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Digital Broadband Seismograph Setup to Study the Seismicity in Maitri Antarctica Region

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Abstract: *165 million years ago, Antarctica was joined to Africa, Australia, India, New Zealand and South America forming the super continent, Gondwanaland. Antarctica is like a different planet on earth, owned by nobody. Antarctica is designated as "a natural reserve, devoted to peace of science"(Environmental Protocol 1991).The world windiest, coldest continent has an area of 14 million Sq. Km. Seismicity in the Antarctica and surrounding ocean is evaluated based on the compiling data by the International Seismological Centre (ISC),United Kingdom(UK). The Antarctica continent and surrounding ocean have been believed to be one of the aseismic regions of the Earth for many decades. However, according to the development of Global Seismic Networks and local seismic arrays, the number of tectonic earthquakes detected in and around the Antarctica continent has been increased. India research station "Maitri" (70°45'58" S and 11°43'56"E) has digital broadband seismometer installed that operates in continuous mode of data recording. National Centre for Antarctic and Ocean Research (NCAOR),a research and development body functioning under the Ministry of Earth Sciences, Government of India to controls the Indian Antarctic program and to take up and implement such scientific programmers in the polar and southern ocean regions. That will ensure a lead role for India amongst the nations involved in polar research.*

Keywords: *Broad-band Seismograph, Antarctica, Continent, Earthquakes and Data recording*.

I. Introduction

National Geophysical Research Institute (NGRI), Hyderabad, India has established a permanent Seismological Observatory at Maitri (70° 45' 58" S; 11° 43'56" E).The Indian Antarctica Station in the ice-free Oasis of Schimarchar as shown in Fig.1.During XVII Indian Antarctic Expedition (IAE) in 1997 with the primary objectives of monitoring the seismicity in and around Antarctica and also in the Indian Ocean. Initially an analog and digital short period seismometer were commissioned, which were upgraded to the state-of-the-art high resolution three component digital broadband seismometer in January 2001 during XX IAE.The observatory is continually operation since inception. In addition to these, the tele-seismic and near events recorded at Maitri give a holistic understanding of the seismicity in and around Antarctica. The seismic data were contributed to International Seismological Centre (ISC), United Kingdom for the preparation of worldwide seismic bulliten.The bulletin, with very valuable details of seismicity in and around Antarctica, would definitely be a worthy benchmark for the current and future research in Antarctica and also serve as a source of vital information for the earth science community worldwide.

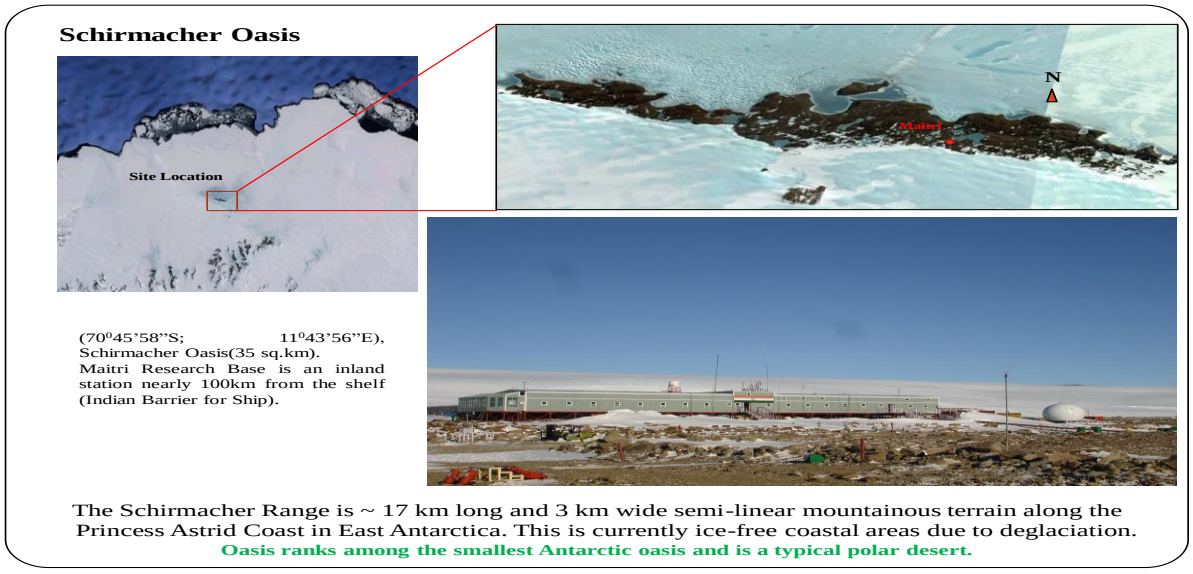

Figure 1. Map of Maitri Seismic Station

Objective and function of India Antarctica Expedition

1. To undertake, aid, promote guide and co-ordinate scientific research in the fields of polar science and Southern Ocean Oceanography.
2. To establish and maintain to monitor seismic activity in the icy continent of Antarctica.
3. Antarctica is the world's greatest natural laboratory and attract scientist for research. It is a stable platform for caring out scientific investings.Being far away from all industrial areas remains an unpolluted region. The changes due to pollution all the Globe can be monitor from here.
4. Contributing data to National Earthquake Information Centre (NEIC), Colorado is a part of United States Geological Survey (USGS) and International Seismological Centre (ISC), UK through NCAOR, Goa.
5. Seismological observatory Maitri has gone global by becoming one of the permanent seismic stations in Antarctic Seismic Web Resource (AnSWeR).To play a perceptible and active role in Antarctica affairs in the International platform of Nations.

II. Instrumentation

1. Construction of Seismic Vault

To have long term stability in monitoring of seismicity, stationary instrumentation scheme is used. Three channel digital broadband seismometer is installed in underground pit of over 2 meters has been dug in the bedrock. A specially designed thermally insulated vault of dimension 2m (length) × 1m (width) × 2m (depth) was housed inside the pit , as the digital broadband seismometers are highly sensitive to temperature and atmospheric variations. The schematic diagram of the vault is shown in Fig. 2 [1]. The seismic vault is suitably covered by adiabatic walls and also is temperature controlled electronically to maintain a constant temperature inside vault at 15° ± 0.5°C as shown in Figure 3.

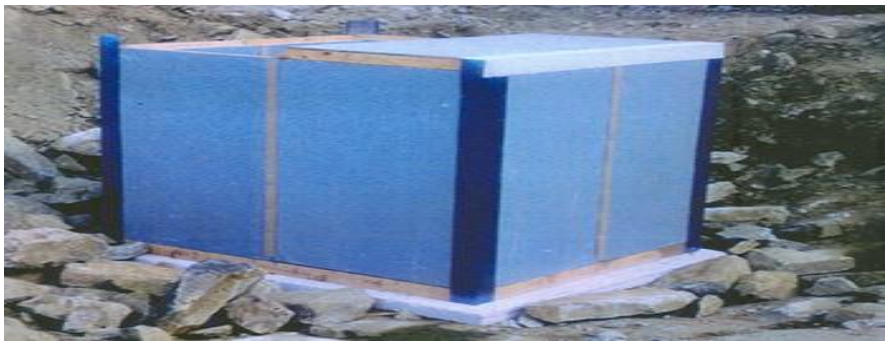

Figure 2. The completed seismic vault platform anchored to the bedrock.

2. Installation of digital Broad-band Seismometer

Figure 3. Installation of Broadband Seismometer inside the Seismic Vault.

3. Set-up of Seismograph Unit

Seismograph unit setup at Maitri Antarctica as shown in Fig 4.Consists of 3-channel Broadband Digital Seismometer is a force-balance feedback type, featuring low noise and large dynamic range with a frequency bandwidth of 0.0083 Hz to 50 Hz, sensitivity of 2000V/m/s and power consumption of 1.3 W [2]. It is sensitive to diurnal temperature variation and hence it will be enclosed with a thermal shield cover.

Figure 4. Block diagram of Seismograph Setup at Maitri Antarctica

The Data Acquisition System (DAS) is a 3 channel, 24-bit Broadband seismic recorder. The DAS is a compact, lightweight, low power consumption system and has 6 input/output connectors, LCD display. It has 10 to 16 VDC input and dynamic range of > 135 dB [4].The seismic data recorded by DAS is locally stored in the compact flash card of 4 Gb as well as it if FTP to NCAOR,Goa data server time to time. The Global Positioning System (GPS) uses linked set of 24 satellites to give the location of the seismic station as well as the accurate time, which is tagged on to digital data. The unit is powered by 12 V DC from DAS.It supplies time and position information serially to the DAS together with 1 Hz pulse.

4. Data Processing and Analysis

The data acquired was processed and analyzed at National Geophysical Research Institute (NGRI), Hyderabad. SEISAN the earthquake analysis software [3] was used for the final processing and analysis of data. The seismic station of Maitri, Antarctica, was one of the primary Indian station has gone global by figuring in Antarctic Seismic Web Resource, with station code MAIT,Picking P and S phases in the digital seismograms and computed the epicentral distance from the difference of P and S arrival time. After final analysis of seismic broadband digital data, the complete phase data had been reported to ISC, and to be included in the global data center for global access by any other agency and can be accessed at: http://www.isc.ac.uk

III. Earthquakes of Antarctica- John Search

Antarctica is mostly earthquake free. Only a few earthquakes greater than magnitude 3.0 have been recorded on continent. The list of Antarctica earthquakes shown in table 1.

Table 1: List of Earthquakes in Antarctica region

S/N	Year of Earthquake	Region of earthquake	Magnitude	Cause of Earthquake
1.	1952	Northern Victoria Land	4.0	
2.	1974	Northern Victoria Land	4.9	Tectonic earthquake, but was most likely a result of movements within ice.
3.	1982	East Antarctica, about 1200 Km from the coast of Droning Maud Land	4.5	This is the first earthquake located in the interior of the Antarctica continent.
4.	1995	82.064 S,49.993 N	4.7	
5.	1999	71.049 S,23.335 E	3.4	Queen Maud Land
6.	1998	Balleny Island Region	8.1	This was caused by post glacial rebound.
7.	2007	Australian Antarctic Territory	5.8	

Cause of Antarctic earthquake are, post glacial rebound, fracturing of the ice sheet, calving of icebergs from the Ross Ice Shelf, and volcanic activity. Antarctica, on average, is the coldest, driest, and windiest continent and has the highest average elevation of all the continents. The temperature in Antarctica has reached -89°C (-129°F).There are no permanent human residents, but anywhere from 1000 to 5000 people reside

throughout the year at the research stations scattered across the continent. Not own by any countries. It is a land that symbolizes unit and fraternity. Table 2 shows the members (Approx.) from different countries stays for research work today in Antarctica.

Table 2: Country members staying in Antarctica for research work

S/N	Country of Origin	Population
1.	Argentina	667
2.	Australia	200
3.	Brazil	40
4.	Chile	359
5.	China	90
6.	France	125
7.	Italy	60
8.	Germany	90
9.	**India**	**65**
10.	Japan	125
11.	New Zealand	85
12	Norway	44
13.	Poland	40
14.	South Korea	70
15.	Russia	429
16.	South Africa	80
17.	Ukraine	24
18.	United Kingdom	217
19.	Uruguay	70
20.	USA	1293
21.	Belgium	20
22.	Bulgaria	200
23.	Czech Republic	20
24.	Ecuador	26.
25.	Finland	20
26.	Peru	28
27.	Spain	50
28.	Sweden	20
29.	Romania	13
	Total	**4570**

India and Antarctic Treaty, India officially acceded to the Antarctic Treaty System on 1 August 1983.On 12 September 1983, the country became the fifteenth Consultative Member of the Antarctic Treaty.

IV. Results and Discussion

1. Seismic records

There are various constraints in seismic site selection, which affect station distribution. If seismic noise is high, benefit of modern instrument is lost and poor detection will results. If we compare Hyderabad and Maitri seismic station. Maitri is a stable platform for caring out scientific investing being far away from all industrial areas remains an unpolluted region. The changes due to pollution all the Globe can be monitor from here. The motion is recorded in 3 directions (one vertical and two horizontal) with digital broadband seismometers in the frequency range 0.0083 Hz to 50 Hz .The sampling rate is 100 sec.The seismic noise is a permanent motion of the earth. It includes, Microseismic primarily due to the interaction of ocean with solid earth with periods T=4-10s.They are mostly Rayleigh waves. Noise of anthropogenic origin is more complex and appears predominantly at period T<1s due to anthropic activity. It includes body waves (P and S waves) and surface waves (Rayleigh and Love) generated by traffic, industrial and domestic activity and the interaction of wind with buildings. .To check the site characteristic at each site, Maitri seismic station have no cultural noise seen in Seismogram during austral winter record whereas Hyderabad seismic station have microseismic noise are clearly visible in the austral winter seismogram record as shown in Fig.5.

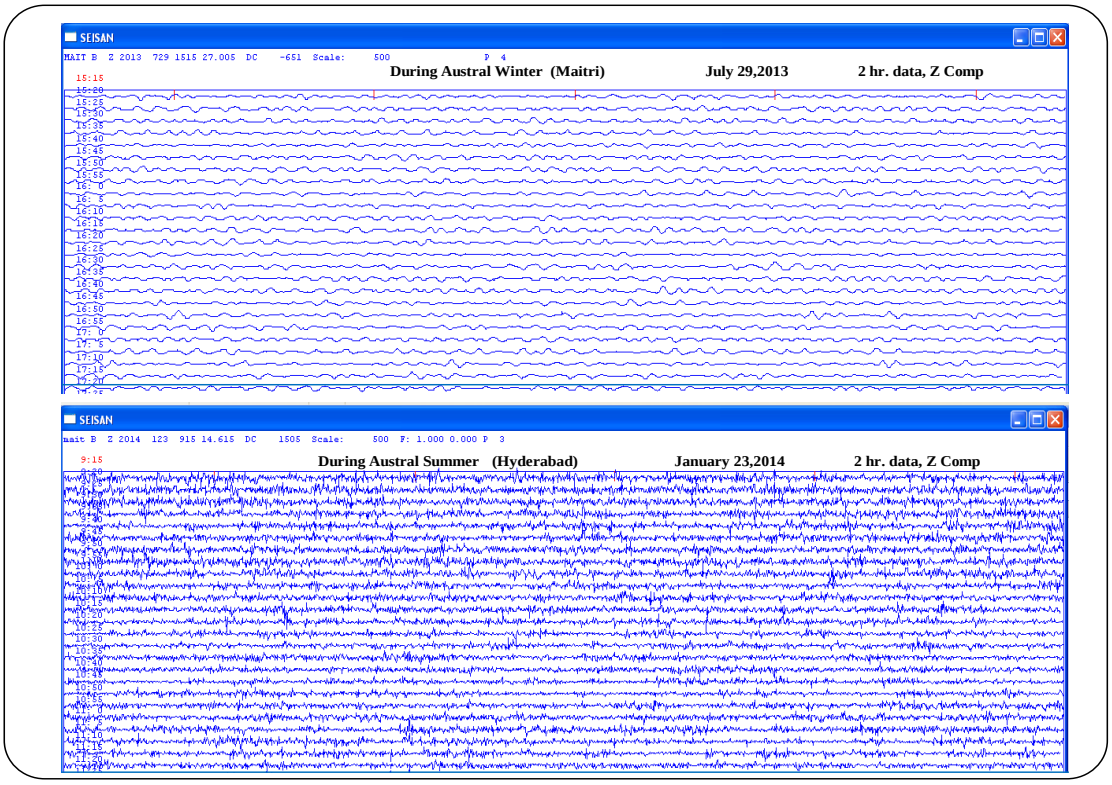

Figure 5. Austral winter Seismogram record of Maitri and Hyderabad Seismic Station

2. Site Response Study

Ambient noise is analyzed using J-Sesame software [4] for Maitri and Hyderabad broad-band seismograph data. The Horizontal to Vertical (H/V) method appears as a valuable tool to investigate the seismic properties. Horizontal to vertical spectral ratio commonly used to analyze soil response for seismic risk evaluation. It reveals a main resonance peak in spectral ratio at frequency 18.5 Hz and amplification factor 0.7 for Maitri data and 10.5 Hz with amplification factor 1.9 in case of Hyderabad data. Dominant frequency observed at each seismic station, where amplification is strongest and a peak can be seen in the H/V ratio. It is observed that as Value of dominant frequency (DF) increase, the destruction from earthquakes decreases and dominant frequency can be related to the geological conditions and intensity damage that characteristize site [5].

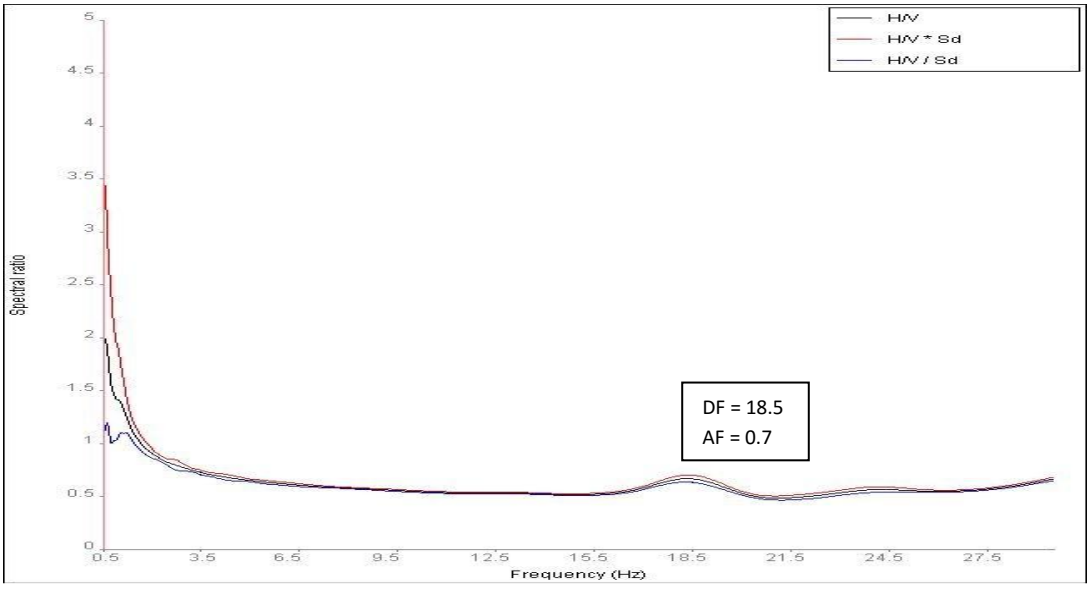

Figure 6. Value of dominant frequencies and amplification factor
at Maitri Seismic Site.

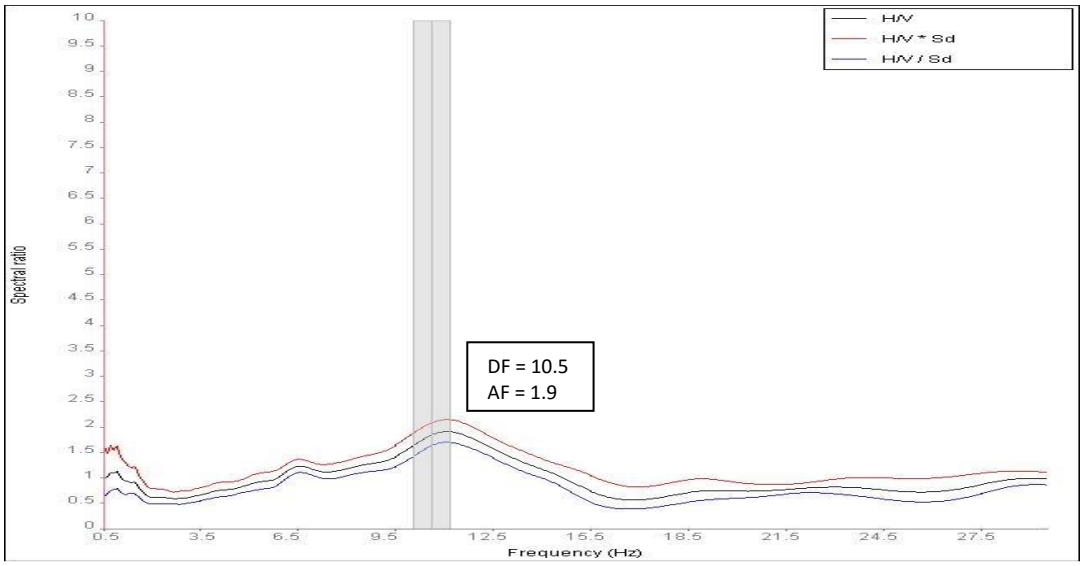

Figure 7. Value of dominant frequencies and amplification factor at Hyderabad Seismic Site.

V. Conclusion

Seismicity of the interior of the continent is due to tectonic forces but is nearly completely suppressed by ice cover. Seismicity of the continental margin is mostly likely to be dominated by the glacial rebound processes. Fundamental advance in Antarctica seismicity could be made by installing more remote recording stations in the continental interior. There is also another reason why there are fewer earthquakes located in Antarctica than within other places. It is because smaller quakes are much more likely to go undetected in Antarctica because there are very few seismic stations operating inside continent of Antarctica. Poor weather at a particular recording station often leads to low signal-to-noise response and insufficient stations records for an earthquake to be located. Good results from station on ice are possible provided the seismometer is placed deep enough to couple with hard ice and the bed rock.

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