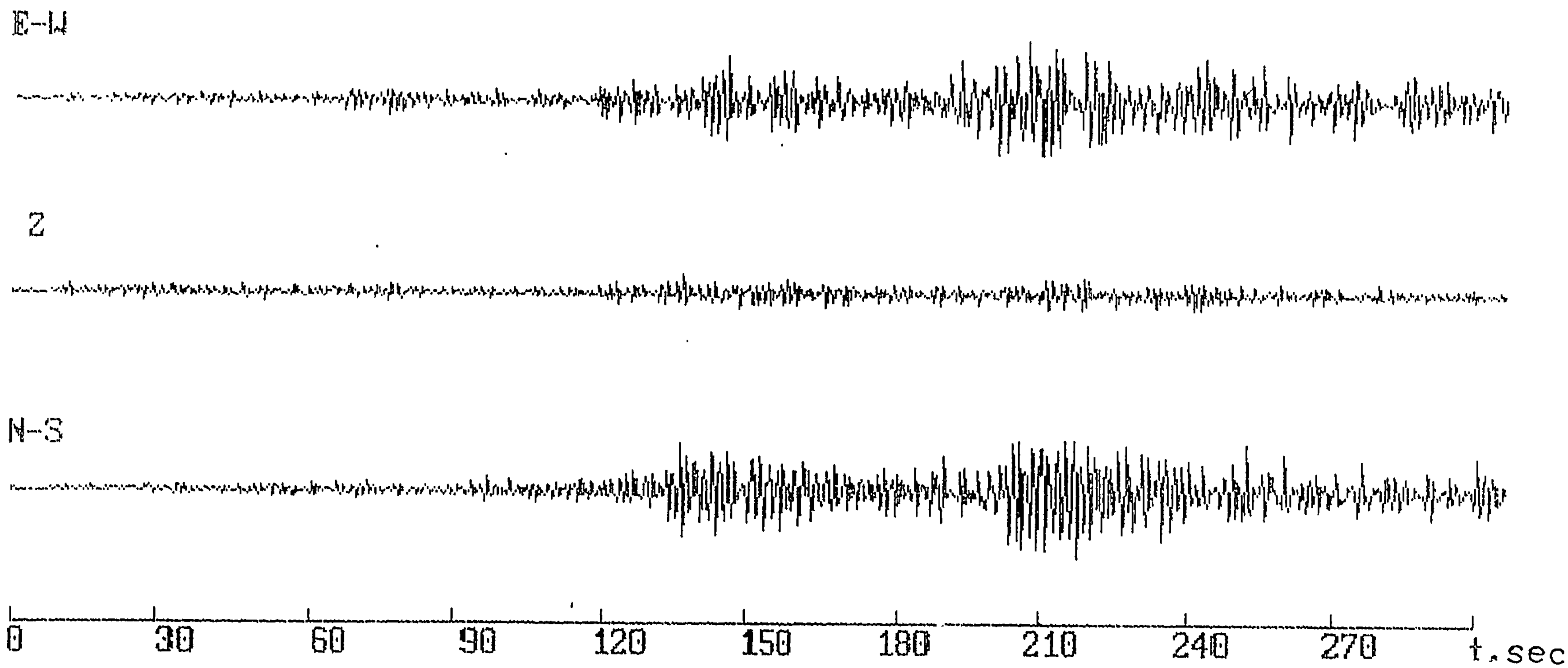
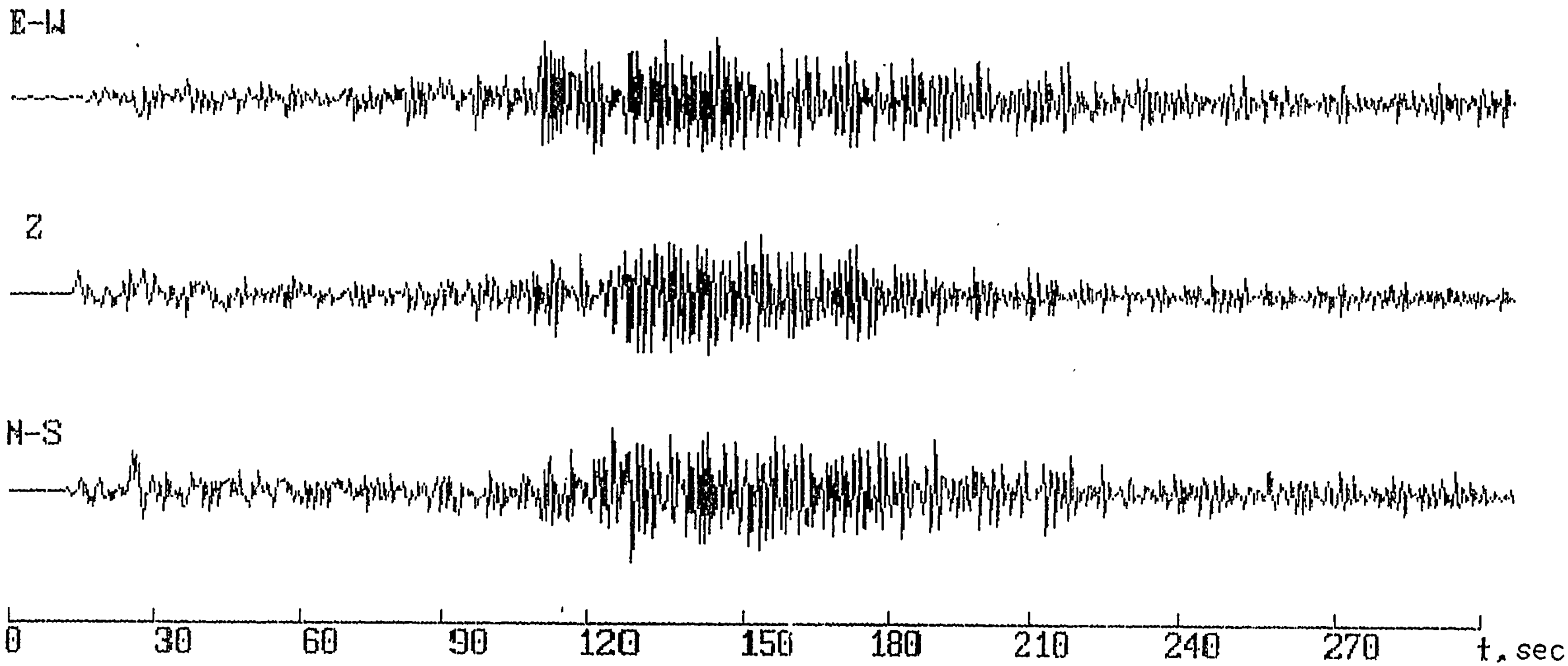
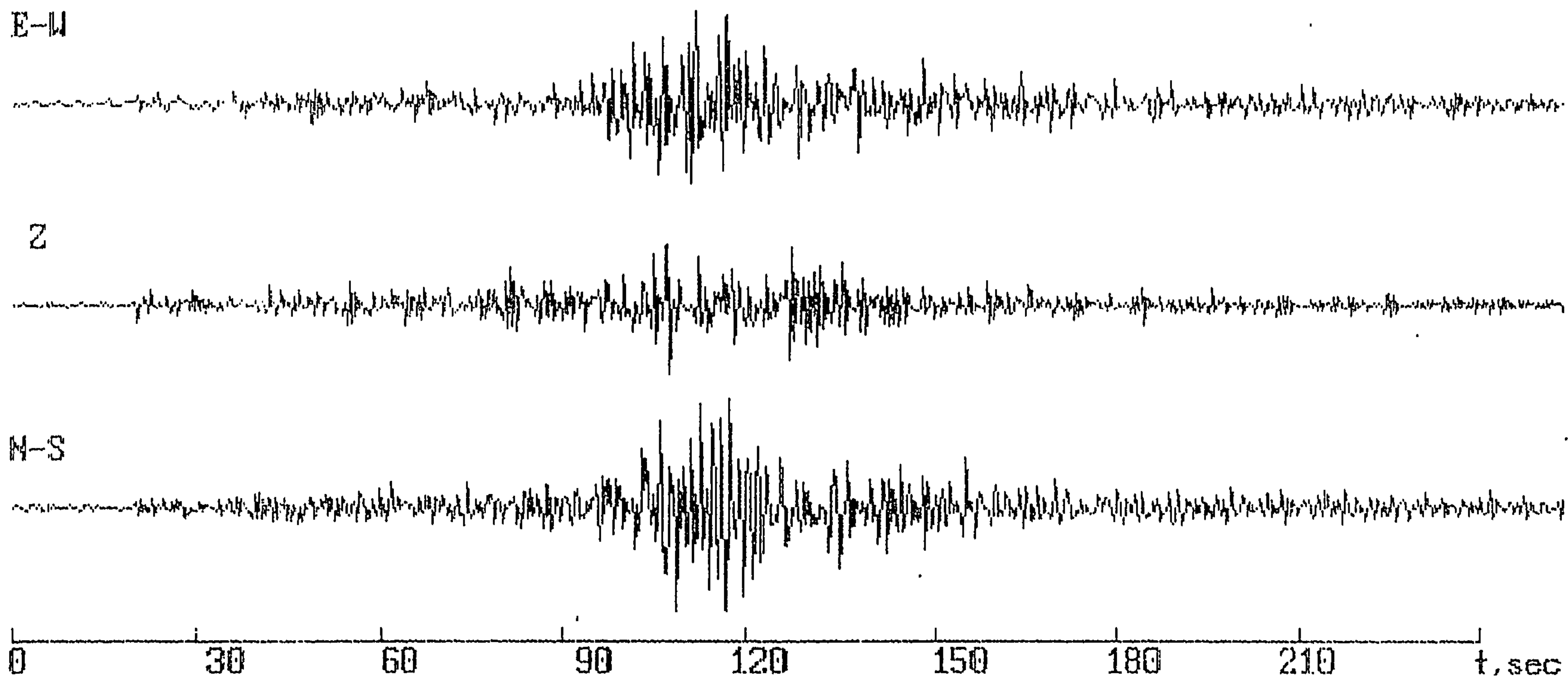
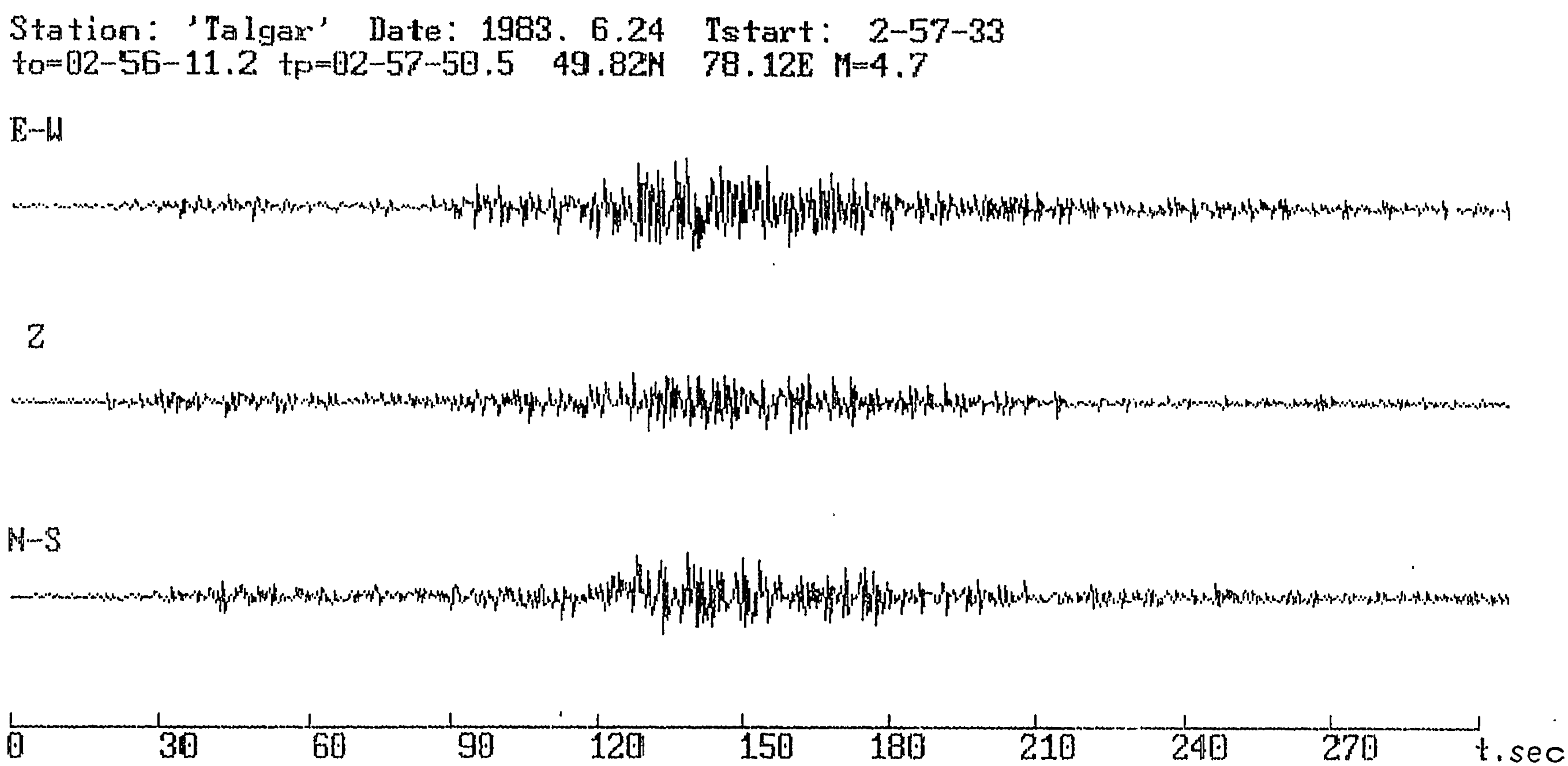


Station: 'Talgar' Date: 1983. 6.12 Tstart: 2-38-15
to=02-36-43.7 tp=02-38-26.6 49.90N 78.97E M=6.1



Station: 'Talgar' Date: 1983. 6.18 Tstart: 12- 7-10
to=12-06-21.0 tp=12-08-50 47.30N 81.60E ML=3.6




Station: 'Talgar' Date: 1983. 6.24 Tstart: 2-57-33
to=02-56-11.2 tp=02-57-50.5 49.82N 78.12E M=4.7
E-W
Z
N-S
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120
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180
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240
270
t.sec

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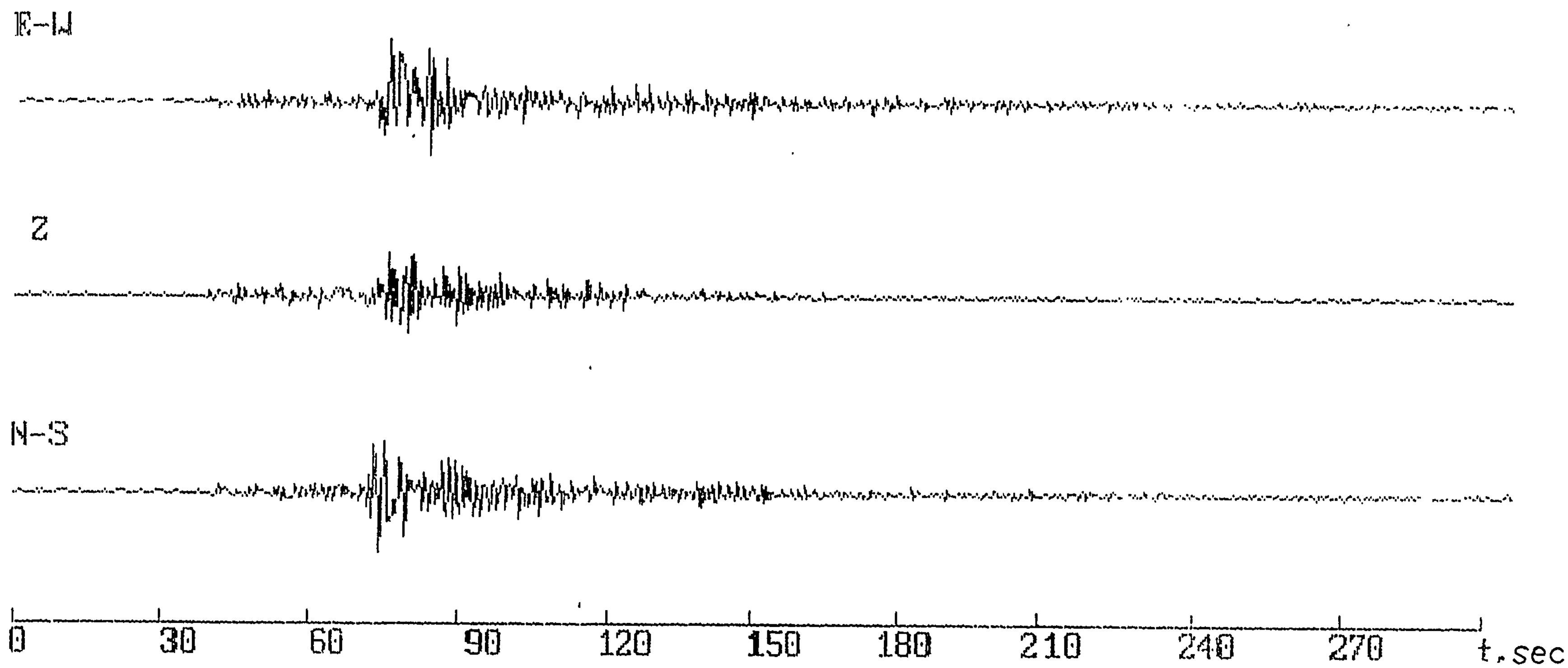
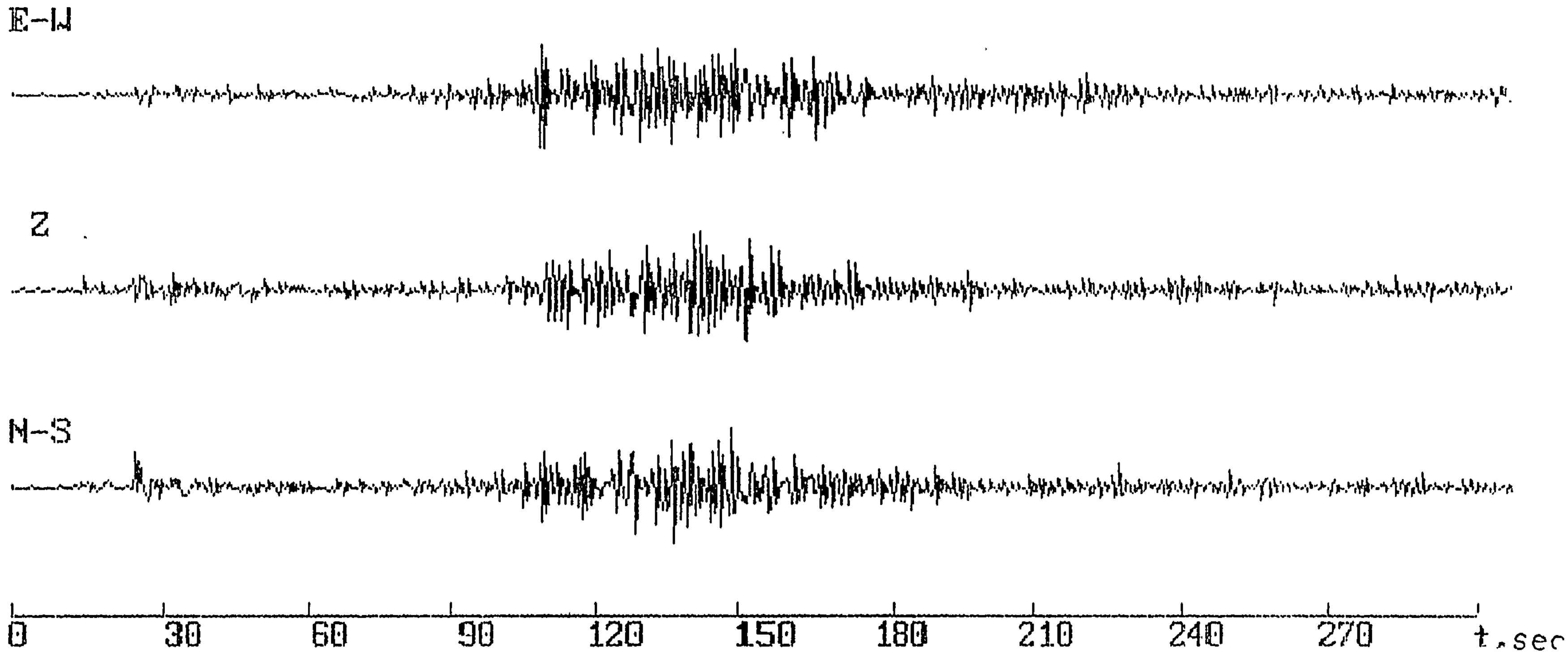
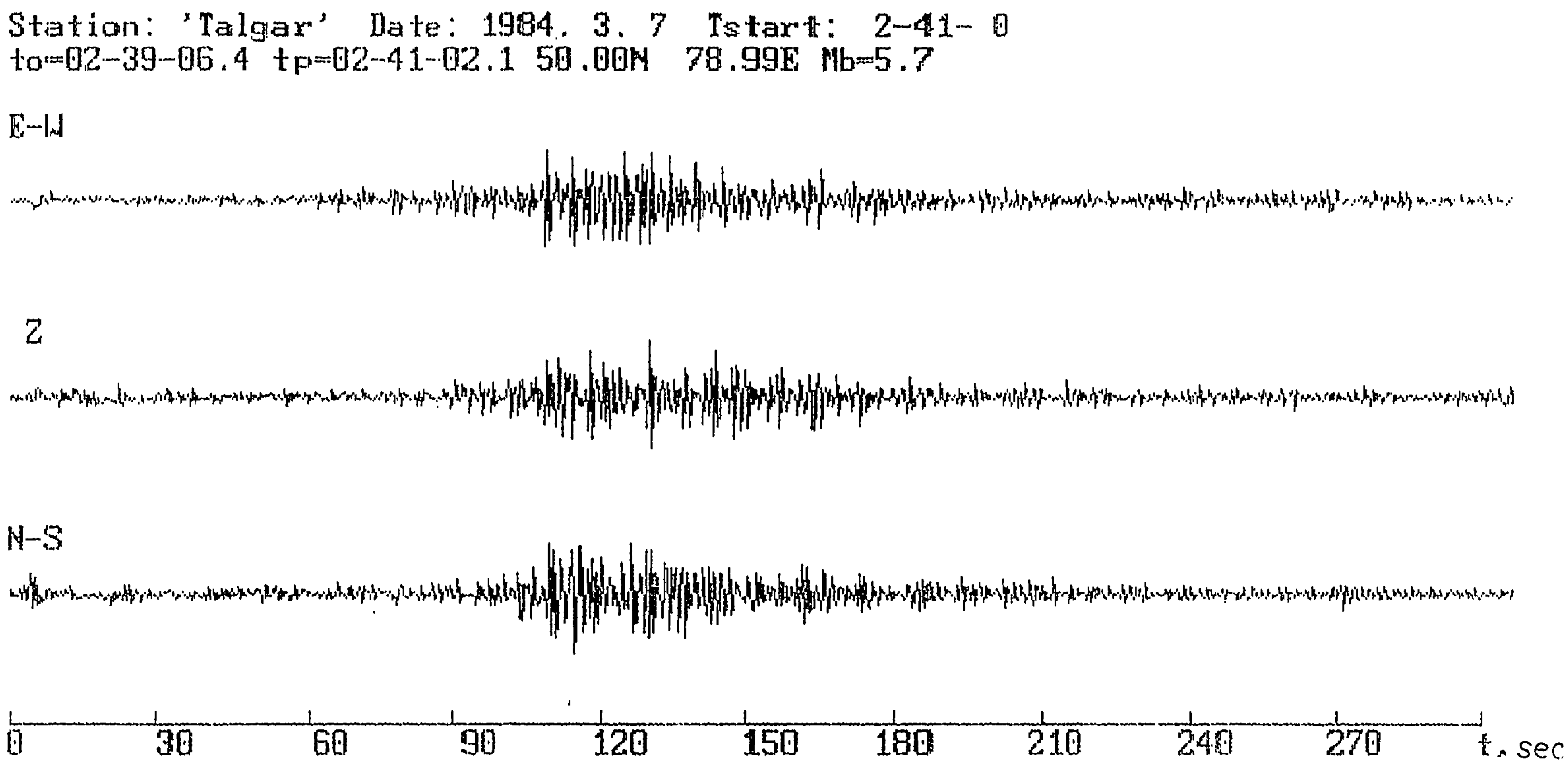
to=21-39-58.5 tp=21-47 43.32N 45.70E M=4.6 H=16



Station: 'Talgar' Date: 1984. 2.19 Tstart: 3-58-50
to=03-57-03.5 tp=03-58-45.9 49.86N 78.80E M=5.9




Station: 'Talgar' Date: 1984. 3. 7 Tstart: 2-41- 0
to=02-39-06.4 tp=02-41-02.1 50.00N 78.99E Mb=5.7
E-W
Z
N-S
0
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120
150
180
210
240
270
t, sec

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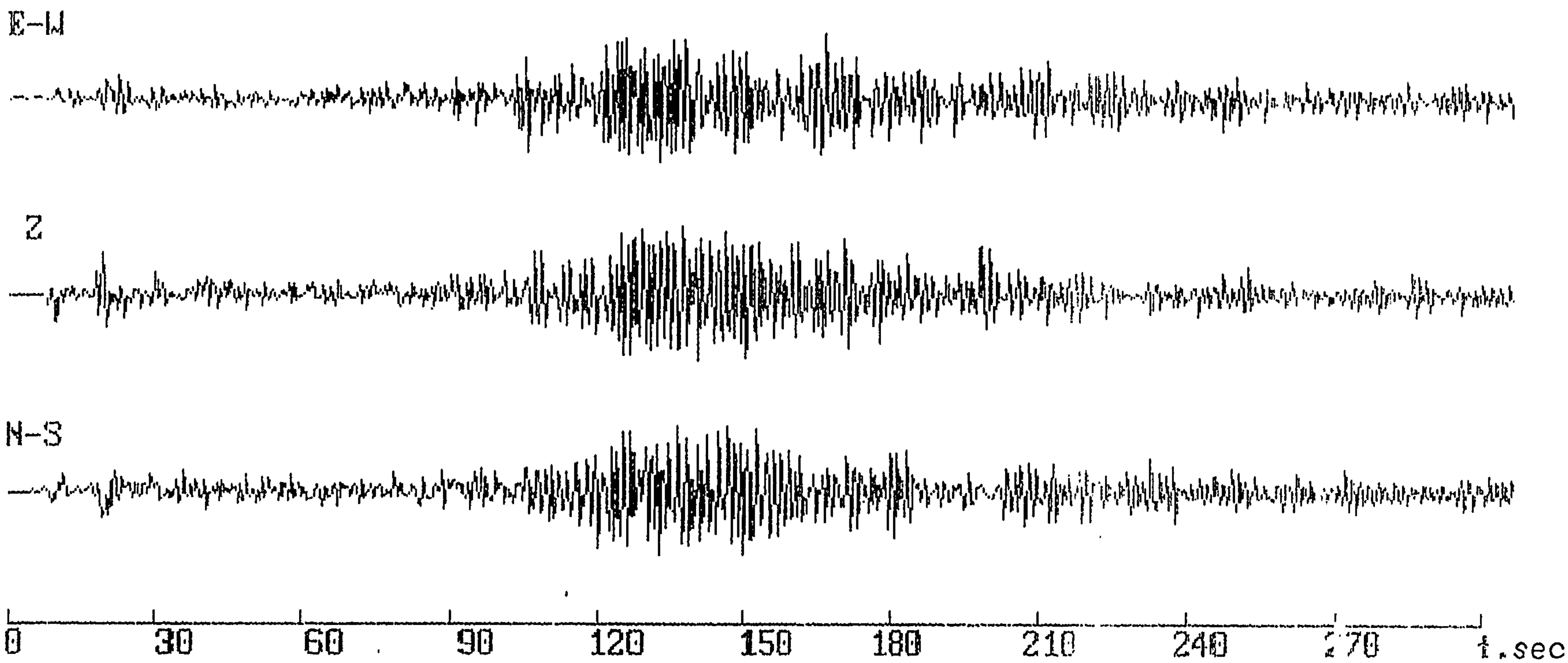
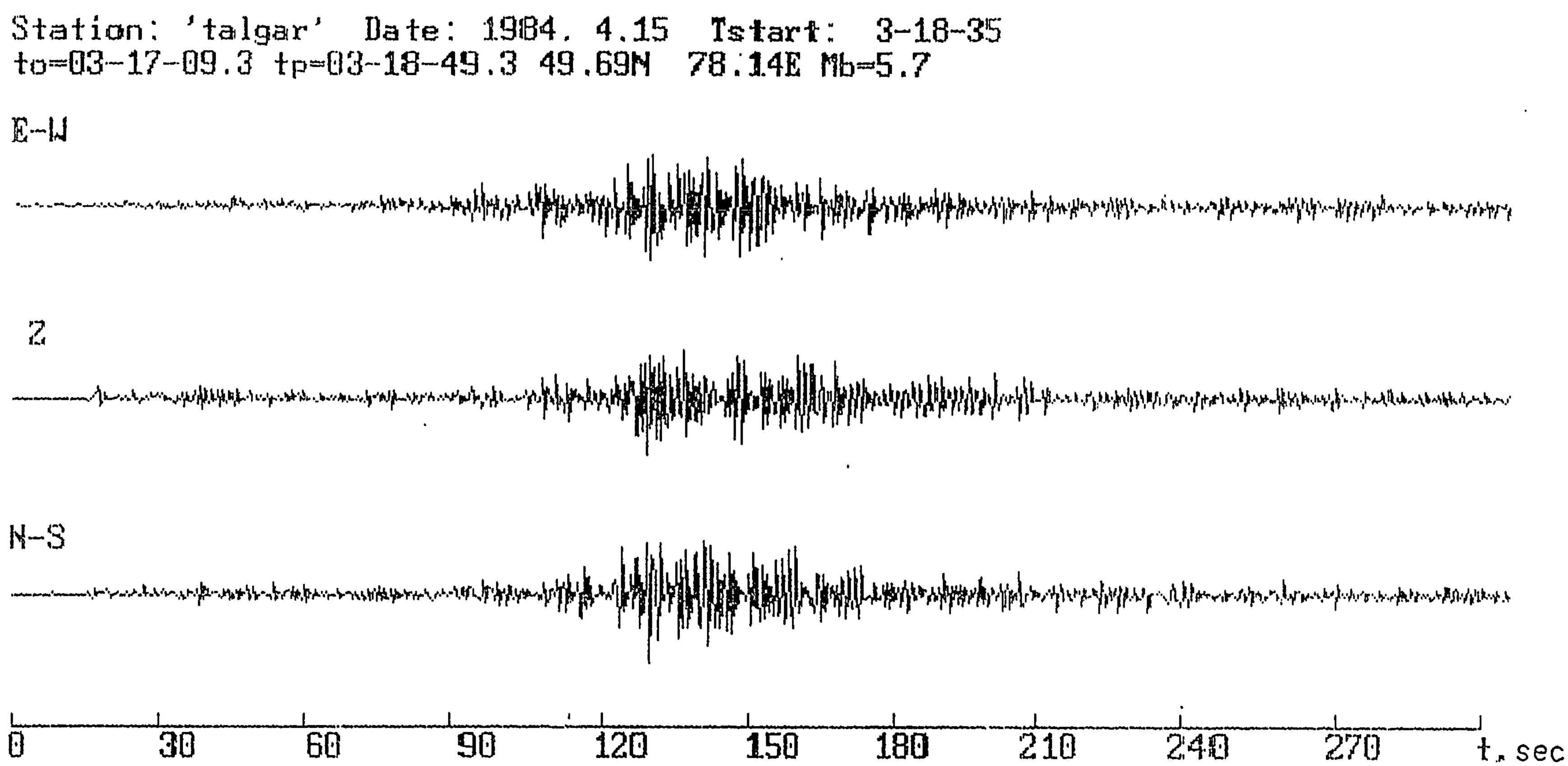
to=05-19-08.3 tp=05-21-14 49.87N 78.97E M=5.9




Station: 'talgar' Date: 1984. 4.15 Tstart: 3-18-35
to=03-17-09.3 tp=03-18-49.3 49.69N 78.14E Mb=5.7
E-W
Z
N-S
0
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120
150
180
210
240
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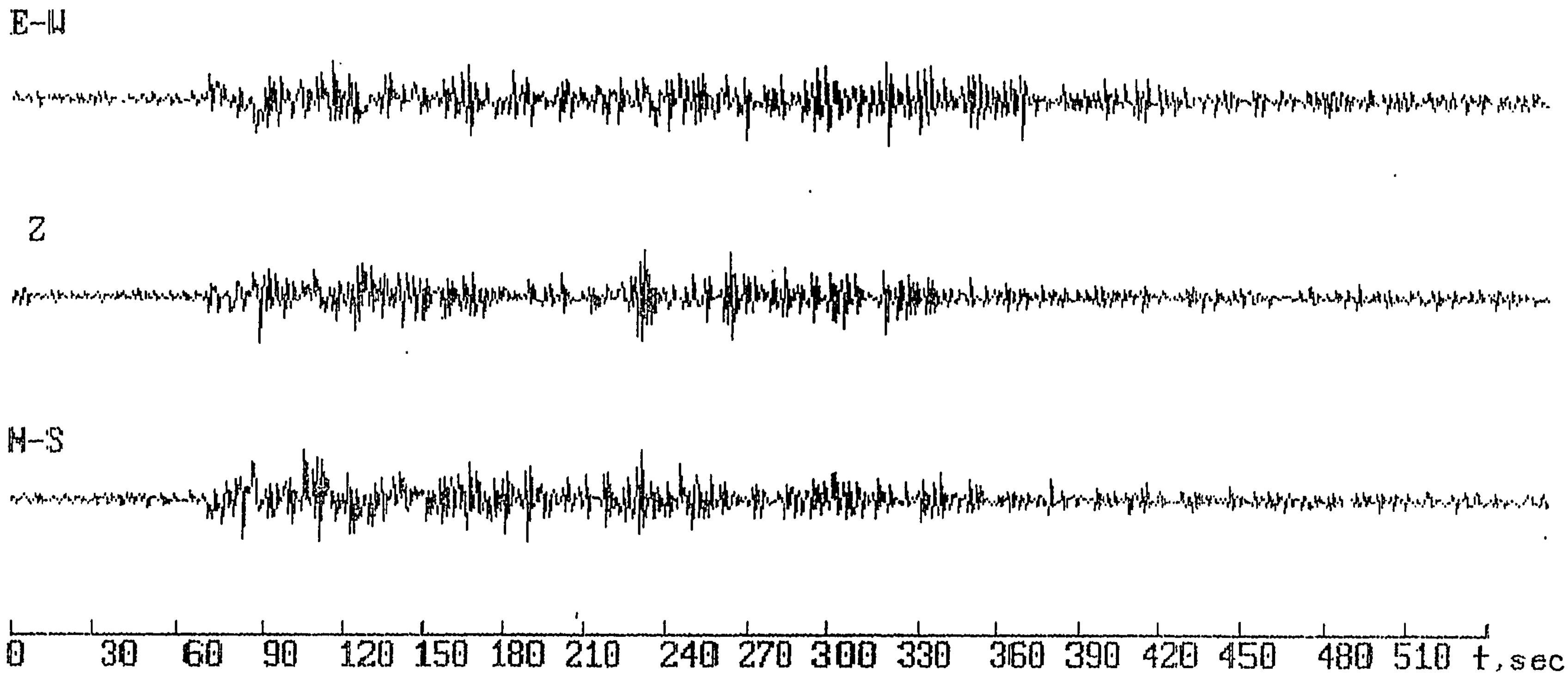
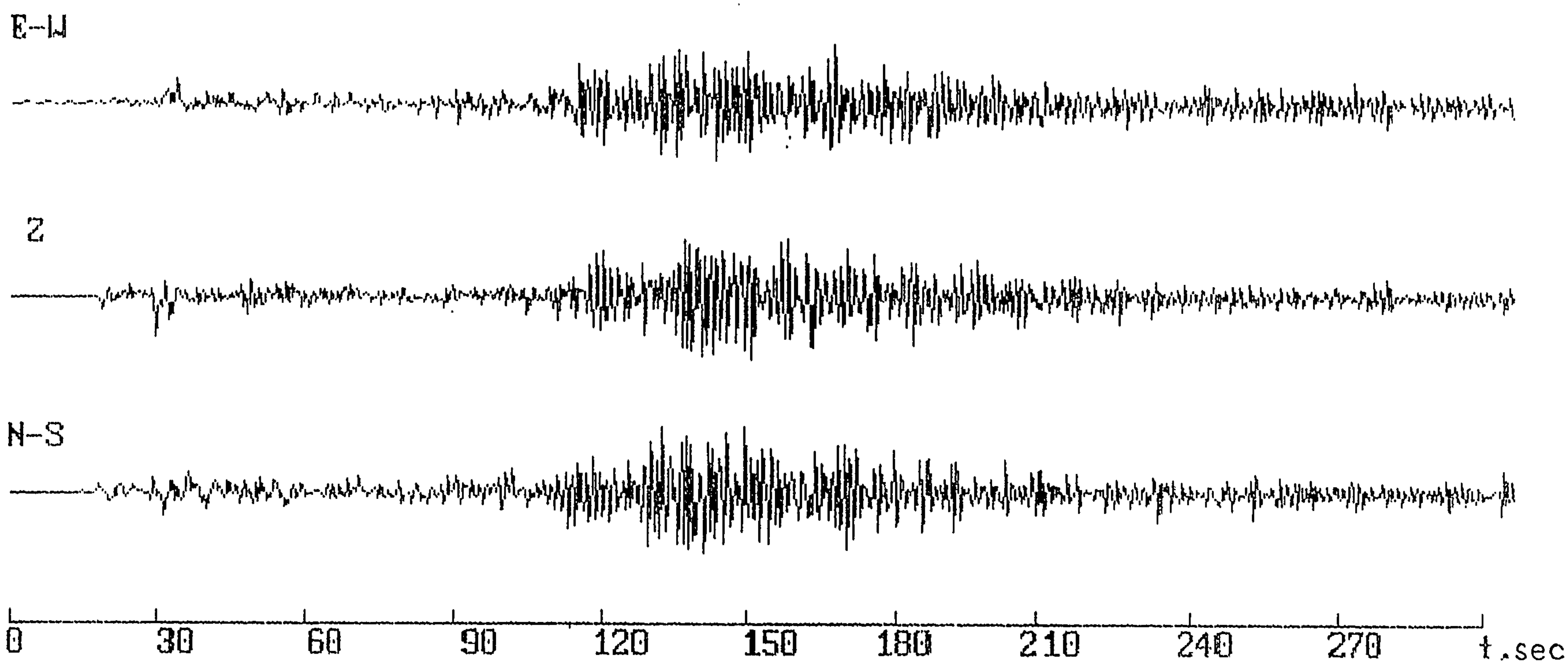
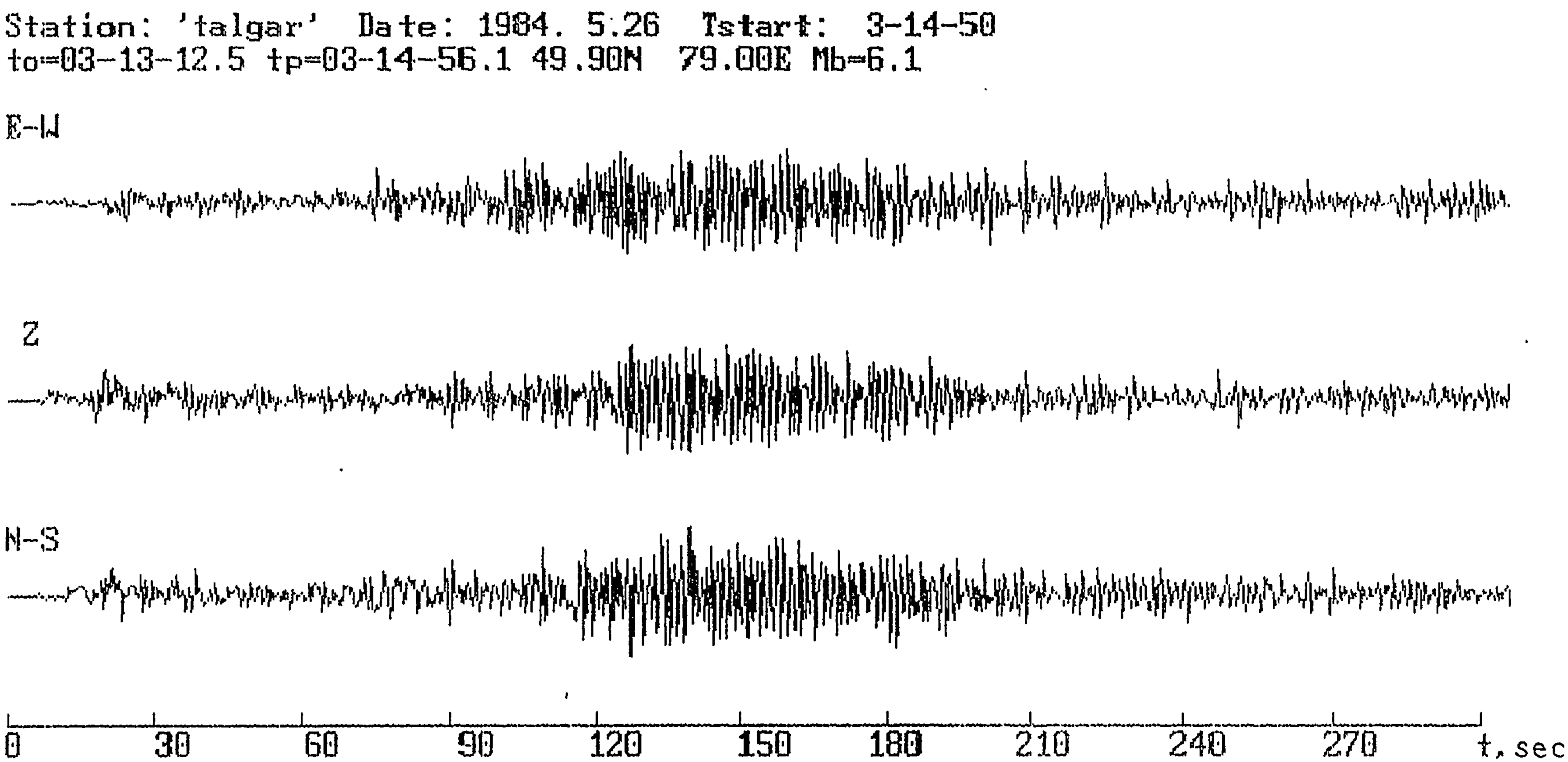
t, sec

Station: 'Talgar' Date: 1984. 4.15 Tstart: 4-58-30
to=04-56-42 tp=04-59-57.8 31.70N 82.20E Mb=5.0



Station: 'Talgar' Date: 1984. 4.25 Tstart: 1-10-30
to=01-09-03.7 tp=01-10-47.1 49.90N 78.90E Mb=6.0




Station: 'talgar' Date: 1984. 5.26 Tstart: 3-14-50
to=03-13-12.5 tp=03-14-56.1 49.90N 79.00E Mb=6.1
E-W
Z
N-S
0
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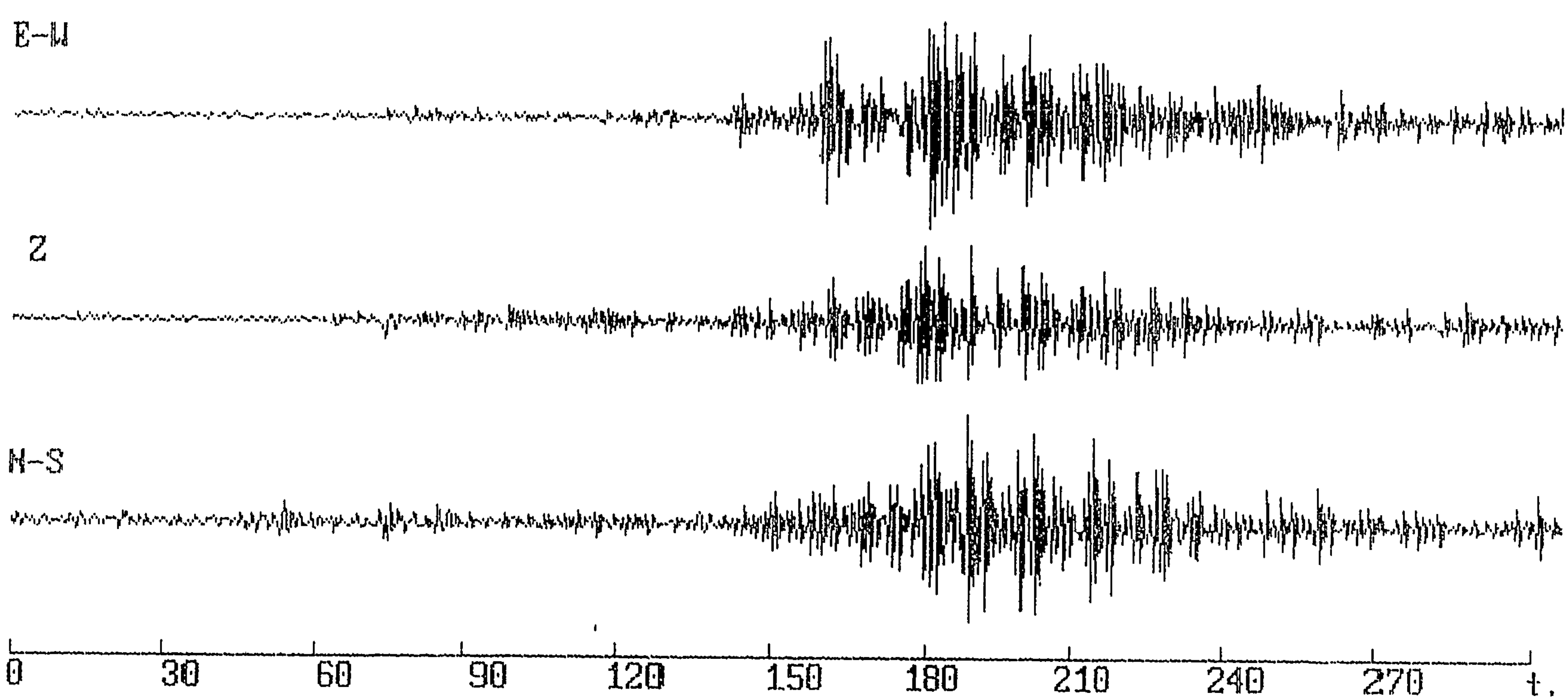
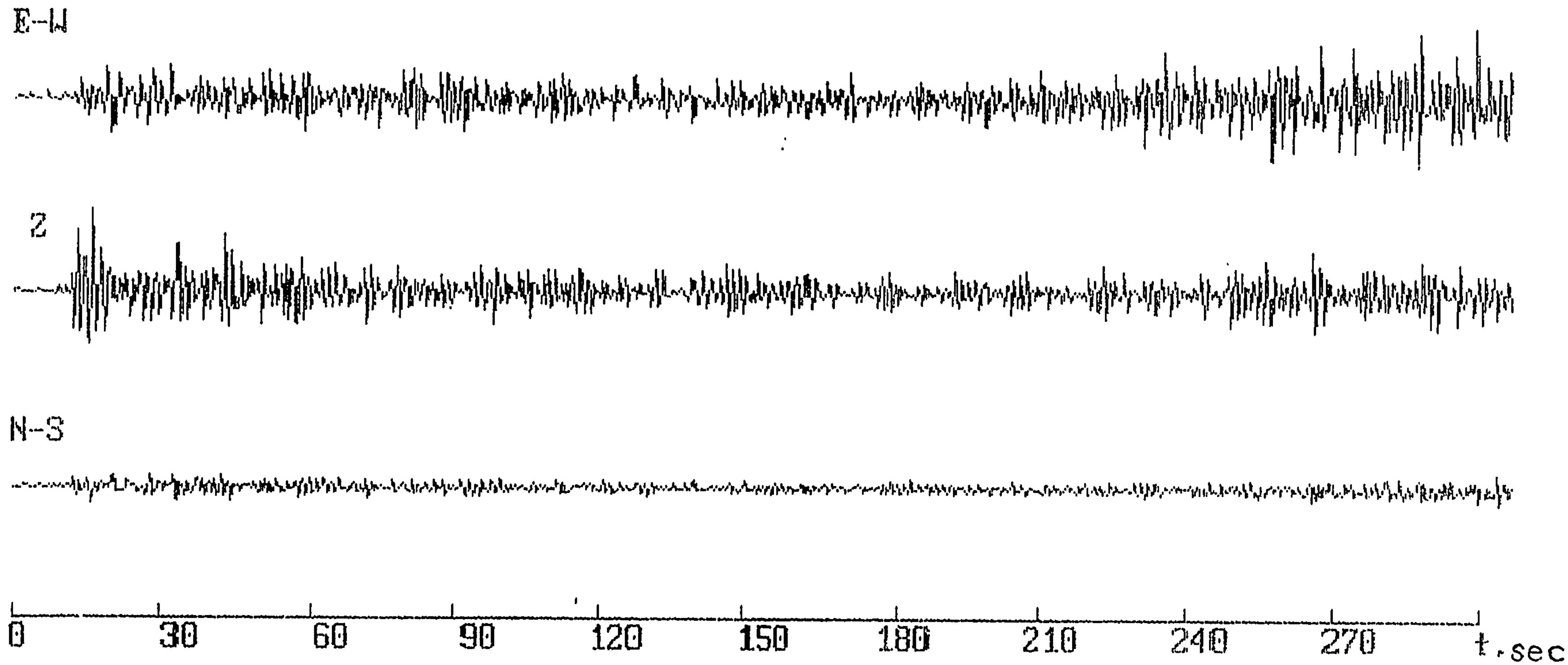
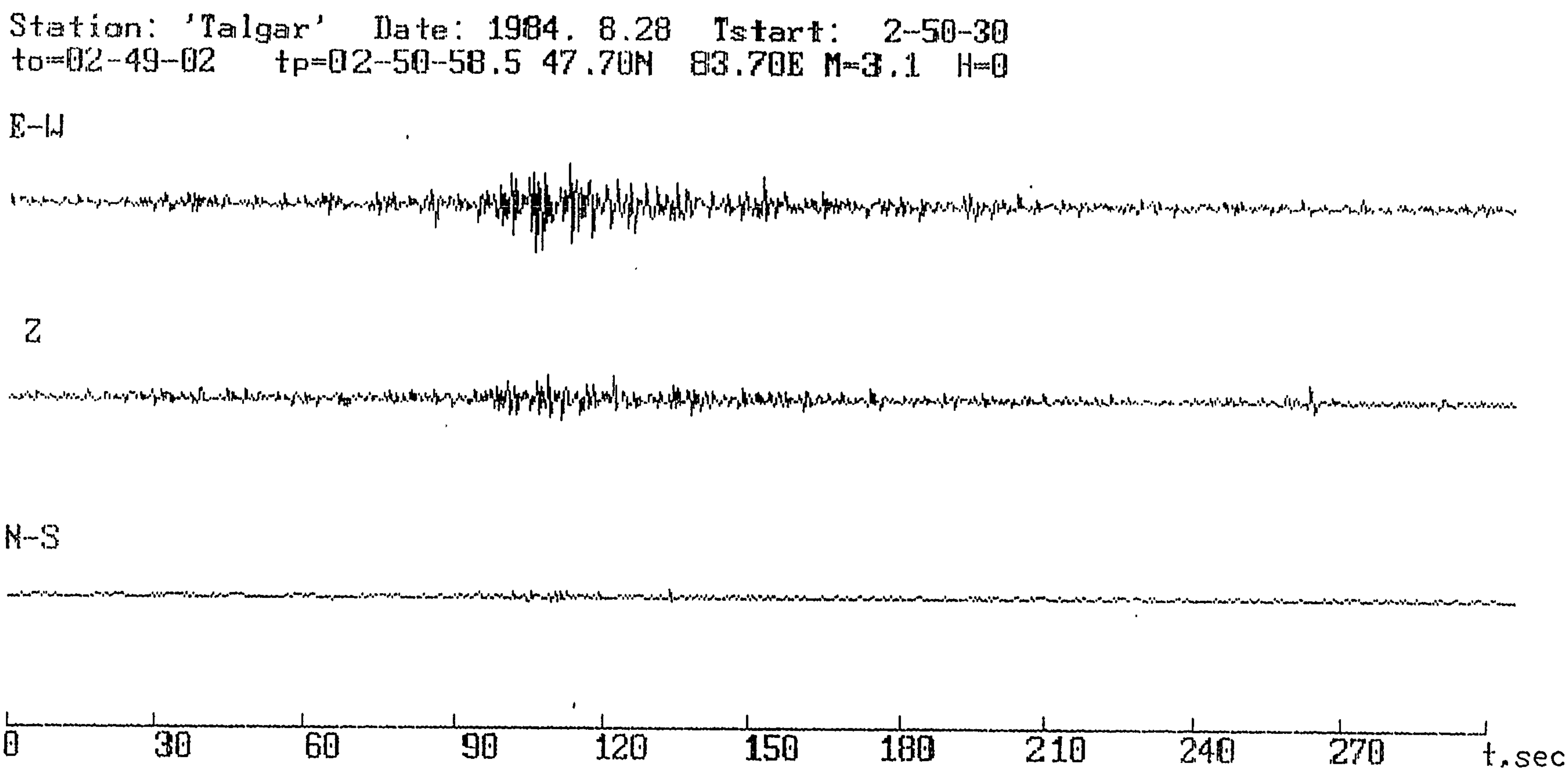
180
210
240
270
t, sec

Station: 'Talgar' Date: 1984. 6.23 Tstart: 2-57-55
to=02-57



Station: 'talgar' Date: 1984. 8.25 Tstart: 19- 4-10
to=18-59-58.7 tp=19-04-18.3 61.88N 72.10E Mb=5.3




Station: 'Talgar'   Date: 1984. 8.28   Tstart: 2-50-30
to=02-49-02   tp=02-50-58.5 47.70N 83.70E M=3.1 H=0
E-W
Z
N-S
0
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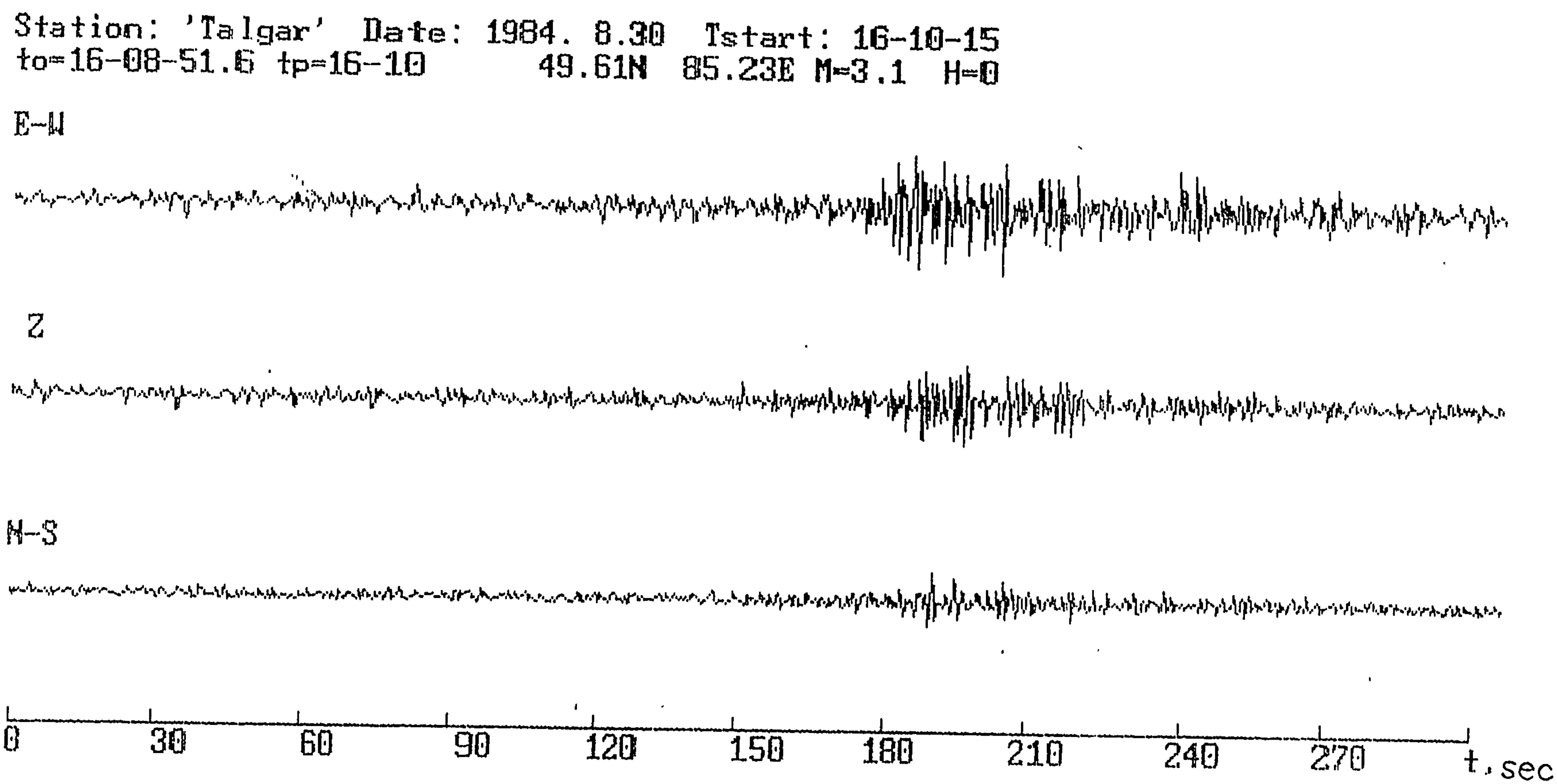
240
270
t,sec


Station: 'Talgar' Date: 1984. 8.30 Tstart: 16-10-15
to=16-08-51.6 tp=16-10 49.61N 85.23E M=3.1 H=0
E-W
Z
N-S
0
30
60
90
120
150
180
210
240
270
t, sec

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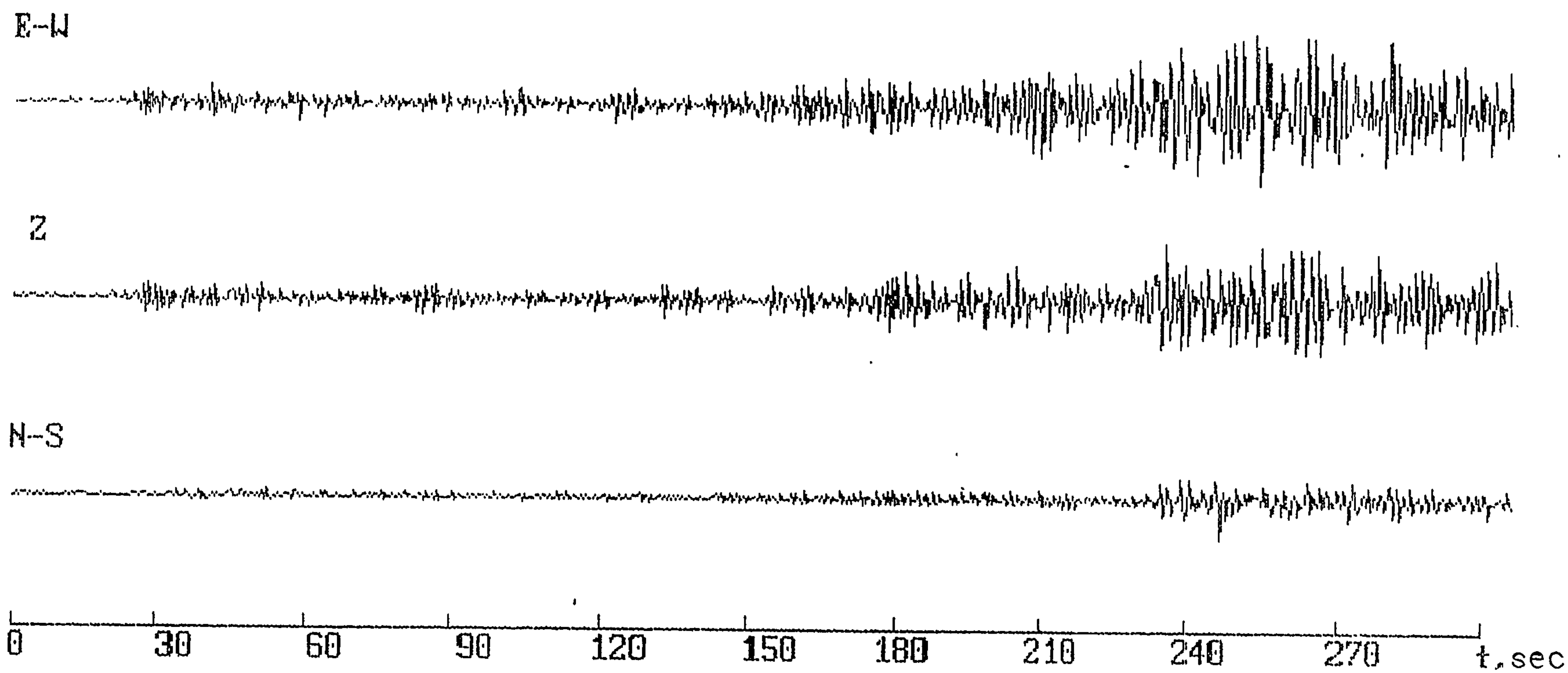
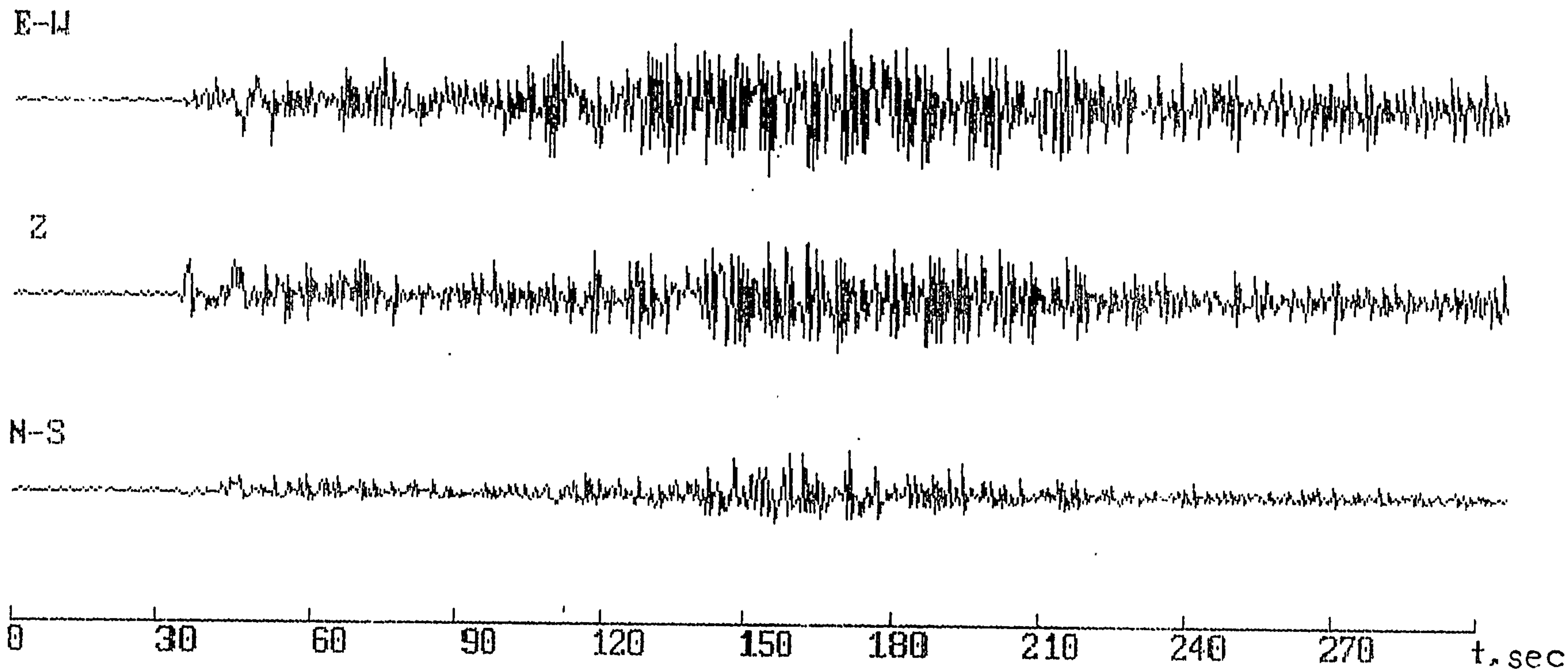
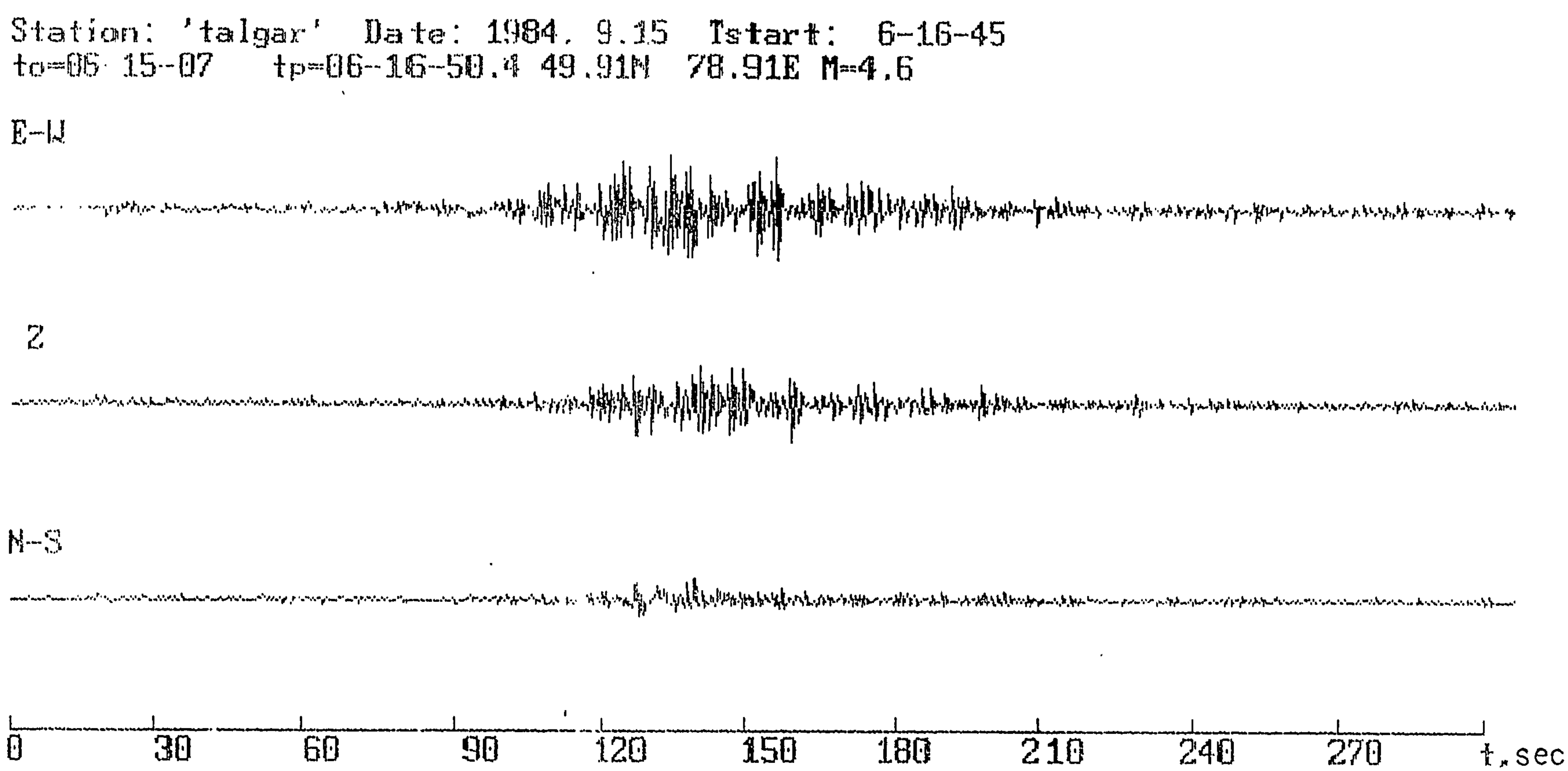
to=05-23-30 tp=05-26-21.1 41.14N 93.14E M=4.9

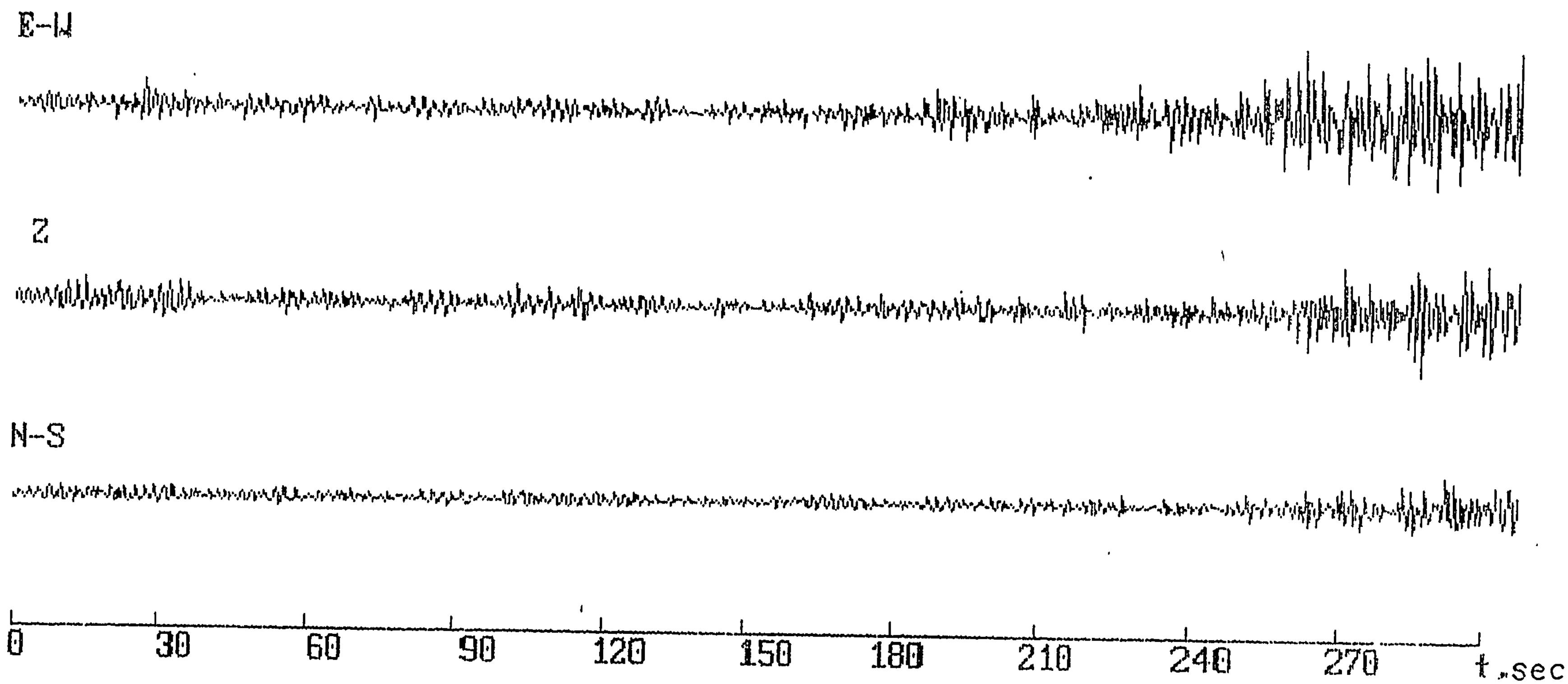


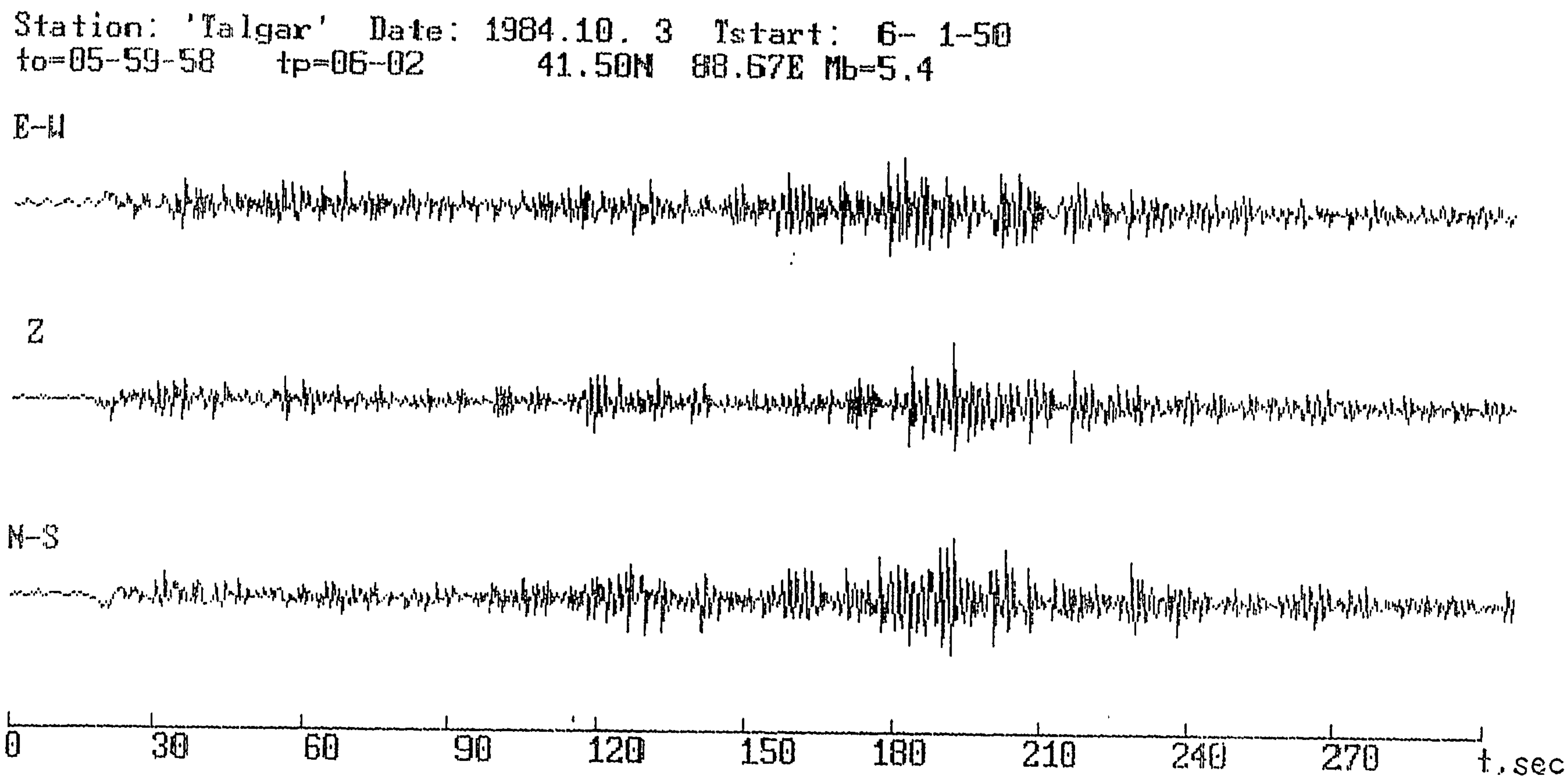
Station: 'Talgar' Date: 1984. 9. 9 Tstart: 3- 0-15
to=02-59-06.5 tp=03-00-47.2 49.80N 78.15E M=5.1



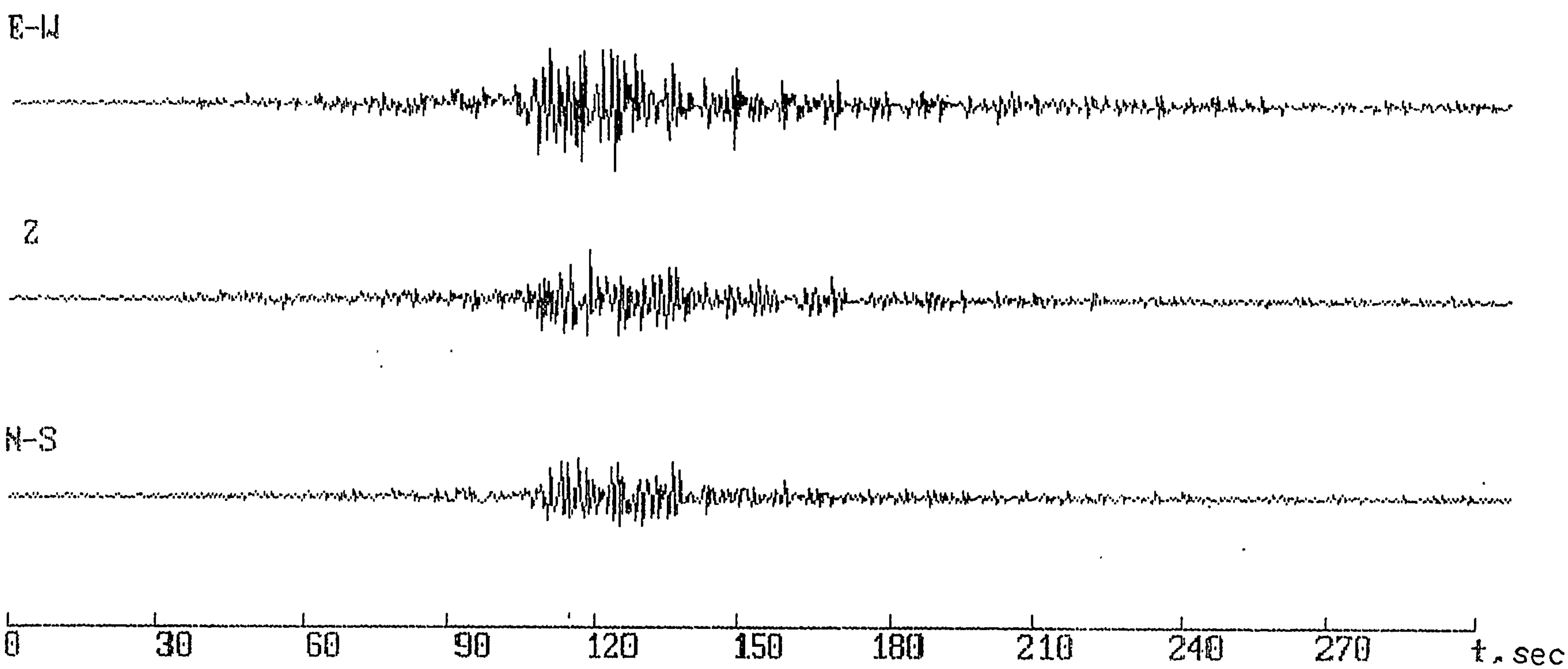

Station: 'talgar' Date: 1984. 9.15 Tstart: 6-16-45
to=06 15-07 tp=06-16-50.4 49.91N 78.91E M=4.6
E-W
Z
N-S
0
30
60
90
120
150
180
210
240
270
t,sec

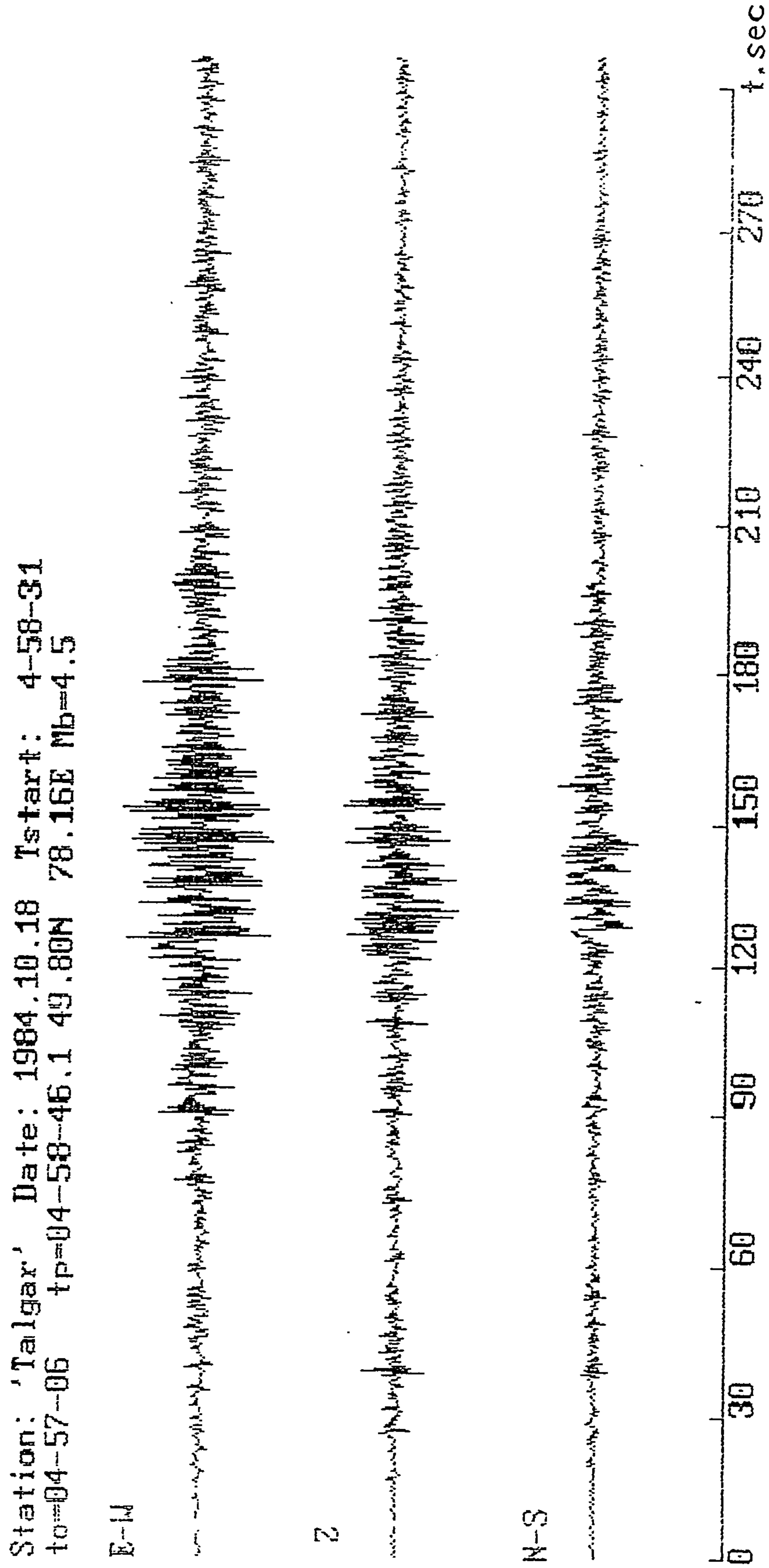
Station: 'Talgar' Date: 1984. 9.17 Tstart: 21- 3-11
to=20-59-57.7 tp=21-03-19.5 55.86N 87.46E M=5.0




Station: 'Talgar' Date: 1984.10. 3 Tstart: 6- 1-50
to=05-59-58 tp=06-02 41.50N 88.67E Mb=5.4
E-W
Z
N-S
0
30
60
90
120
150
180
210
240
270
t, sec

Station: 'Talgar' Date: 1984.10.18 Tstart: 1-12-31
to=01-11-46 tp=01-13-01.1 47.30N 81.70E M=3.5 H=0




Station: 'Talgar'   Date: 1984.10.18   Tstart: 4-58-31
to=04-57-06   tp=04-58-46.1 49.80N 78.16E Mb=4.5
E-W
Z
N-S
0
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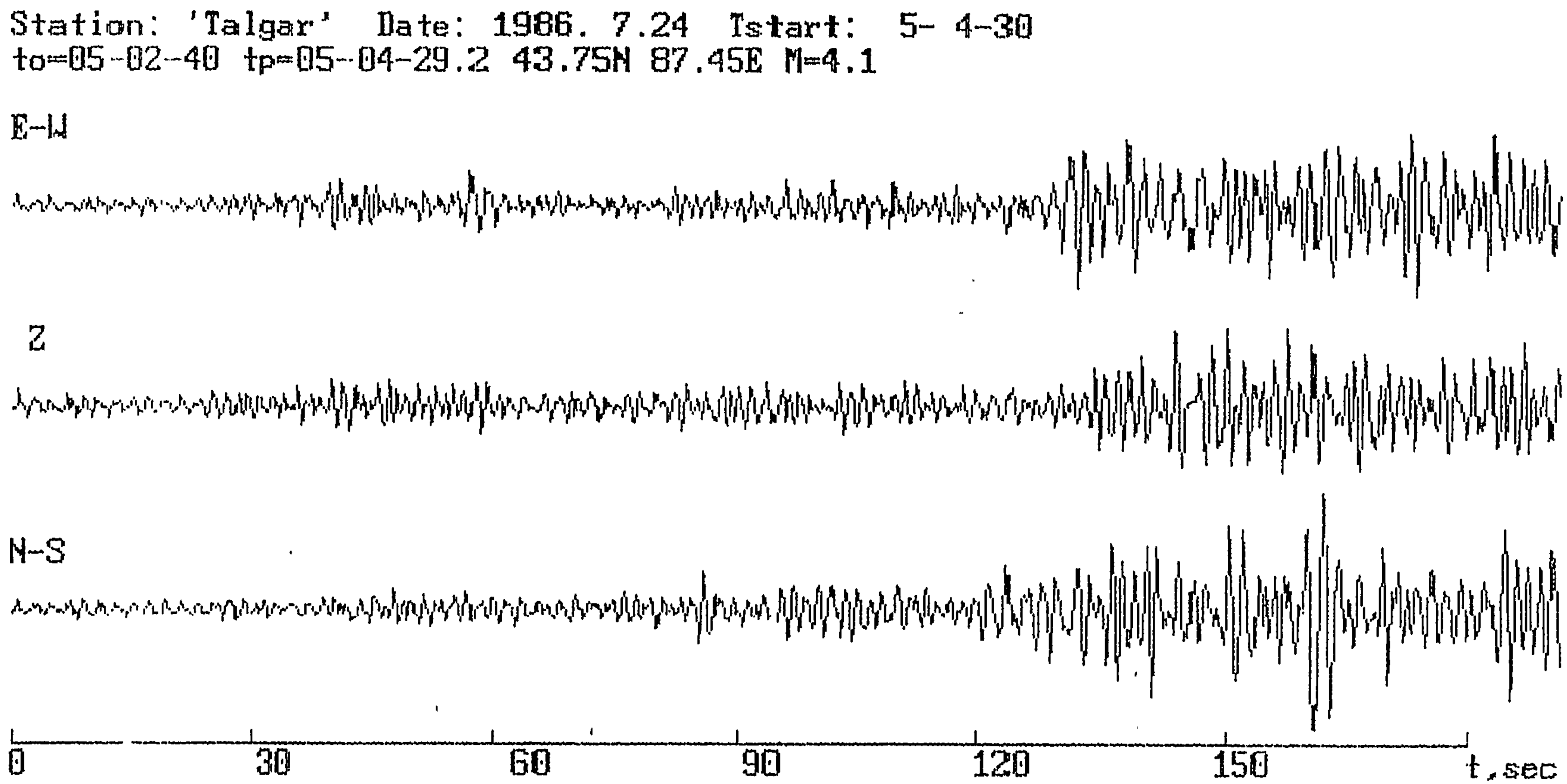
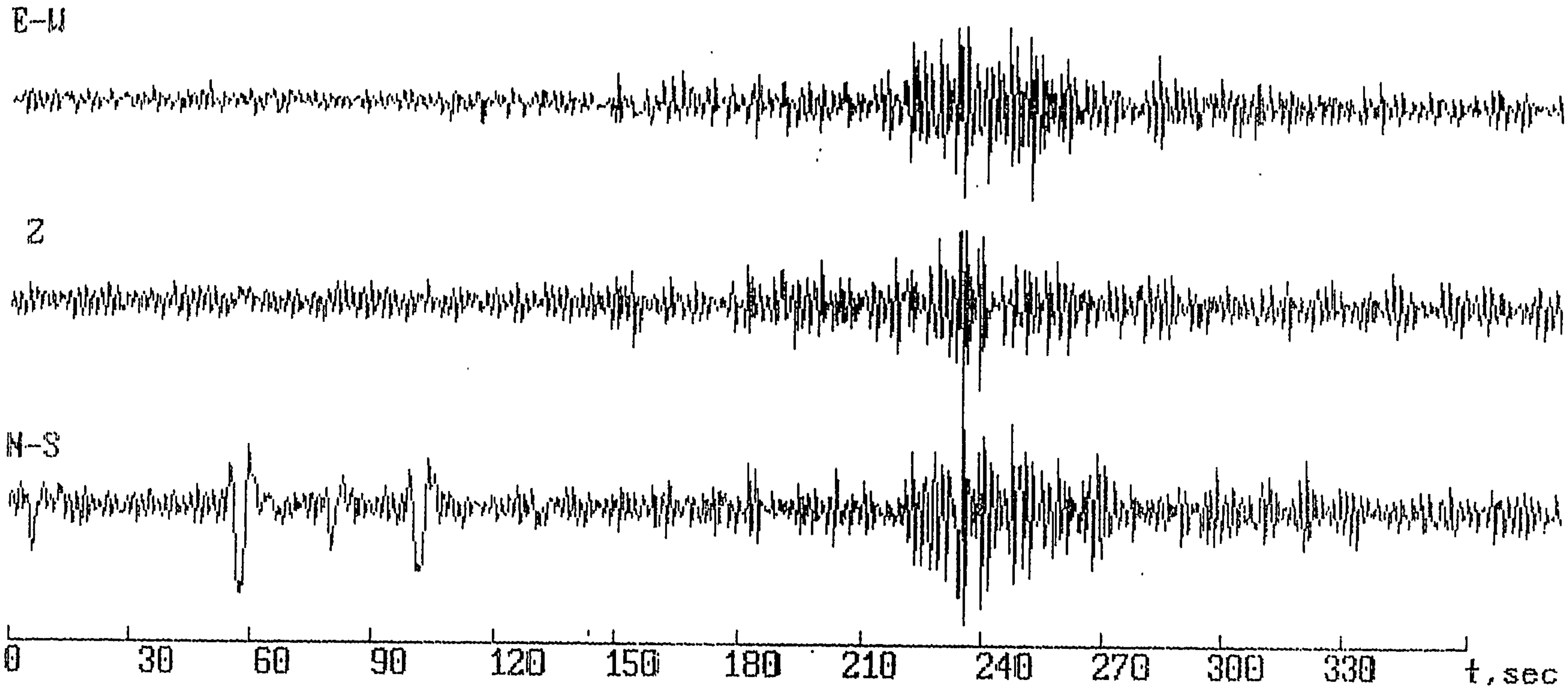
t,sec


Station: 'Talgar' Date: 1986. 7.24 Tstart: 5- 4-30
to=05-02-40 tp=05-04-29.2 43.75N 87.45E M=4.1
E-W
Z
N-S
0
30
60
90
120
150
t,sec

Station: 'Talgar' Date: 1986. 8.24 Tstart: 0-29-20
to=00-27-16 tp=00-29-49.6 41.02N 91.50E Mp=4.2



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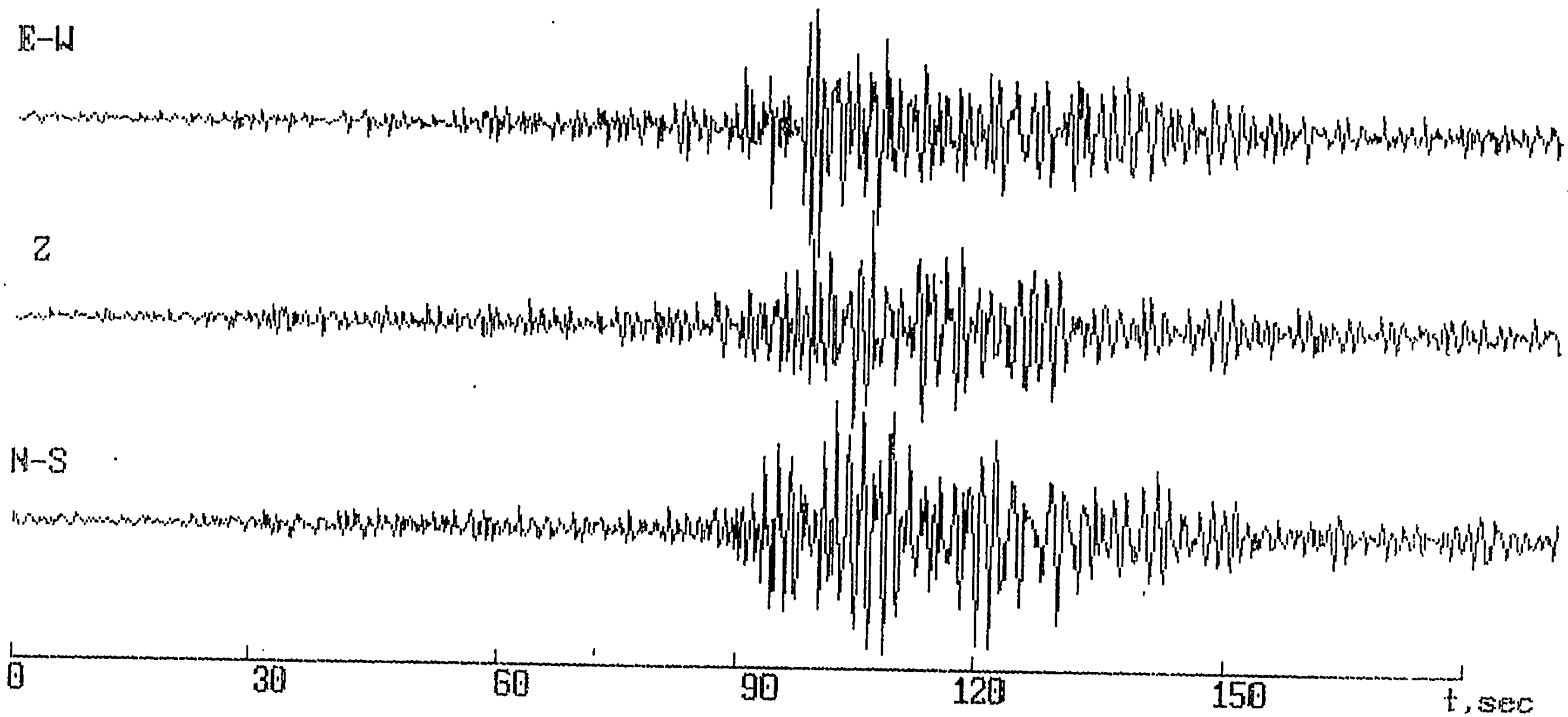
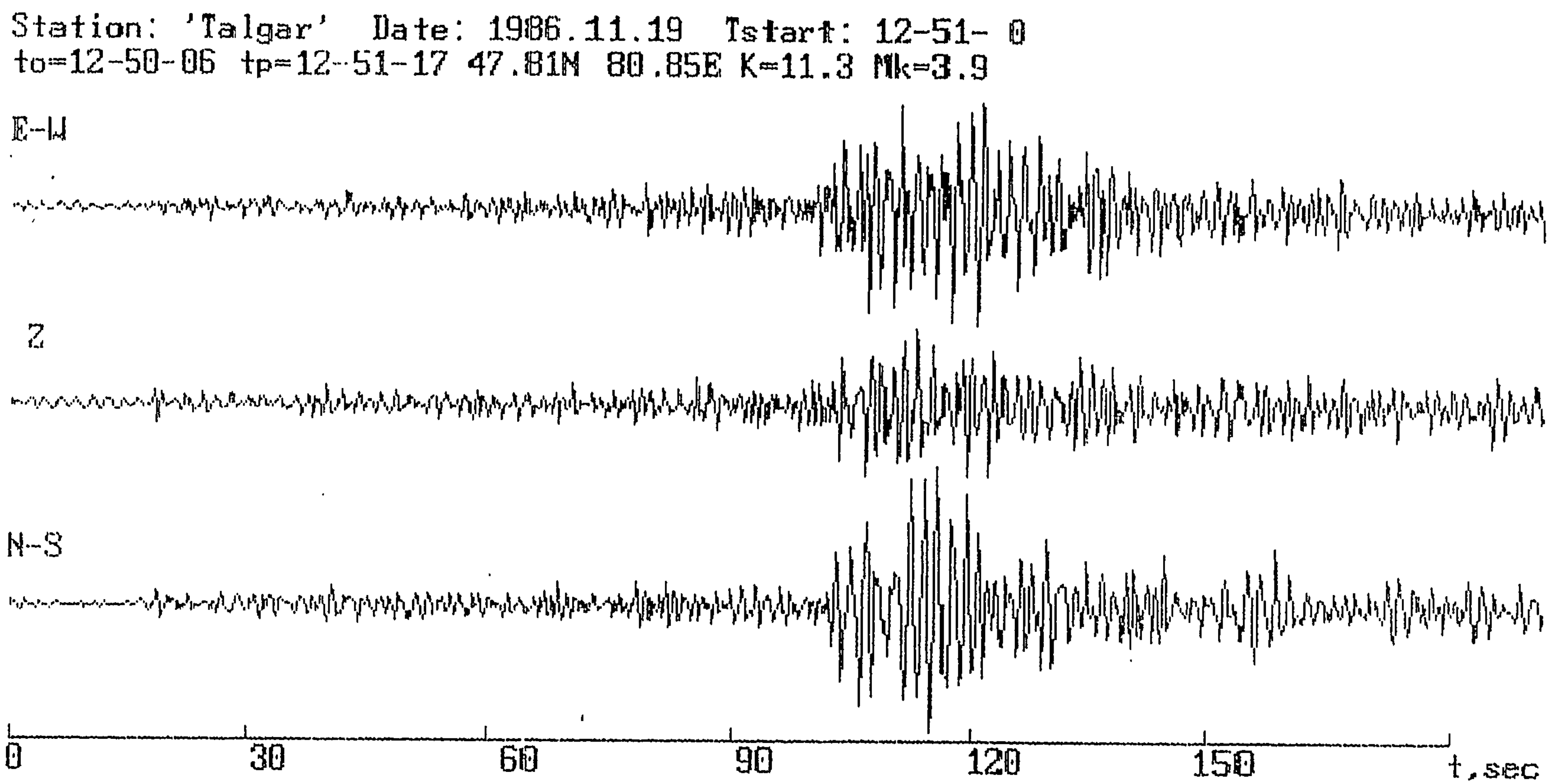
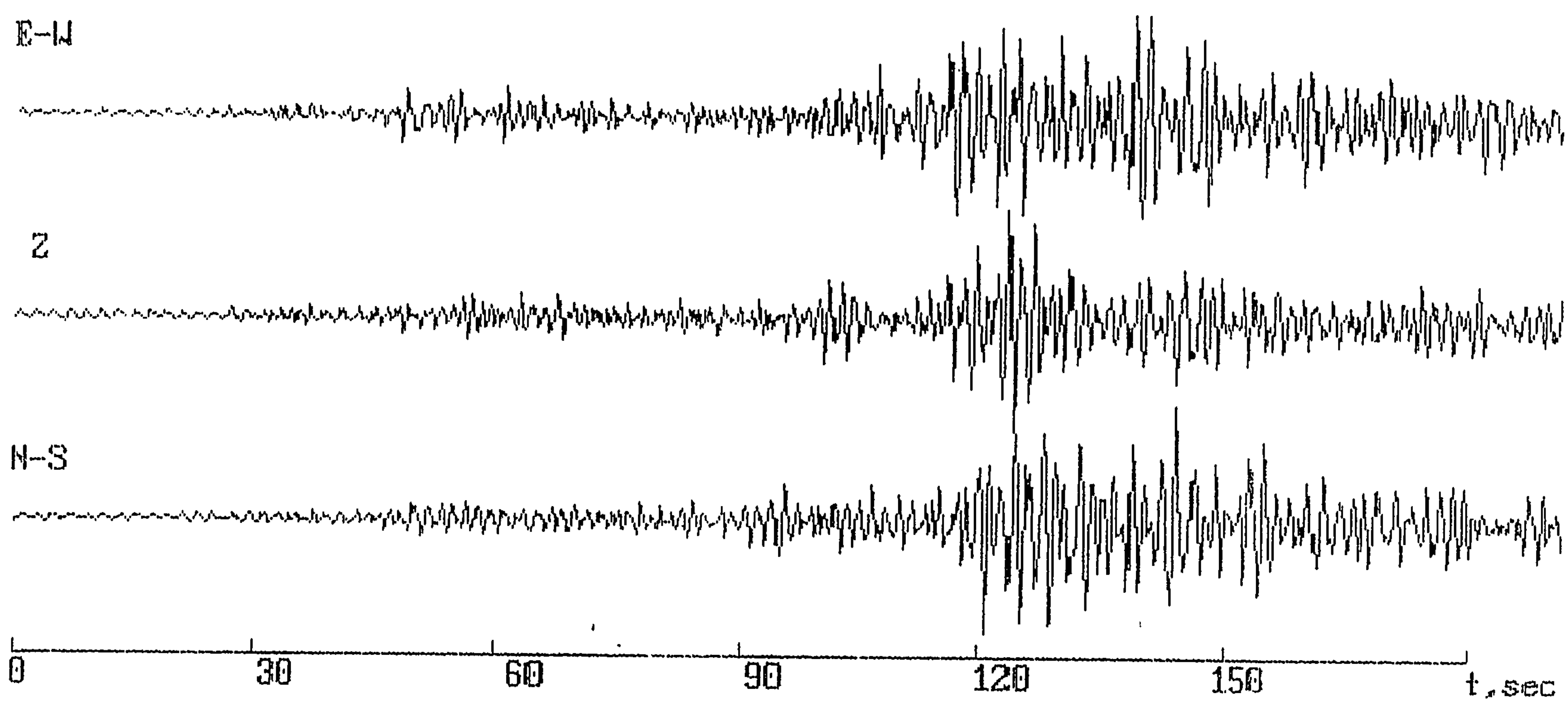
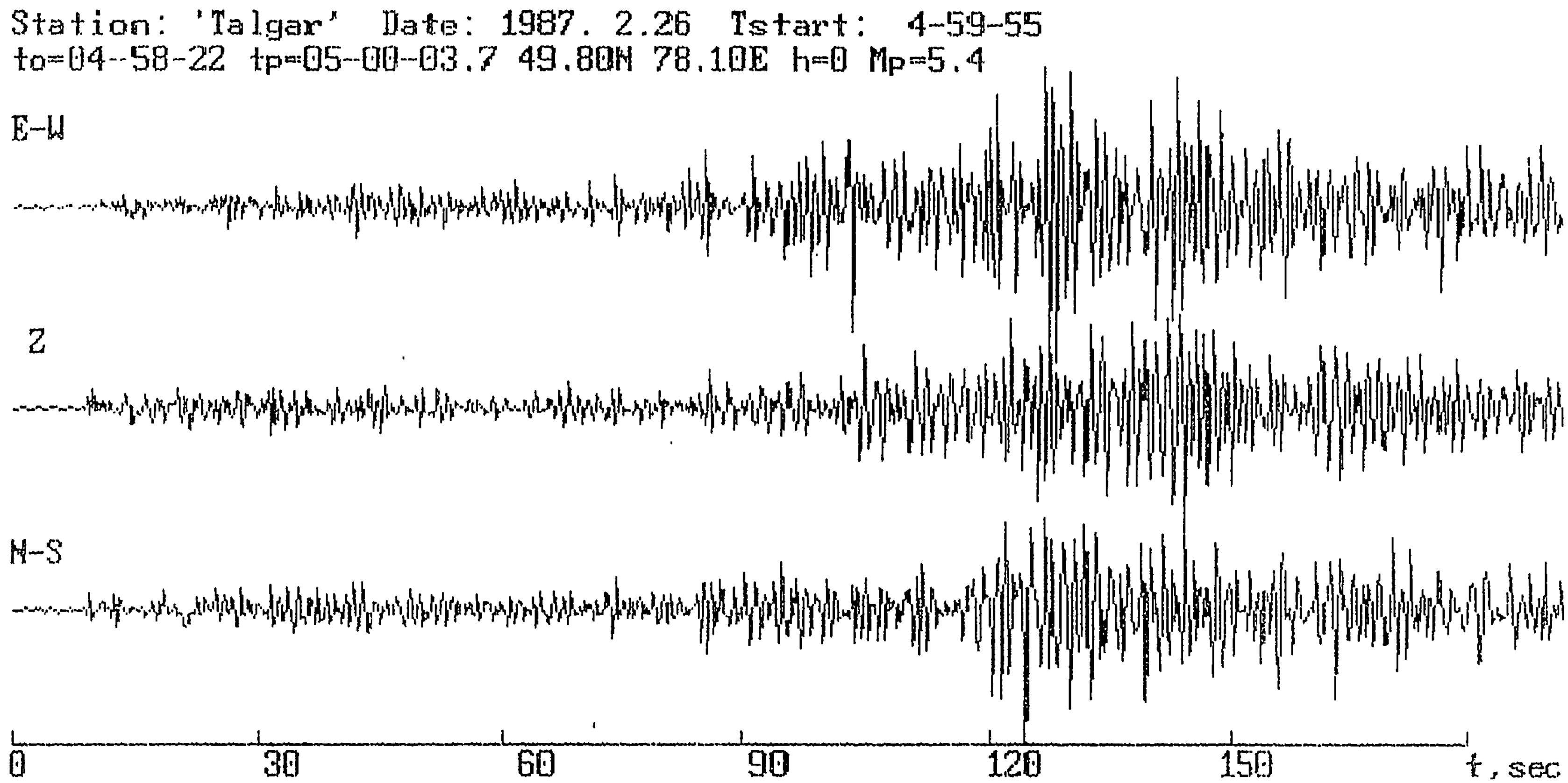



Station: 'Talgar' Date: 1986.11.19 Tstart: 12-51- 0
to=12-50-06 tp=12-51-17 47.81N 80.85E K=11.3 Mk=3.9
E-W
Z
N-S
0
30
60
90
120
150
t,sec

Station: 'Talgar' Date: 1986.11.20 Tstart: 2-41-20
to=02-40-24.3 tp=02-41-45.1 41.95N 84.10E h=33 M=4.6




Station: 'Talgar' Date: 1987. 2.26 Tstart: 4-59-55
to=04-58-22 tp=05-00-03.7 49.80N 78.10E h=0 Mp=5.4
E-W
Z
N-S
0
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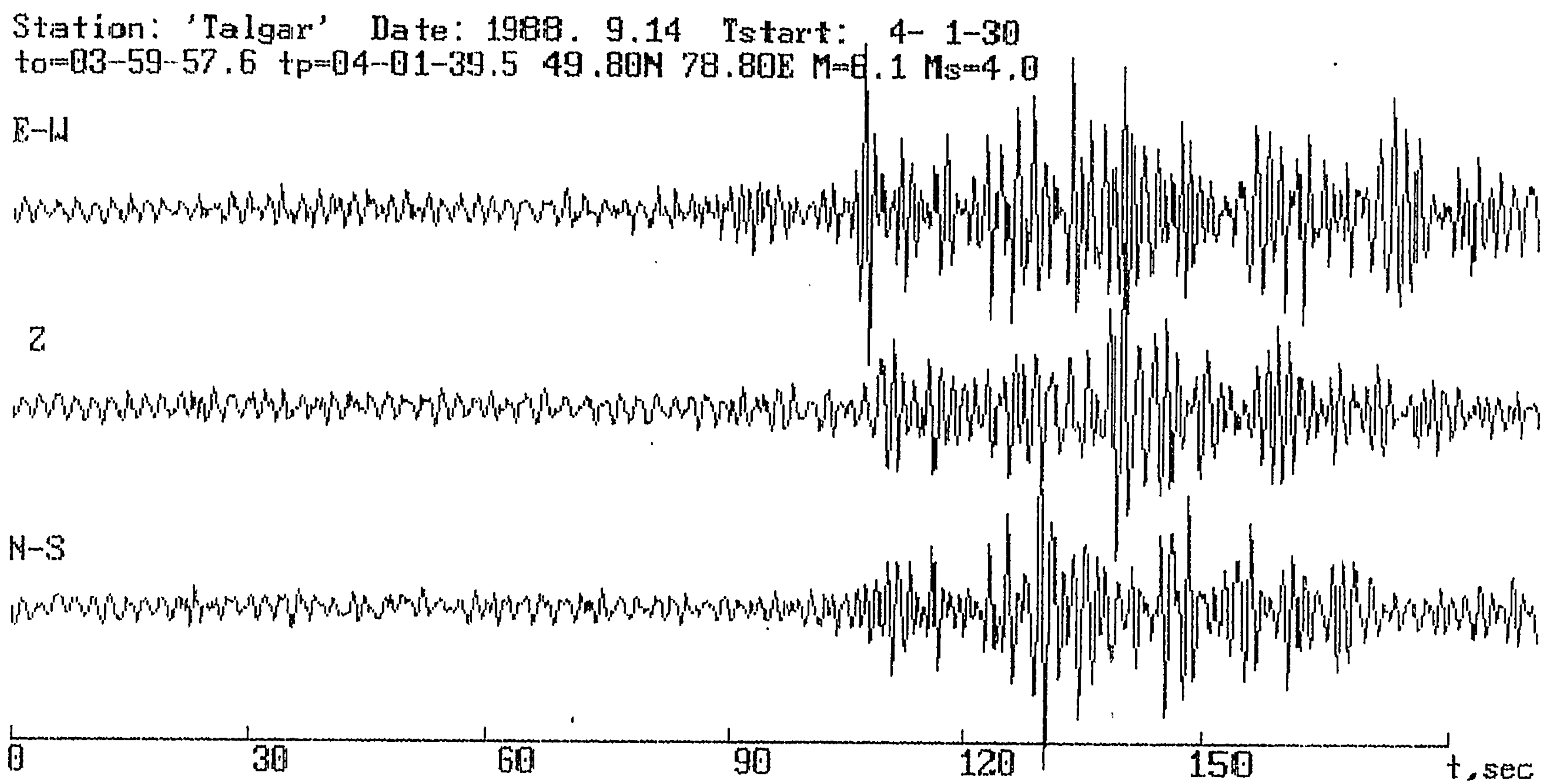
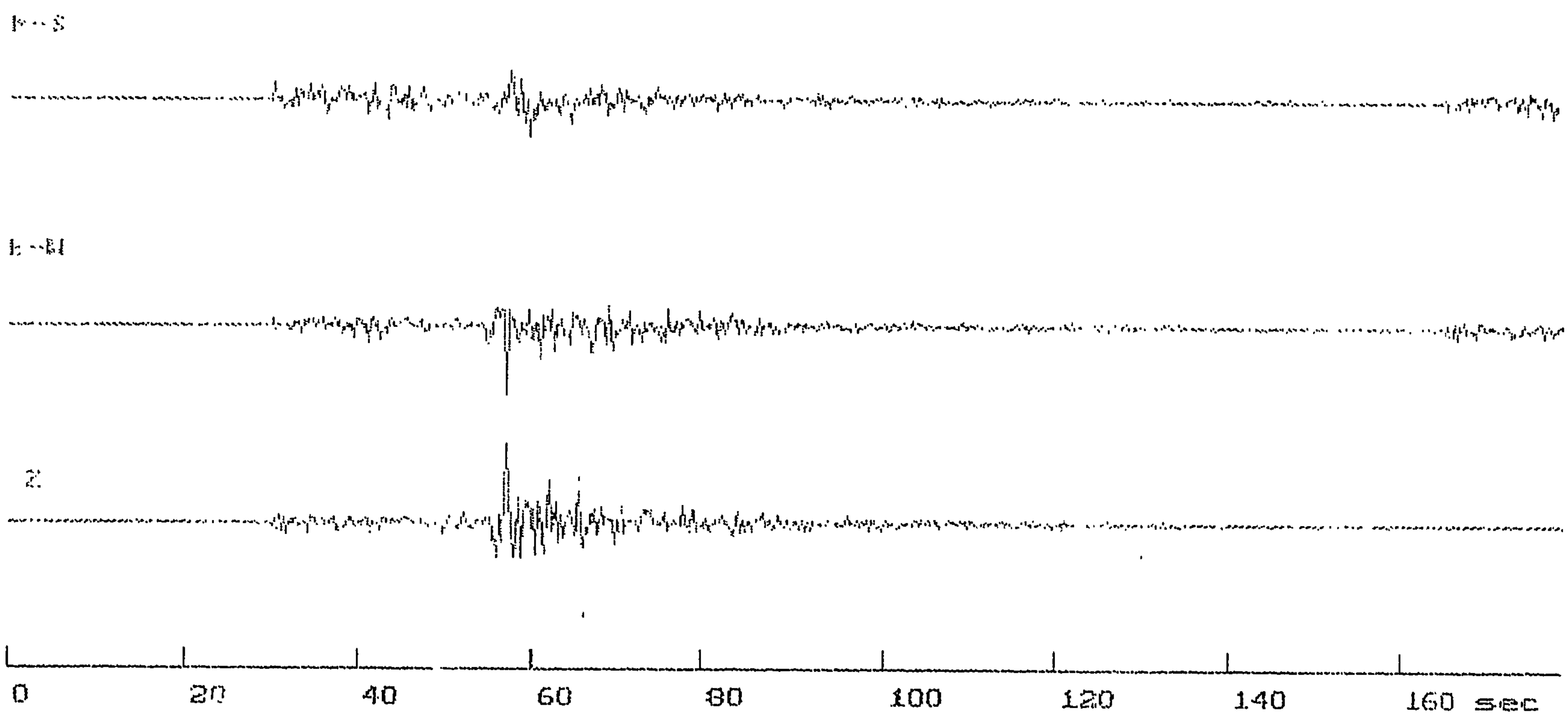
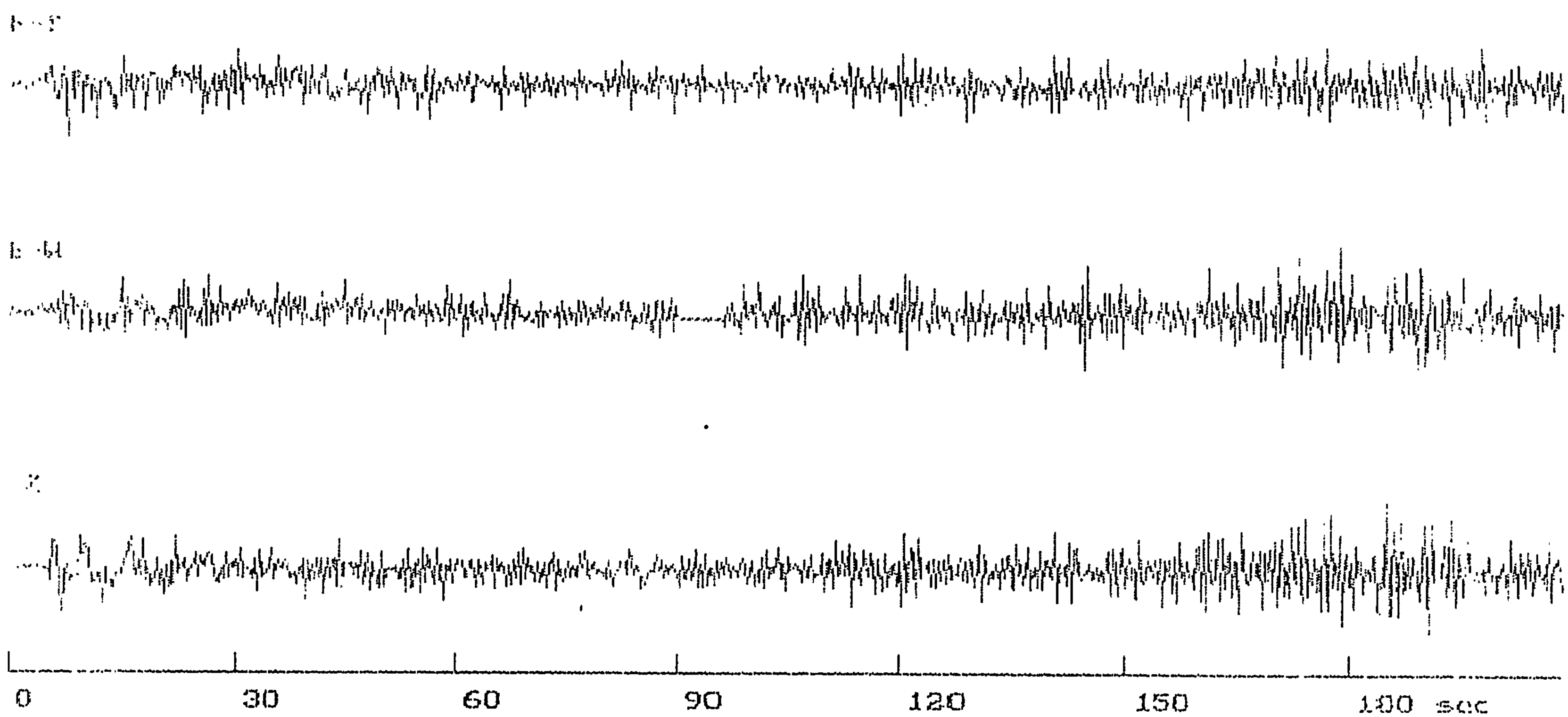
60
90
120
150
t, sec

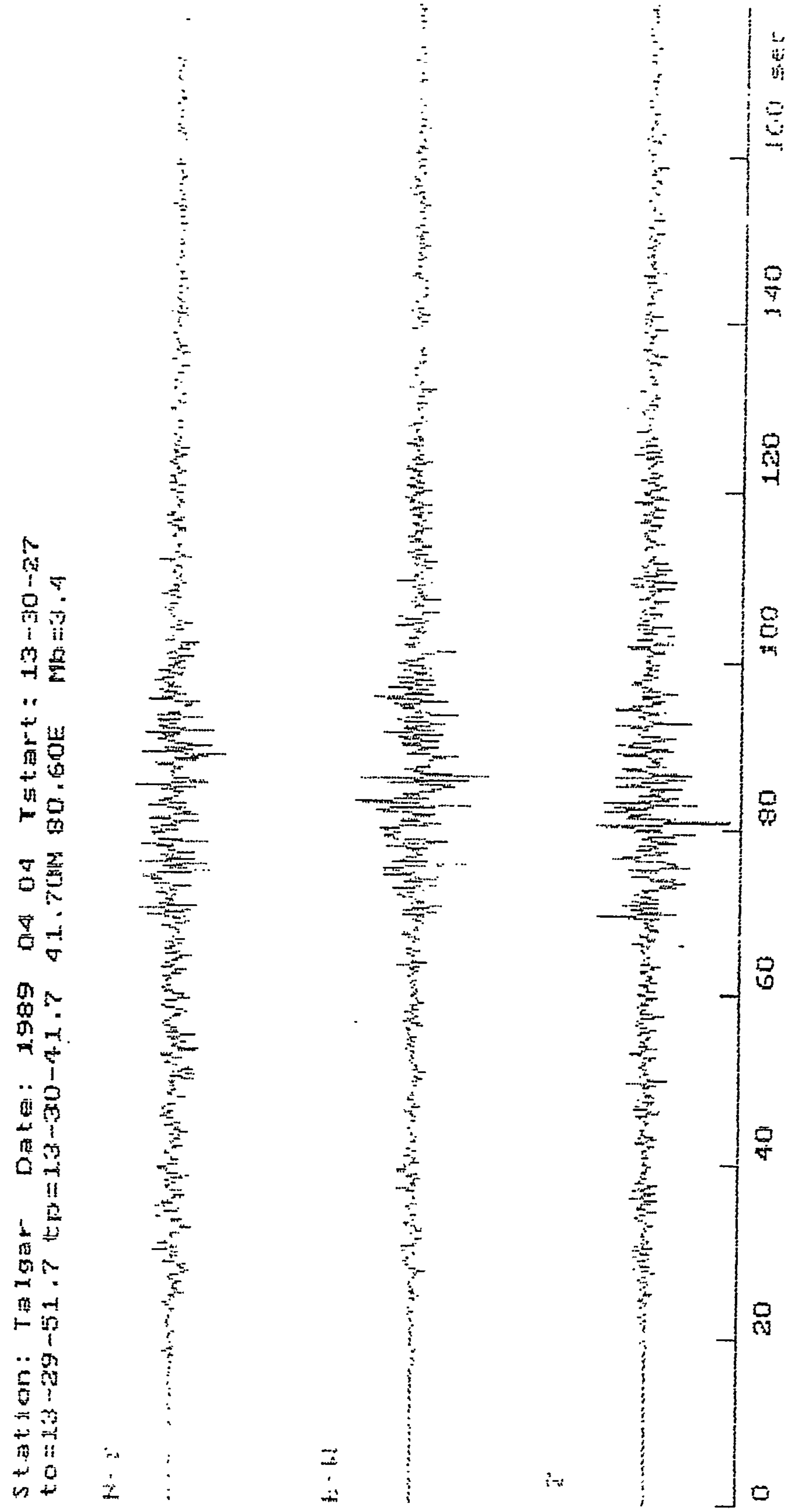

Station: 'Talgar' Date: 1988. 9.14 Tstart: 4- 1-30
to=03-59-57.6 tp=04-01-39.5 49.80N 78.80E M=6.1 Ms=4.0
E-W
Z
N-S
0
30
60
90
120
150
t,sec

Station: Talgar Date: 1988 08 06 Tstart: 04-58-04.69
to=04-58-03 tp=04-58-28.0 44.60N 78.60E Mb=3.4



Station: Talgar Date: 1988 09 29 Tstart: 07-02-03.40
to=07-00-02.0 tp=07-02-09.5 41.52N 88.15E Mb=4.6




Station: Talgar Date: 1989 04 04 Tstart: 13-30-27
to=13-29-51.7 tp=13-30-41.7 41.70N 80.60E Mb=3.4
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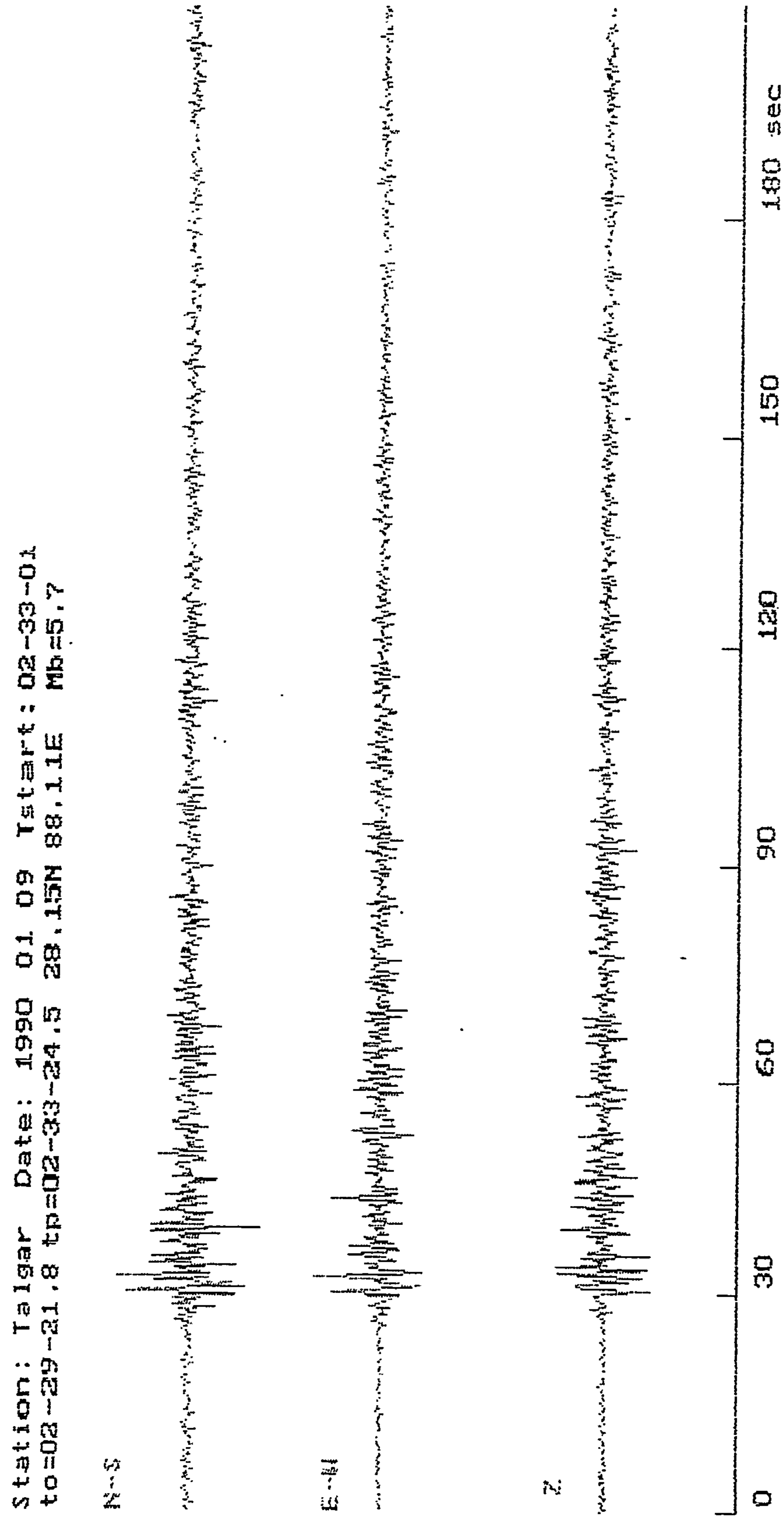
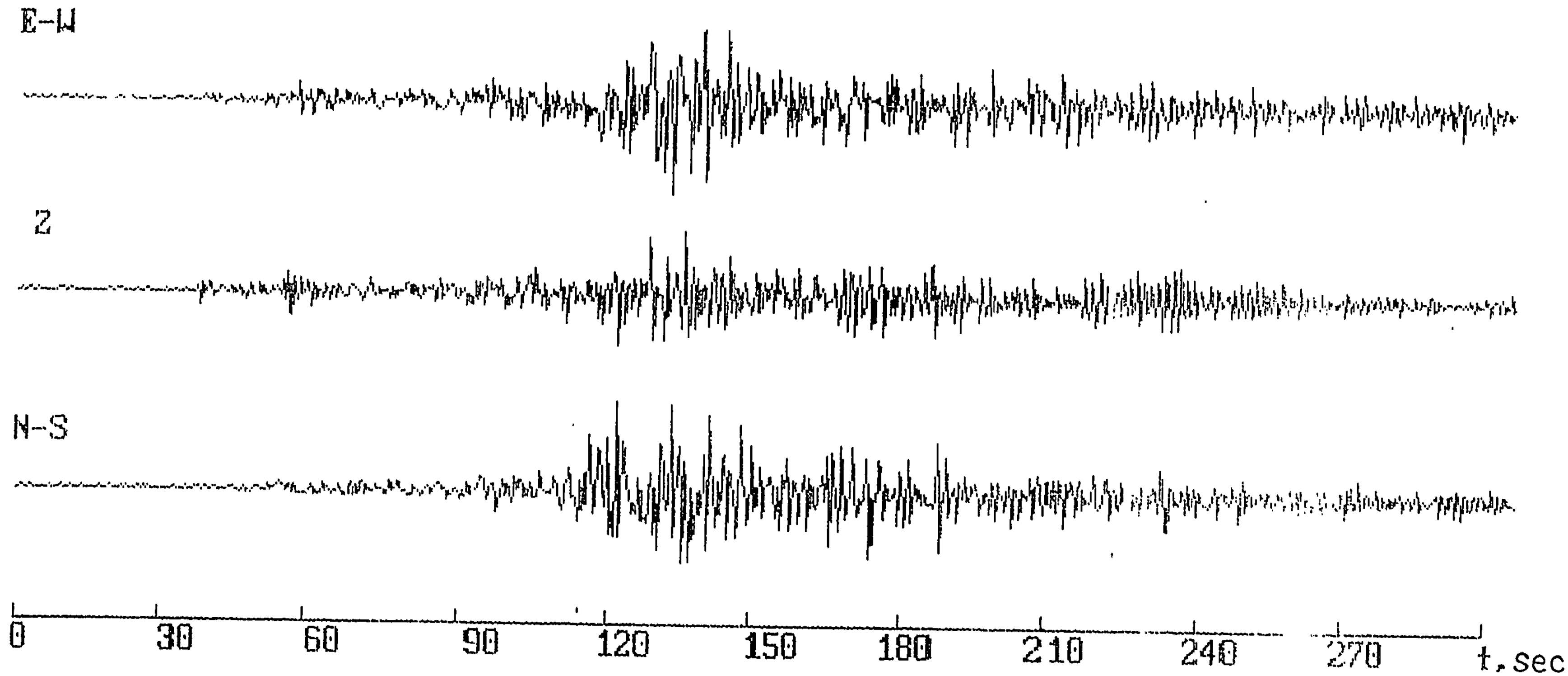
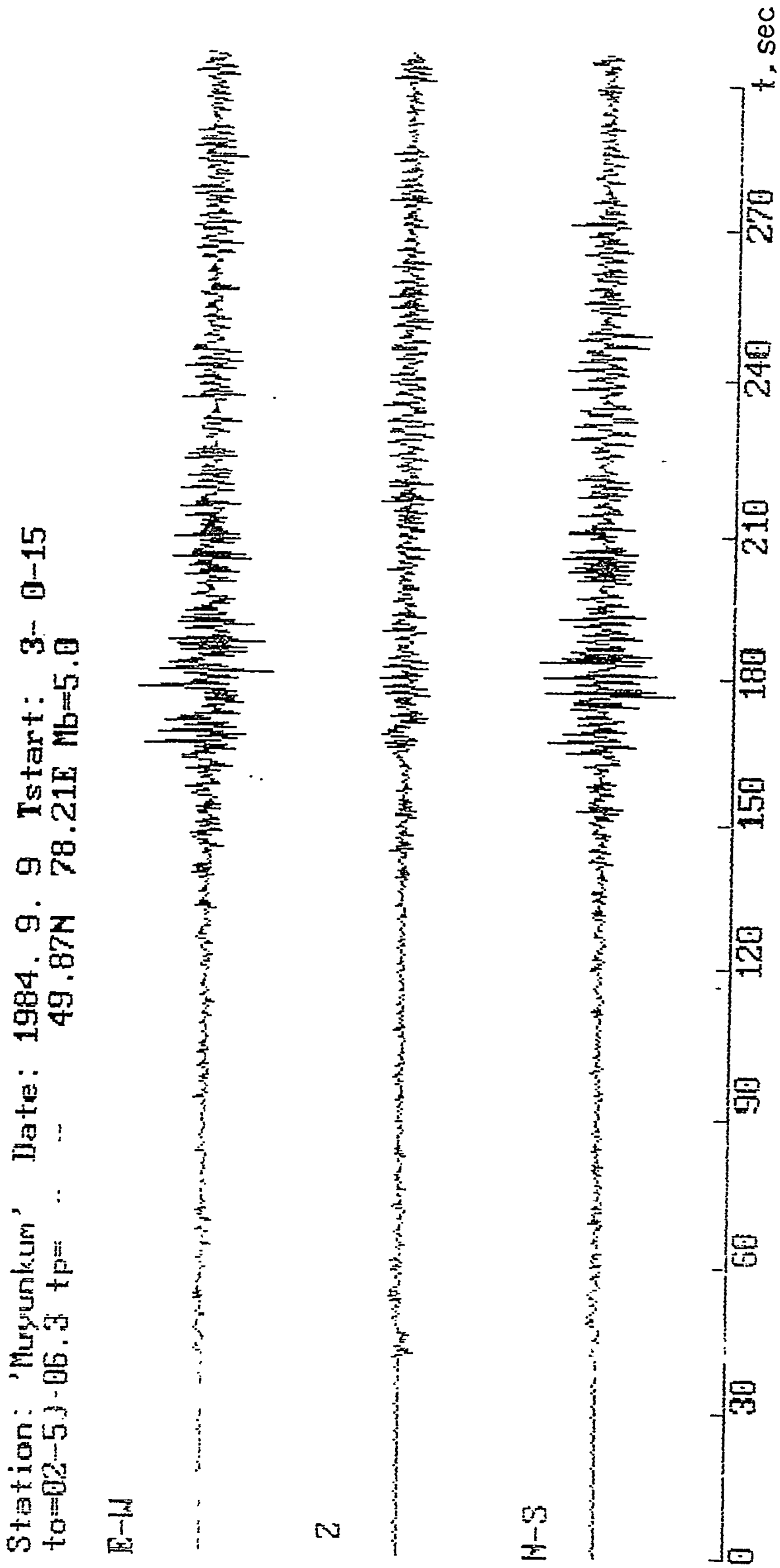
40
60
80
100
120
140
160 sec


Station: Talgar Date: 1990 01 09 Tstart: 02-33-01
to=02-29-21.8 tp=02-33-24.5 28.15N 88.11E Mb=5.7
N-S
E-W
Z
0
30
60
90
120
150
180 sec

Station: 'Muyunkum' Date: 1984. 8.21 Tstart: 14- 9-10
to=14-08-32.6 tp=14--09-46.5 44.10N 71.61E Mb=4.4




Station: 'Muyunkum' Date: 1984. 9. 9 Tstart: 3- 0-15
to=02-53-06.3 tp= : : 49.87N 78.21E Mb=5.0
E-W
Z
N-S
0
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120
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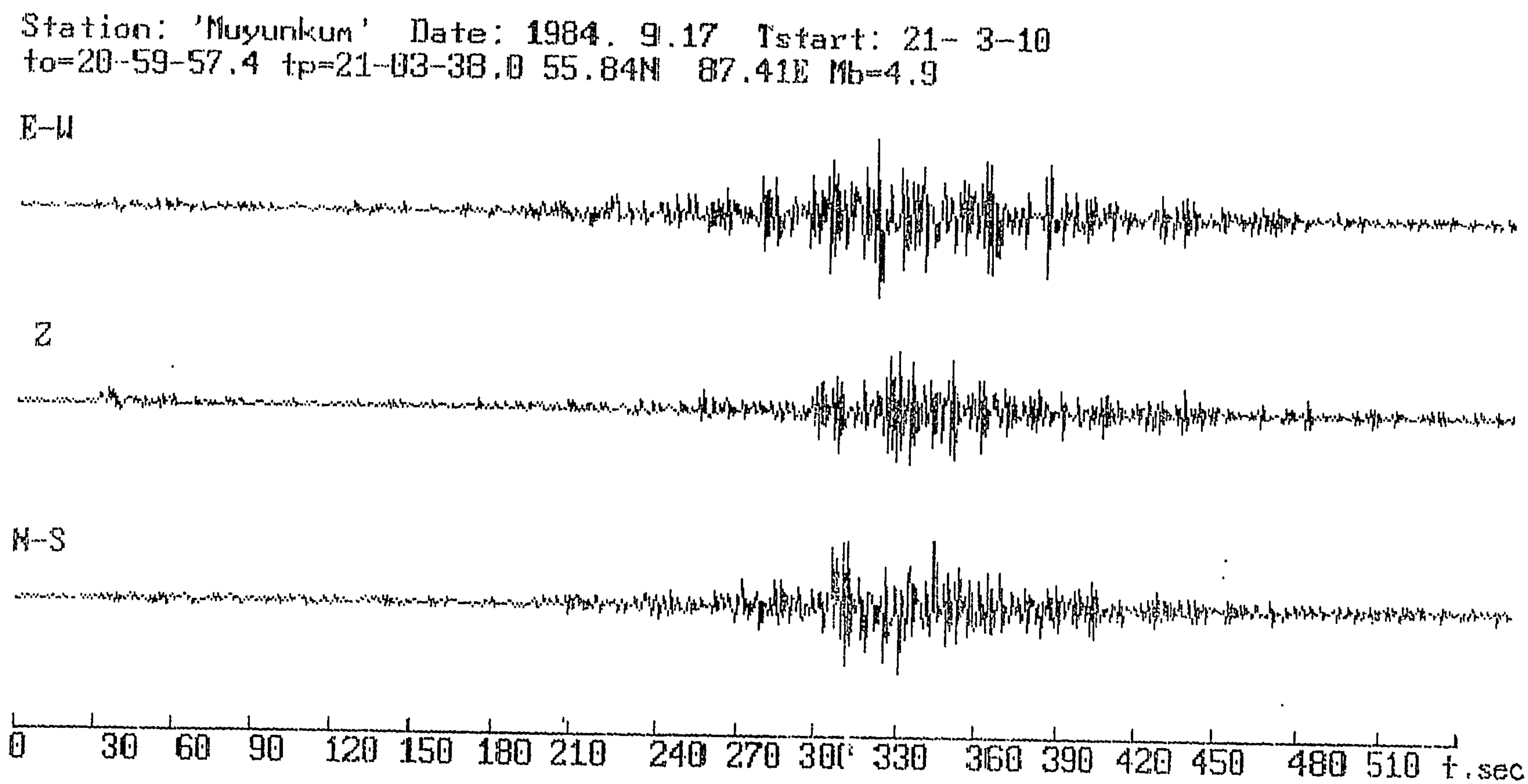
180
210
240
270
t, sec


Station: 'Muyunkum' Date: 1984. 9.17 Tstart: 21- 3-10
to=20-59-57.4 tp=21-03-38.0 55.84N 87.41E Mb=4.9
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Z
N-S
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150
180
210
240
270
300
330
360
390
420
450
480
510
t.sec

CONCLUSIONS.

In this report, we describe the results of the work on the establishment of the data base of regional seismic recordings from earthquakes. chemical and nuclear explosions in the former Soviet Union. These data were received either by digitizing the analog records (mainly), or directly in digital form using the magnetic recording system.

The equipment, methods of investigations and primary data processing were described.

The largest number of digital seismograms (55) corresponds to the permanent seismic station Talgar, situated in the North Tien Shan region, to the east of the city of Almaty. More than half of them are the records of underground nuclear explosions and chemical explosions. The UNE have been recorded mainly from the Semipalatinsk test site (at distances of about 700 km). In addition, we have recorded seismograms for an UNE from the Chinese test site Lop Nor and for an industrial nuclear explosion from West Siberia.

A few records of the chemical explosions were also picked out (two of these have been produced directly at the Semipalatinsk test site). We have obtained 6 records of crustal earthquakes from the Altai region, close to the Semipalatinsk test site, and 8 records of earthquakes from the West China region, close to the Lop Nor test site. Seismograms of earthquakes from some other regions of

Eurasia have been also digitized.

In addition, we have included a small number of earthquakes and nuclear explosions seismograms recorded by small arrays of temporary stations which were situated in the southern Kazakhstan region.

3-component seismograms were digitized, with a frequency of digitization in different cases of 20 or 25 Hz (usually), and also 40 or 100 Hz. The record duration varies from 180 to 410 sec.

The file structure was described in detail. All digital seismograms were copied into floppy-disks, which are given to the University together with this report.

It is worth noting, that only a small part of the data accumulated by the CSE, is included in this report. As mentioned above, the major volume of the data obtained by the CSE is in the form of photographic or usual paper seismograms. Due to this a problem of digitizing this huge information archive is still extremely important. As a first step we can suggest to digitize records of underground nuclear explosions from the Semipalatinsk and Lop Nor test sites, and also nearby chemical explosions and earthquakes. The major volume of information, most important for solving the problem of discrimination of nuclear and chemical explosions, and also earthquakes, is obtained by the Talgar and Zerenda stations (northern Kazakhstan, near Borovoye). These stations have been working continuosly from 1961 and 1969, respectively. Note, that only one unique station Zerenda, which had a magnification about 1 million at a narrow-band channel, centered at 1 Hz, have recorded for this time period many hundreds of relatively weak explosions, either nuclear or chemical, with magnitudes m_b=3.0-4.0 and even less.

To solve this problem it is necessary to have corresponding equipment - computers, scanners as well as specialized software.

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