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Seismological Station at Maitri, Antarctica

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ABSTRACT

A new seismological station (code named MAIT) equipped with matched 3-component short period digital and a vertical short period analog seismographs has been commissioned at Maitri, the Indian Antarctica base station. The station became operational from 26th Jan. 1998. A noise survey for selecting a suitable site and feasibility study with the aim of operation of Broad-band seismographs at the station subsequently was carried out during the Antarctica summer, in Jan-Feb, 1997. While the normal background noise due to artificial and natural sources was found to be very low, a very high level of noise was observed due to heavy winds during the blizzards which rage the icy continent very often. A thermally insulated vault has been specifically designed and buried underground as the Broad-Band seismographs are very sensitive to the temperature and pressure variations. The vault has been further provided with an electronically controlled device which maintains inside temperature at 15° +/- 0.5° Celcius. The digitization is done @ 50 samples per second and recording is done in continuous mode on 24 bit digitizer. An internal GPS with the data acquisition system provides accurate time. The station continued to operate uninterruptedly since Dec.] 998. The digital and analog data was analyzed daily and the phase data was e-mailed to NORJ Hyderabad weekly. The complete digital data was archived on DAT tapes. In this report the details of instrument , their calibration, and details of specially designed seismometer vault have been described. The station has been in continuous operation.

INTRODUCTION:

With the objective of installation of a permanent state-of-the-art digital Broad-band seismological station at Maitri, the Indian Antarctica base station, a reconnaissance for site selection and a feasibility study was carried out during the XVI Indian Scientific Expedition to Antarctica in Jan-Feb, 1997. The aim of the station is to monitor earthquakes in and around Antarctic continent, the region with very low level of seismic activity, if any, and mainly monitoring of global distant teleseismic earthquakes. This station would be specifically useful in the locations of hypocentres in the Indian Ocean, south of Asia and South America and southern and central Africa.

Presently only a three component short period digital Seismic system has been commissioned along with a short period vertical analog seismograph. The station was formally inaugurated by Mr. Alexander Kandratiey. the leader of 42nd Russian Antarctica Expedition to NOVO base station, on 26th January 1998, on the occasion of the India's Republic Day celebrations at the Maitri station.

The station coordinates are :

Latitude: 70°45.94'South	Longitude 11^0 44.13'East
Elevation: 115 meters	Station Code: MAIT

The location of the seismological station in the MAITRI complex is shown in Fig. 1.

SEISMIC STATUS

The Antarctic continent is seismically very quiet. Its surroundings are also less active except in portions near New Zealand in east, which is far away from the present station. No large earthquakes are known to have occurred in the Antarcrctic region during the last 100 years or so, which the seismographs under operation worldwide would have detected. No information was available about the low and medium level earthquakes due to the absence of any habitation and very few seismological stations in the southern hemispere. The operation of a seismological stations in Antarctica are very useful as they provide valuable control on global hypocentral determinations for the earthquakes in higher latitudes in the southern hemisphere. The exposed bedrock in the Antarctic continent amounts to less that 2% of its surface area along the margins of the continent. This puts restriction on the location of the seismic stations in Antarctica as operation of stations in the ice-covered areas is difficult during the winter months. Even most of the base stations of various countries are located along the exposed lands. However USA is maintaining SPA station at the South Pole with an ice cover of about 2,900 meters.

A temporary station was operated in Antarctica as early as 1902-1903 at Scott-Base. Later on, various countries between 1940-52 operated some more stations intermittently. During the International Geophysical Year (1957), four stations were operated at MIR, SBA, WILKES and ADELIE (Richter, 1958). Two World Wide Seismological Stations Network (WWSSN) stations of USA are in operation since 1963-64 at SBA and SPA. Subsequently, many countries have installed seismographs at their base stations in Antarctica. The locations of seismological stations are shown in Fig. 2. (After Kaminuma: 1992). Due to difficult environmental conditions and logistics, many stations had a very high down-time. Operation of sensitive seismographs and recording equipment become difficult and repairs are not possible. Perhaps for this reason, the first hypocentre in the region could be instrumentally located by National Earth

quake Information Service of U S A which is monitoring the global seismic activity since 1963 located first event in Antarctica mainland as late as January 12, 1995 when an event of magnitude 4.4 occurred at 62° S & 44.1° W. As per the International Seismological Centre (ISC) catalogue, 14 stations from southern hemisphere reported this event. A low level seismic activity has been observed in Antarctica after the establishment of many seismological stations by various countries (Kaminuma and Chadha, 1997). Total 10 events with magnitudes < 5.0 have been located during the last three decades out of which 6 have occurred in Wilke's land, in southeast Antarctica along the continental shelf. An earthquake of magnitude 5.1 occurred off Terra Nova Bay in Ross Sea on 31, May 1995 (ISC).

With the addition of more stations and their uninterrupted operation, many more events of small magnitudes may be located which may provide valuable information about technically active zones below the ice cover, as it is not possible to study the geological features directly. Thus, there is a great need of addition of more stations. Accordingly, a seismological station has been started at Maitri, the Indian Base Station in Antarctica.

The present day technological advancement has made possible setting up of Broad-band Digital Seismographs, which makes possible obtaining complete frequency spectrum of various seismic phases from distant sources and analysis of waveform data on computers. Presently at least 10 Broad-band Digital Seismographs are under operation in Antarctic continent. The MAIT station is being upgraded by Broadband seismographs of model CMG-3ESP manufactured by M/S Guralp-Systems Ltd., U.K..

GEOLOGIC SETTING:

The Indian Antarctica Base Station, Maitri is located in a region known as Dronning Maud Land which covers roughly Longitudes from 10° W to 40° E at an average Latitude of about 700S. The bed rock is of pre-Cambrian gneiss which is in permafrost condition and highly fragmented at the top. Locally the area is known as Schirmacher Oasis. There are number of lakes nearby the station. A lake in the immediate vicinity of the Maitri is known as Zub lake but the same has been now renamed as Priyadarshini lake. This lake is not causing any noticeable seismic noise as it is very shallow and is frozen most of the time. At the time of blizzards it may be causing some noise but the same is mixed up in the heavy noise due to the blizzards.

SEISMOMETER VAULT:

Based on the initial design prepared at NGRI, a thermally insulated cabin was fabricated by the Research and Development Engineers of the Defence Research and Development Organization at Pune. The inside dimensions of the vault are 1m (width) x 2 m (length) x 2m (depth). The schematic sketch of the cabin is shown in Fig. 3. The material used for building the side panels are 125 mm thick of special heat proof, synthetic material that is commonly used for the construction of structures in Antarctica. This underground vault also helps in providing a thermally stable environment, which is also free from atmospheric fluctuations as it is airtight. A deeper vault would have provided better controlled environment especially to the Broad-band seismometers which are highly sensitive to temperature and pressure fluctuations but the striking of somewhat compact bedrock near the surface and difficult logistics in Antarctica for digging in hard rock limited the depth of the vault.

Bull dozers available at the Maitri base were utilized for digging in the hard-rock i.e. the Archean gneiss (fragmented at the surface), the exposed bed rock at Maitri. To dig a pit to a depth of over 2 Mts,. first a very large cavity was made to facilitate the operation of the Bulldozers. Fig. 4 shows the digging operation. At the bottom of the pit a platform of prefabricated cement concrete blocks of 100 mm thickness was anchored to the Bedrock. The vault structure was erected on the platform. All the joints of the cabin were sealed to make it airtight. A complete view of the vault in position is shown in Fig. 5. The space around the vault has been filled tightly with boulders and loose sand. A view of the buried seismometer vault after filling of the surrounding space is shown in Fig. 6 The vault has been completely buried and is covered further with a canvas sheet. The vault during the winter covered with snow is shown in Fig 7, No noise has been noticed due to the loose filling outside the vault. Which indicates that the filling is quite compact.

SHORT PERIOD SEISMOGRAPHS:

A three-component short period digital seismograph system has been initially operational at Maitri, The inside view of the seismometer vault with the four seismic sensors under operation is shown in fig. 8. A vertical component analog seismograph is also under operation for which the recording is done on RV 320 B Portacorder from Teledyne-Geotech, U.S.A.

Following are the details of the system:
Seismometer Make: Teledyne-Geotech (now Teledyne-Browning) U.S.A.

Model:	S-13
Pendulum Period:	1.0 sec
Damping:	λ = 0.67
Data Acquisition System:	Reftek, U.S.A.
Model:	72 A
Digitizer:	24bit
Sensitivity:	1.907 uv/counts
Sampling rate:	50 samples per second
Recording mode:	Continuous
internal Memory Hard Disk:	IGB
Data retrieval:	DAT Tapes

Recording is done in a separate room known as Tirumala hut by carrying the signals through cables of about 25 M length. A view of the recording system is shown in fig. 9.^"

CALIBRATION OF THE DIGITAL SEISMOGRAPH:

All the instruments were first installed, necessary adjustments made and performance was checked at Hyderabad prior to shipment. The calibration of the digital seismographs have been checked by in situ excitation of the auxiliary calibration coil with signals of frequencies of 0.1,1,2,5, & 10 Hz. A portable calibration unit PS-200 by M/S Telcdyne-Gcotech was used for calibration of the seismometers simultaneously after adjusting the free periods of the three seismometers to 1 Hz. The system response of the each seismometer was matched for a damping of λ = 0.67 and the system response for the each component for a constant current of 7 ma to the calibration coil for different frequencies as per the provision in PS-200 unit is shown in Fig 10.

The response of the three seismometers is well matched. The computed displacement response curve for the vertical component seismometer is given in Fig.11. These curves are directly used for obtaining ground amplitudes for the determinations of magnitudes of earthquakes.

DATA ANALYSIS:

The station continued to operate uninterruptedly during Dec 1998 to March 2000. The digital and analog data was analysed every day. The phase data was sent every week to NGR1. Hyderabad by email.

Several telcseismic and regional earthquakes have been recorded. The station recorded altogether 380 numbers of earthquakes. Most of the earthquakes are teleseismic. Few regional earthqaukes with its epicenter at Inidna Oceans were recoreded while very

few near shocks were recorded with its epicenter in the ocean only. The nearest event ever reorded at Maitri is shown in Fig. 12. The preliminary analysis concludes that the epicenter of the lies in the Queen Maud Land region with its epicentral parameter as follows:

Date:	27/09/2000	Origin time:	07:55:17.32 Hours
Latitude:	71°.049S	Longitude:	23^0.335E
Depth:	25 Km (assumed)		
Epicentral Distance:	420 Km	Azimuth:	100^0 North
Magnitude:	3.4 Duration magnitude.		

Plots of earthquake locations recorded at Maitri during Dec 1998 to March 2000 are given in Fig 13.I

FUTURE PLAN:

As per the original plan the station is being upgraded with Broadband seismometers of M/S Guralp CMG3. The possibility of sending the phase data of Maitri station to NEIS for inclusion in global hypocentral determinations through email is under process.

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Figure Captions:

Fig 1. A sketch of the Maitri complex with location of the Seismological station ( ) . Tirumala hut where continuous recording is done is also marked. GPS Antenna is shown by ( ) .

Fig 2. Location of Seismological stations in Antarctica (•) along with Earth quakes observed during the last 3 decades shown by (0) . An earth-quake of mag. 5.1 occurred on May 31;1993 off TerraNova Bay (®) .

Fig 3. A schematic of the thermally insulated seismic sensor vault structure designed and fabricated by R. & D.E. Engineers of Defence Research and Development Organisation, Pune, which was buried underground

Fig 4. Shows digging operation with the help of bulldozers available at Maitri by the Logistic Team of the Indian Army for burying the seismic sensor vault pit.

Fig 5. Shows the vault erected on a cement-concrete platform anchored to the bedrock.

Fig 6. Buried seismometer vault. Frozen Indira Priyadarshini Lake is seen in the background.

Fig 7. A view of the vault covered with snow during winter months.

Fig 8. Inside view of the seismometer vault. Four short period seismometers are shown in their respective orientations corresponding to magnetic directions.

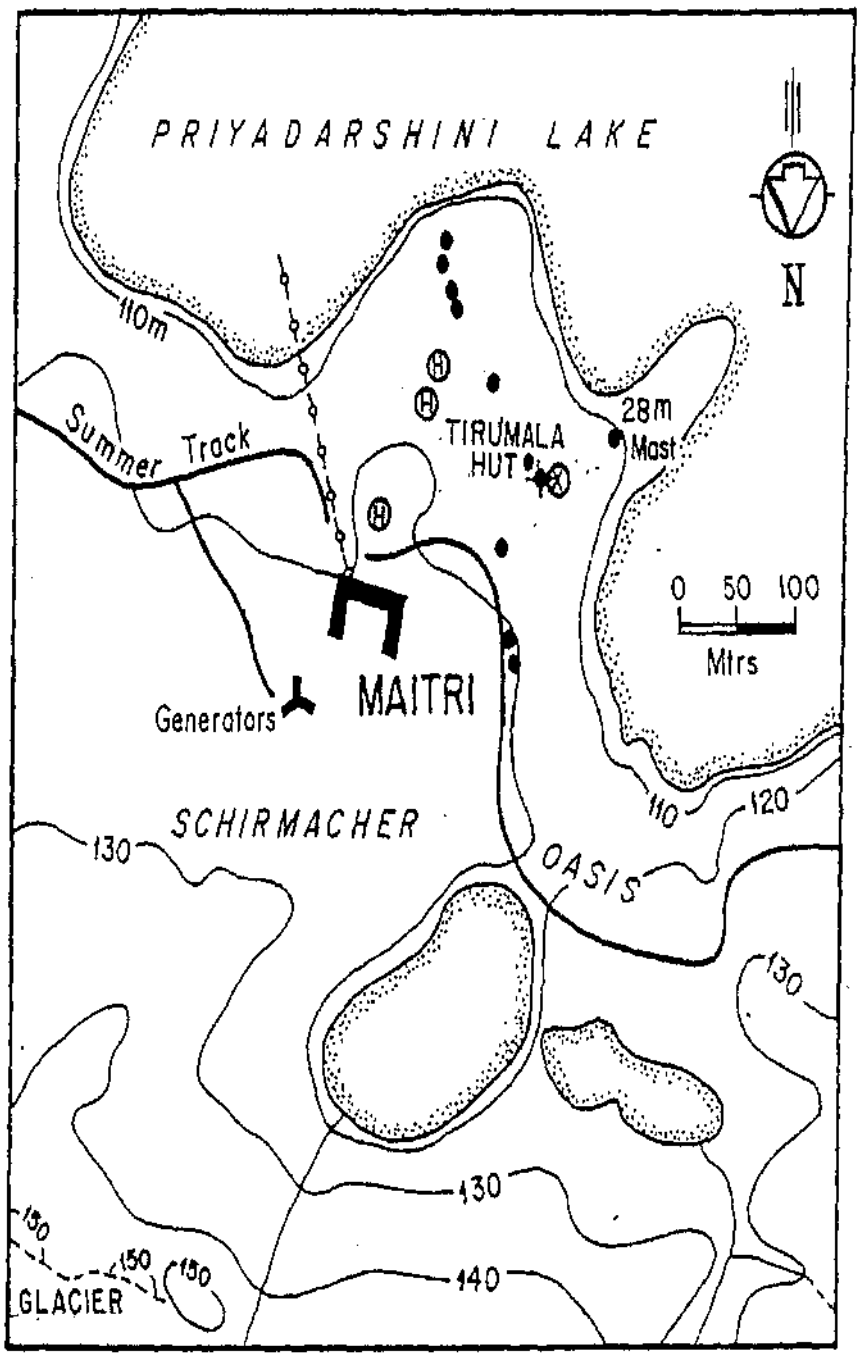
Fig 9. Recording system in operation in the Tirumala hut.

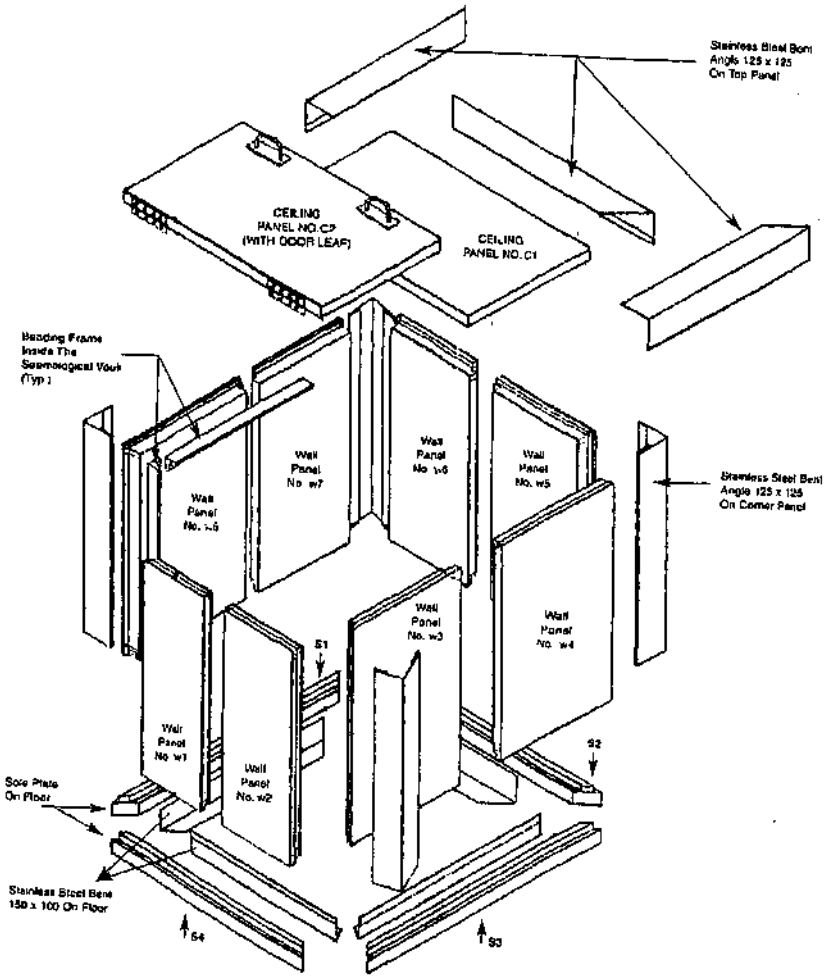
Fig 10. Systems response for the matched three component short period seismometer (S-13) for a constant current of 7 ma to the calibration coil for various frequencies.

Fig 11. Displacement response curve for the vertical component digital seismic sensor for a damping constant of . = 0.67.

Fig. 12 An analog display of digital record of a rare event recorded at Maitri on September 27, 2000 from a distance of 420 km with a magnitude of 3.4,

Fig. 13 Location of events recorded at Maitri station during Dec 1998 to March 2000.


PRIYADARSHINI LAKE
N
110m
Summer Track
TIRUMALA HUT
28m Mast
0 50 100
Mtrs
Generators
MAITRI
SCHIRMACHER OASIS
110
120
130
130
130
140
150
150
150
GLACIER


Stainless Steel Bent
Angle 125 x 125
On Top Panel
CEILING
PANEL NO.C2
(WITH DOOR LEAF)
CEILING
PANEL NO. C1
Bearing Frame
Inside The
Seismological Vault
(Typ.)
Wall
Panel
No. w7
Wall
Panel
No. w6
Wall
Panel
No. w5
Wall
Panel
No. w8
Stainless Steel Bent
Angle 125 x 125
On Corner Panel
Wall
Panel
No. w3
Wall
Panel
No. w4
S1
Wall
Panel
No. w1
Wall
Panel
No. w2
S2
Sole Plate
On Floor
Stainless Steel Bent
150 x 100 On Floor
S4
S3

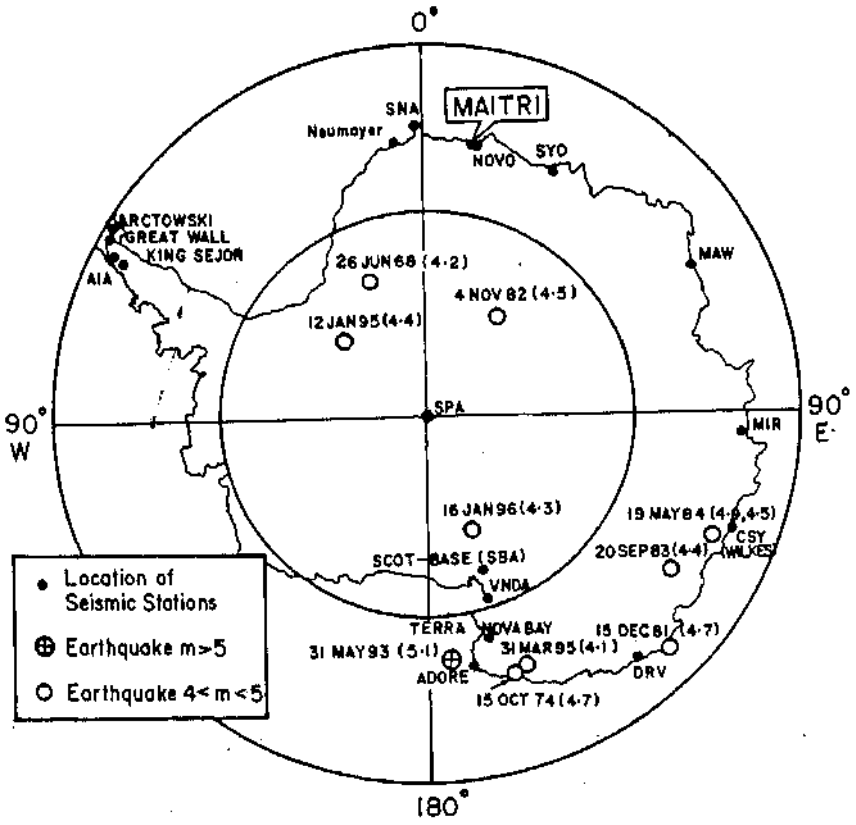

0°
90° W
90° E
180°
MAITRI
SNA
Naumayer
NOVO
SYO
MAW
ARCTOWSKI
GREAT WALL
KING SEJON
AIA
26 JUN 68 (4·2)
4 NOV 82 (4·5)
12 JAN 95 (4·4)
SPA
MIR
16 JAN 96 (4·3)
19 MAY 84 (4·6, 4·5)
CSY (WILKES)
20 SEP 83 (4·4)
SCOT-BASE (SBA)
VNDA
TERRA
NOVA BAY
15 DEC 81 (4·7)
31 MAY 93 (5·1)
31 MAR 95 (4·1)
ADORE
DRV
15 OCT 74 (4·7)
Location of Seismic Stations
Earthquake m>5
Earthquake 4< m <5

Fig.4

Fig.5

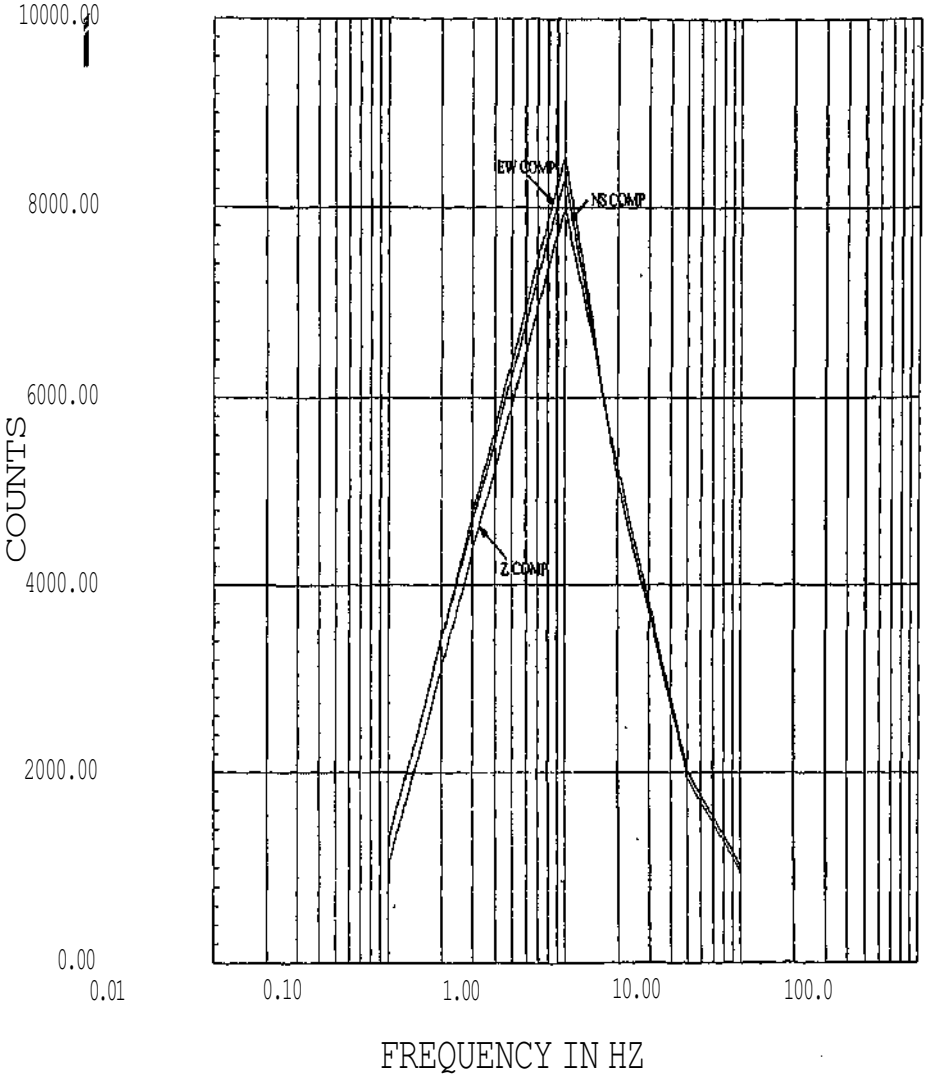
Seisnological Station at Maitri

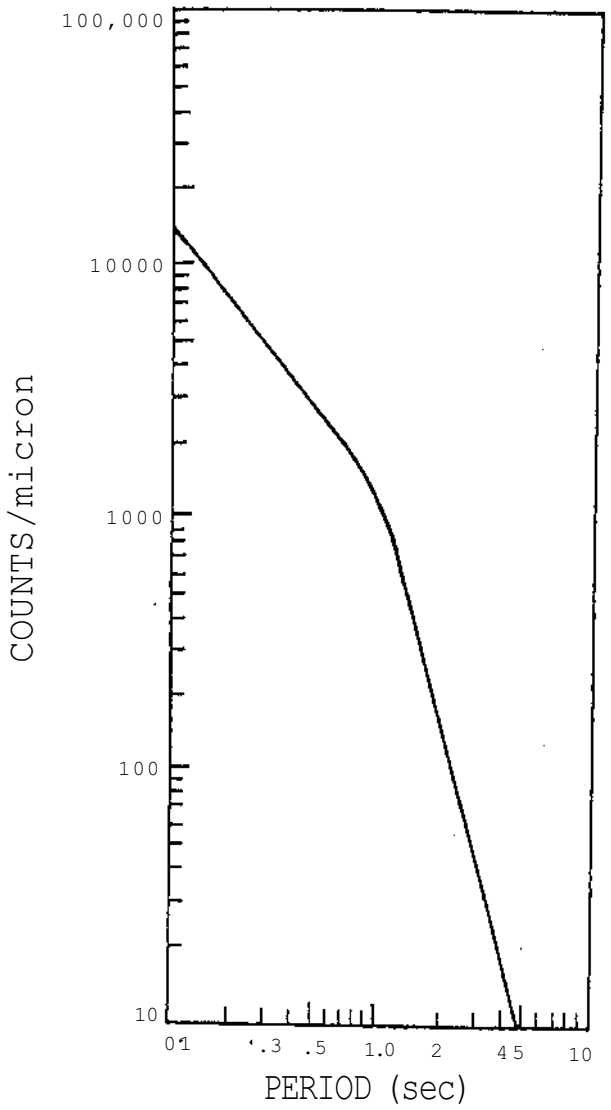
Fig. 6

Fig. 7

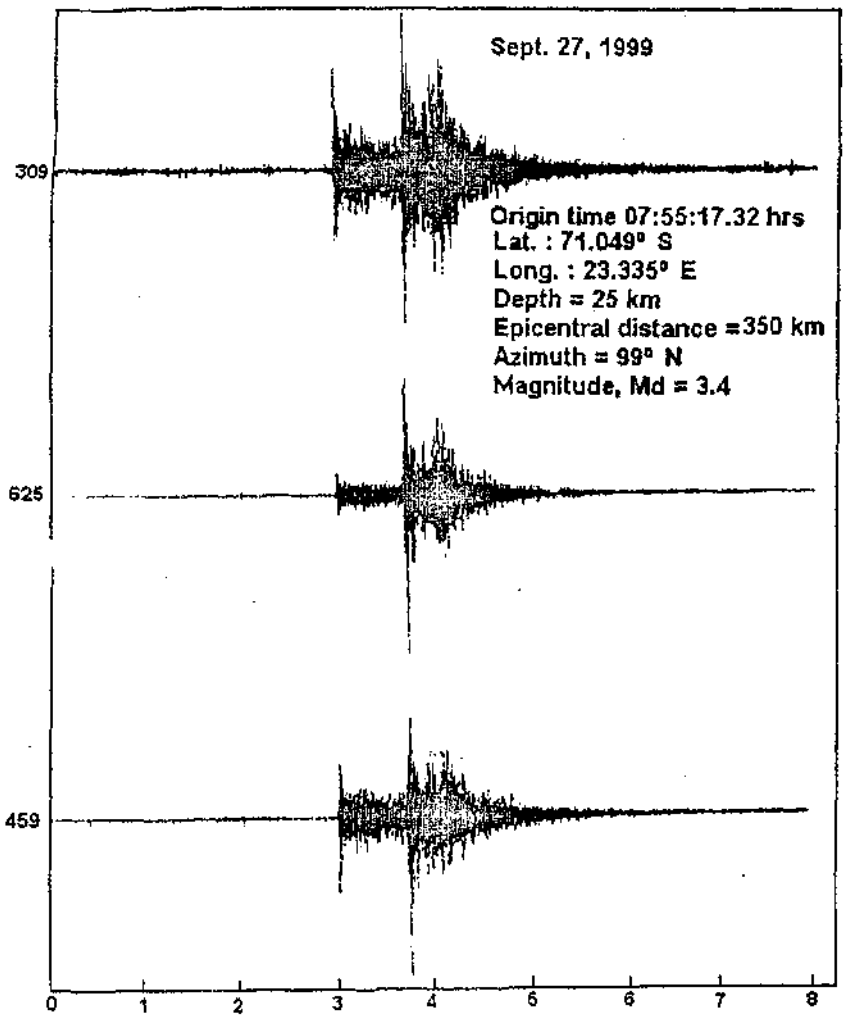
Fig. 8

Fig. 9


10000.00
8000.00
6000.00
4000.00
2000.00
0.00
COUNTS
EW COMP
NS COMP
Z COMP
0.01
0.10
1.00
10.00
100.0
FREQUENCY IN HZ



RESPONSE OF DAS WITH PERIOD
FOR S-13 S.P. SEISMOMETER (VERTICAL)
($\lambda = 0.67$)



NEAREST EVENT EVER RECORDED AT MAITRI

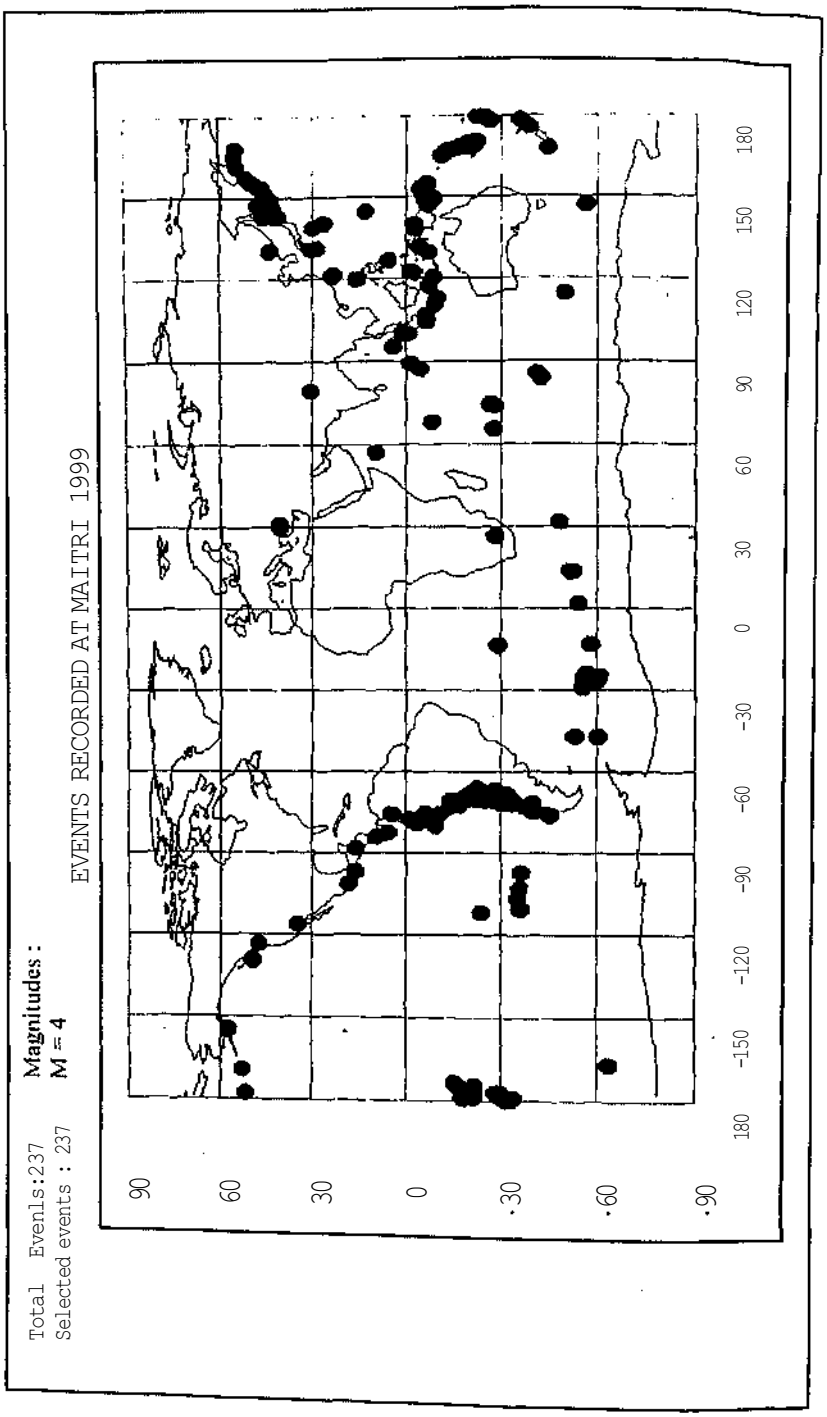

EVENTS RECORDED AT MAITRI 1999
Magnitudes :
M = 4
Total Evenls:237
Selected events : 237
90
60
30
0
-30
-60
-90
180
150
120
90
60
30
0
-30
-60
-90
-120
-150
180

Fig. 13