Operation of Broadband Seismograph at Maitri during the 30th Indian Antarctica Expedition

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Abstract

The seismicity around the Indian base station at Maitri (Antarctica) was studied. We used the data acquired by the seismological observatory at Maitri maintained by CSIR-National Geophysical Research Institute during the 30th Indian Antarctica scientific expedition. A total of 27 earthquakes with magnitude more than 5.0 magnitude including the largest earthquake at Chile 8.8 magnitude. Most of the earthquakes were occurred near the boundary between the Nazca and South American plates. The reason for such concentrated earthquake activity could be the ongoing subduction and the convergence process between the Nazca and South American plates in this region. Few events occurred in the southern hemisphere are also recorded teleseismically with clear seismic phases at Maitri.

Key words: Antarctica, earthquake, plate margin, subduction zone, convergence.

Introduction:

The seismological station at Maitri (Antarctica) has been operated by National Geophysical Research Institute since 1998 (Akilan et al., 2010) to monitor the seismicity around the region in East Antarctica and the Indian Ocean. The location of the seismological observatory is Lat 70°46' and Long 11°44'. Setup of digital broadband seismograph at Maitri, Antarctica as show in figure 1. The data acquired can be used for studying the space and time distribution of earthquakes, release of energy, strain accumulation and stress drop, investigating the velocity structure, earthquake source mechanism, receiver function analysis, attenuation of seismic waves and seismic anisotropy (Navin Chander et al., 2002). The data collected during this expedition were brought to CSIR-NGRI and analysed here. This report gives an insight into the tectonic activity in and around Antarctica and in the Indian Ocean region.

Data processing

The Maitri seismological observatory is equipped with a broadband seismograph during this expedition. This seismograph consists of a

seismometer and a digital data acquisition system (DAS). The DAS is characterized by a 24-bit analog to digital converter (ADC); the greater the number of bits, the larger is the dynamic range and hence the sensitivity of the system. The 24-bit DAS systems are the state-of-the-art systems giving dynamic range of greater than 130 dB. The digital data acquisition system used at Maitri is of the REFTEK 130 model with three channels and a 24-bit recording system.

The Maitri Seismological station is equipped with Guralp model CMG-3T three component Seismometer. The Broadband sensor had a frequency range from 120 s to 50 Hz. Covers the complete seismic spectrum with a single transfer function. The power supply module normally receives input from a battery of 12V/100Ah and converts to various voltages internally required for functioning of several components. The power supply covers 24 hrs a day and throughout the year. The temperature is maintained between 20-30 degree Celsius in the recoding room and in the vault for better performance, where the seismometer is kept. During the 30th expedition the seismological observatory was in operation for 178 days with some data gap in between due to some technical difficulties. The whole data archive was brought back to CSIR-NGRI, Hyderabad after the expedition is over analysed for earthquake locations. The data were analysed using the SEISAN 10.3 software (Havskov and Ottemollet, 2005).

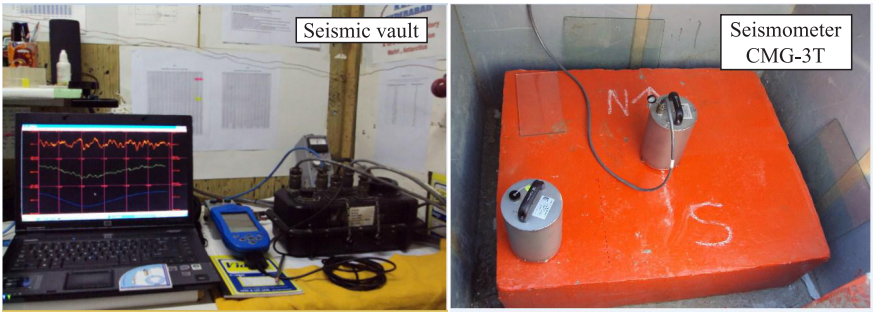


Fig. 1: *Digital broadband seismograph setup at Maitri, Antarctica*

Results and discussions:

There were twenty-seven events with magnitude above 5.0 recorded at Maitri, Antarctica. Epicentre location of events recorded at Maitri is shown in figure 2 (Table 1) from January 2010 to March 2011. Events # 1, # 9 and # 21 occurred in central Peru, where the Peru-Chile trench is running closely in the active boundary collision of the Nazca Plate with the south American plates. The subduction velocity of the Nazca plate near south Chile and north Peru region is ~ 8.7 to 8.8. cm/yr (Pichon et al., 1973), where the earthquakes would have occurred due to the strain accumulation between the Nazca and South American plates. Event #2 (Figure 4) of magnitude 6.8 occurred in the east of the South Sandwich Islands which is the closest event recoded by the Maitri seismological

observatory. Event #3 occurred in the southern Mid-Atlantic Ridge, which is a slow-spreading mid-ocean ridge and there are active volcanic centers. There are 481 seamounts in the Atlantic ridge (Smith and Cann, 1990). The volcanic activity in the ridge/ active sea mounts might be which causing these earthquakes. Event #4 occurred in the Macquarie Island region. Which is the boundary between the Australian and Pacific plates (Verne et al., 2000). This tectonic convergence between the Pacific and Australian plates could be the cause for this earthquake. Events # 5 and # 8 occurred in the Drake Passage, which is the intersection between the west Scotia ridge and Shackleton fracture zone, this region is a slow spreading region (Maldonado et al., 2000) likely cause for the occurrence of volcanic earthquakes. Event # 6 occurred in the Tucuman, Argentina region. This earthquake is close to the boundary zone between the Nazca plate and the South American plate. Events # 7 and # 22 occurred in the Santiago Del Estero, Argentina. Event #10 occurred in the Tristan da Cunha region. Events # 11 and # 12 occurred in the Jujuy, Argentina region. Events #13 (Figure 5), # 14 and # 24 occurred in the offshore Bio-Bio, Chile region. The largest among the event (event #13) is of maximum magnitude 8.8 (Lat -36.122 and Long -72.898) on 27th Feb,2010, where the Nazca plate is suducting under the South American plate. Figure 5 shows the waveform of the vertical component recoded at Maitri. Event #15 occurred in the Southeast India Ridge region, which is the boundary between the Australian and Antarctica continents (Curray J.R., et al 1982). This being a divergent boundary (Akilan et al., 2014), the interaction with the hotspot and the ridge could possibly generate the earthquakes in this region. Event #16 occurred in the off the coast of Maule, Chile. Most of the events occurred in the plate margins. The following events are in the pacific ring of fire, which is encircling Pacific Ocean. Significant earthquakes occurred in the margin of Nazca South American plate margin. About 525 people lost their life and about 15-30 billion loss for the Chile (https://en.wikipedia.org/wiki/2010_Chile_earthquake). It occurred in a seismic gap existed in an area where tectonic loading has been accumulating since the great 1835 earthquake (Lorito et al., 2011). Events #17 to 19 (Figure 2 and 3) occurred on 1st March 2010 in a close proximity in the offshore of Chili. The locations of the events are in the subduction zone between Nazca and South American plates (Barazongi and Isacks, 1976). This region has high strain accumulation (Kreemer et al., 2003). The magnitude ranges from 5.2 to 5.7. There could be several small events, which were not detected by the Maitri observatory, since the complete catalogue of events are not listed in this present report. The earthquake swarms are interlinked with the volcanic activity (Justin-Visentin and Zanettin, 1974) or subsurface plume intrusion (Ukawa and Tsukahara, 1996) may also be possible. The range of magnitude and the sallow depth of occurrence of the events are supporting the argument. Therefore, there could be active underwater volcanic activity in the offshore region of Chile. Events #17, # 18, # 20 and # 25 occurred in the offshore Maule, Chile. Event #19 occurred in the off coast of Libertador O'Higgins, Chile. Event # 23 (Figure 7)

occurred in the Araucania, Chile. There is a cluster of events occurred in the offshore of Chile (event #17-20, # 23 and # 25 also part of that).

Event # 26 occurred in the South of the Fiji Islands. Fiji Islands situated on the convergent boundary between the Pacific and Australian tectonic plates (begg and Gray, 2002). Event # 27 occurred in the South Sandwich Islands region. All events, which are recorded at Maitri seismological observatory occurred in the southern hemisphere.

Table 1: List of earthquakes event of magnitude 5.0 and above recorded at Maitri broadband seismograph station

S.No	Date	Origin Time	Lat	Lon	Depth (KM)	Mag	Location
1.	03.01.2010	20:39:13	-8.802	-77.718	116.8	5.7	Central Peru
2.	05.01.2010	04:55:39	-58.173	-14.695	13	6.8	east of the South Sandwich Islands
3.	06.01.2010	16:38:36	-41.605	-16.568	10	5.6	southern Mid-Atlantic Ridge
4.	07.01.2010	08:29:06	-53.516	159.28	10	5.6	Macquarie Island region
5.	17.01.2010	12:00:01	-57.664	-65.879	5	6.3	Drake Passage
6.	19.01.2010	17:28:15	-27.584	-65.829	26.8	5.2	Tucuman, Argentina
7.	20.01.2010	06:05:46	-26.789	-63.214	559.9	5.4	Santiago Del Estero, Argentina
8.	20.01.2010	19:07:39	-57.773	-65.809	10	5.1	Drake Passage
9.	25.01.2010	22:52:47	-8.498	-74.466	146.7	5.9	central Peru
10.	27.01.2010	15:47:59	-38.815	-15.93	10	5.0	Tristan da Cunha region
11.	28.01.2010	08:04:14	-23.357	-66.712	208.4	5.9	Jujuy, Argentina
12.	07.02.2010	17:09:47	-23.225	-66.564	238.9	5.6	Jujuy, Argentina
13.	27.02.2010	06:34.12	-36.122	-72.898	22.9	8.8	offshore Bio-Bio, Chile
14.	28.02.2010	19:48:35	-38.099	-73.68	18	5.9	offshore Bio-Bio, Chile
15.	05.02.2010	06:59:06	-47.912	99.593	1	6.2	Southeast India Ridge
16.	01.03.2010	01:15:13	-35.174	-73.819	35	5.0	off the coast of Maule, Chile
17.	01.03.2010	02:44:42	-35.039	-72.487	22.9	5.7	offshore Maule, Chile
18.	01.03.2010	07:49:09	-34.707	-73.119	33	5.3	offshore Maule, Chile
19.	01.03.2010	14:36:30	-34.39	-73.504	30.9	5.2	off coast of Libertador O'Higgins, Chile
20.	02.03.2010	04;09:28	-35.794	-73.233	35	5.4	offshore Maule, Chile
21.	16.12.2010	07:11:58	-10.786	-73.459	113.6	5.3	central Peru
22.	01.01.2011	10:04:12	-26.803	-63.136	576.8	7.0	Santiago Del Estero, Argentina
23.	02.01.2011	20:24:52	-38.355	-73.326	24	7.2	Araucania,Chile
24.	11.02.2011	20:05:30	-36.422	-72.96	26	6.9	Offshore Bio-Bio,Chile
25.	14.02.2011	03:40:09	-35.38	-72.834	21	6.7	Offshore Maule, Chile
26.	21.02.2011	10:57:52	-26.142	178.394	558.1	6.5	South of the Fiji Islands
27.	06.03.2011	14:32:36	-56.422	-27.063	87.7	6.5	South Sandwich Islands region

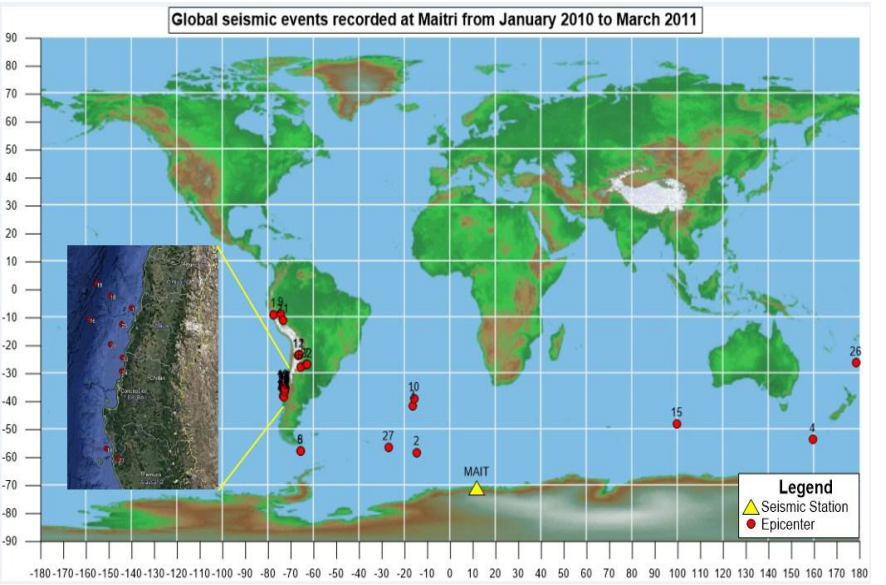
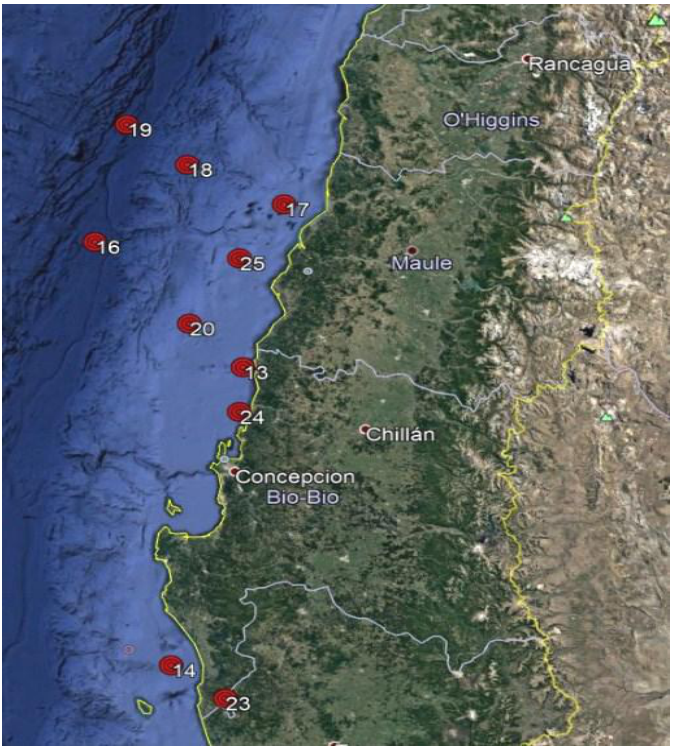


Fig. 2: *Global seismic events of magnitude ≥ 5.0 recorded at Maitri during the period of study*



Chile

Fig. 3: *Cluster of events occurred in Chile and its offshore region*

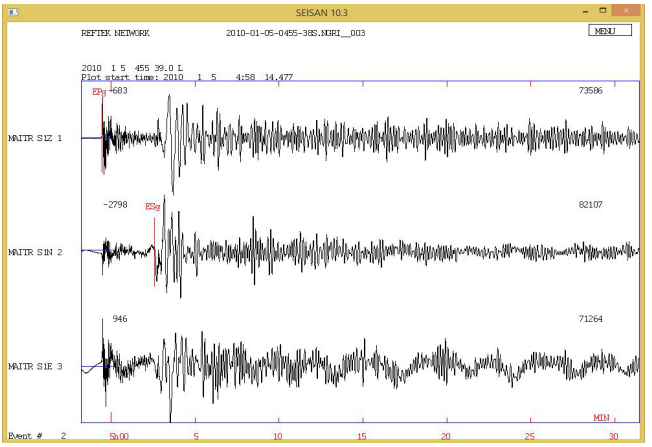


Fig. 4: *Event # 2: Digital waveform of teleseismic event recorded at Maitri observatory located at East of the South Sandwich Islands; Magnitude: 6.8; Depth 13 Km.*

Figure 4 shows the nearest event recoded at Maitri marked with the primary wave (EPg) and the secondary wave (ESg) and the surface waveform were visible. There is no events were reported and recorded within the Antarctica continent during the 30th Indian Antarctica expedition.

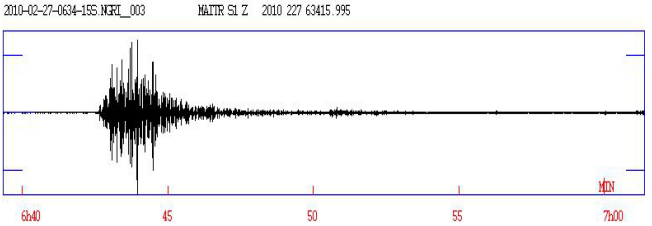


Fig. 5: *Event #13 shows the event of magnitude 8.8 recoded at offshore Bio-Bio, Chile on 27-2-2010*

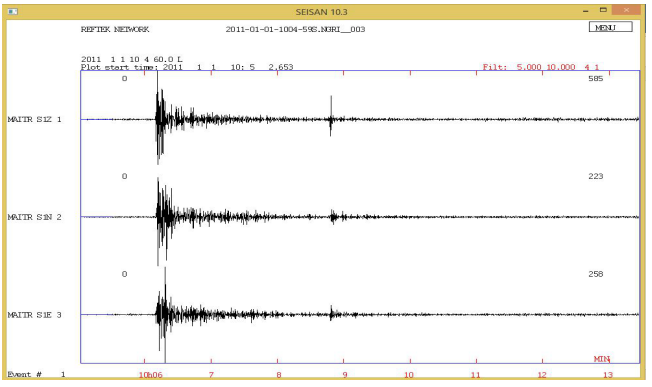


Fig. 6: *Event # 22: Digital waveform of teleseismic event recorded at Maitri observatory Location: Santiago Del Estero, Argentina; Mag: 7.0; Depth: 576.8 Km*

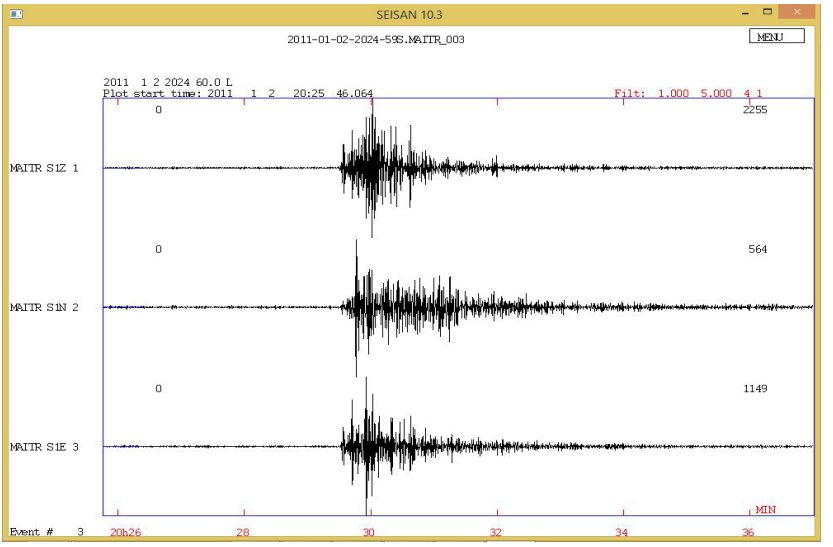


Fig. 7: *Event # 23: Digital waveform of teleseismic event recorded at Maitri observatory Location: Araucania, Chile; Mag: 7.2; Depth: 24 Km; Date: 02.01.2011*

Figures 6 and 7 show the two large events recoded at Maitri observatory with magnitude 7.0 and 7.2 respectively. The waveform shows the vertical, north-south and the east-west components of motion. These events are located in South America.

Conclusions

There were twenty-seven earthquakes recorded at Maitri (Antarctica) with magnitude 5.0 and above. The events mostly occurred in the Sothern hemisphere plate boundaries. There were three large earthquakes of magnitude 7. 0 and above, which were recorded in and around South America along the Nazca- South American plate boundary region. The convergence process between the Nazca and South American plates is active and the crustal shortening is in progress. There is no local event recorded during the expedition.

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