

New Seismological Stations in Trelew and Rio Grande, Argentina

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Introduction

As a result of an agreement reached among the Italian *Programma Nazionale di Ricerche in Antartide* (PNRA), La Plata National University and the Argentine Antarctic Institute, BB13 sensors and a PDAS100 seismograph were borrowed from PNRA to La Plata Faculty of Astronomical and Geophysical Sciences in 1996.

During the year 1997, a LE-3Dlite Lennartz Electronic, three directional 1 Hz geophones (Germany, 1993) and a three-channel data acquisition with DAC of 16 bits were carried to Trelew (Patagonia) in order to study the soil conditions. A characterisation of the station was made through a comparative analysis of the seismic noise and the processing of events recorded in Trelew and those of La Plata seismological station.

Afterwards, in the year 1998, one BB13 sensor was placed to take into consideration the installation of the whole equipment in Trelew. The site selected was on the property of the Geomagnetic Observatory belonging to La Plata Faculty of Astronomical and Geophysical Sciences, which is located on a 44 Ha terrain, 8 km from the city of Trelew.

As a consequence of the studies that were done with the data obtained from the Lennartz and the BB13, the construction of a subterranean vault was finished in February 1999. Trelew UNLP station, whose coordinates are $\phi = 43^{\circ}15'54.8''$ S, $\lambda = 65^{\circ}22'38.4''$ W, is been operated by a resident geophysicist who sends the data to La Plata since April 1999.

Besides, on the framework of a project with the aim of studying the geophysics and geodynamics of Tierra del Fuego Is, another new seismological station has been operational in Argentina since June 1999. Rio Grande Station is located on "Despedida" farm, 50 km south west of the city of Río Grande (Tierra del Fuego). The sensor has been situated on a NW-SE outcrop, 500 m away from the main farmhouse. The station coordinates are $\phi = 53^{\circ}57'13.046''$ S, $\lambda = 68^{\circ}16'00.521''$ W. The Rio Grande Astronomical Station personnel run the seismological station. Data is downloaded on a regular basis; the events are extracted and sent to La Plata.

Geological and Geodynamic Framework

A region called Patagonia extends in the southern area of the South American continent. The Strait of Magellan separates Tierra del Fuego being situated in the south of

Patagonia, from the continent. Patagonia cannot be distinguished from the rest of the continent neither by means of a well-defined physical boundary nor by means of a geological one. If we hold to the oceanic outline, this limit could be marked out at 41° -latitude approximately.

Although Patagonia and Tierra del Fuego are composed by two areas that are orographically and geologically different, they are joined together by gradual stages: a mountainous area in the west and a plateau region in the east. The unevenness between the top mountain range and the eastern region, relatively low, is not, however, as accentuated as the northern zone of the continent. The Fuegian Cordillera has, in fact, rather reduced elevations. The average altitude of its summits can be estimated at 2000-2500 m.

On the other hand, the eastern region does not form a uniform and low plain, but it comprises a series of terraces and plateaux nearly extensive that generally descend in steps from the mountain range. The average altitude of the extra-Andean terraces is less in Tierra del Fuego than in Patagonia.

Trelew station is on the Region of North Patagonia, which comprises the plains in the Río Negro and Chubut Provinces, located south of the Limay and Negro Rivers, east of the Patagonic Range and just north of the middle and lower course of the Chubut River, which reaches the Atlantic coast. This geostructural unit is considered a post-Precambrian mesocraton.

Thick sedimentary layers are found in the western reaches of the Chubut Province and in the area north of Santa Cruz, near the effusive Jurassic rocks, which lie directly above a "basement" of granitic and metamorphic rocks in the eastern zone. With respect to the rest of the Province, a different tectonic style and a minor degree of deformation perturb the sedimentary layer in the central and northeastern regions of Chubut Province.

The western continental margin of South America is a convergence zone, and from the Isthmus of Panama to latitude 46° S, the Nazca plate is subducting ENE beneath the continent at 78-84 mm/yr. In the region between 36° S- 46° S, there are no deep-focus earthquakes. Here the intermediate-depth foci are much less than in the north. These circumstances indicate a relatively youthful present phase of convergence. The oceanic plate is evidently descending at a very small angle or not at all as it is absorbed beneath the South American plate. The motion of

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subduction is in the azimuth N80°E.

At Rio Grande station the regional setting is complex, with fractures of different magnitude and orientation. The station is located on a conglomerate outcrop called Despedida, ascribed to the Eocene-Oligocene. The present limit between the South American and Scotia plates is a 3000-km long transform fault zone of left-lateral movement (East-West), south of 50° latitude. It crosscuts the South-American continent between the north Scotia rift and the Chilean trench. In the region where the transform fault system intersects the continent, a regional fault system has been identified, the most important of which is Magellan. Geological evidence and the system orientation suggest that the principal fault is parallel to Fagnanos Lake axis.

Instrumentation and Housing

Trelew station: Three broad-band seismometers BB13 (1988), Geotech Teledyne (USA) were installed. These are instruments that sense seismic acceleration over a bandwidth of DC to 20 Hz and each unit may be operated as a horizontal or a vertical instrument. Before the definitive installation of the sensors, calibration curves were done, by using both weight lift at the vertical component and tilt at the horizontal components. The broad-band response was verified with noise signal generated by the PDAS100. The seismograph, a PDAS100 Geotech Teledyne (USA) was optimised with storage on Iomega ZIP (100 Mbytes). The operation was set to be event triggered STA/LTA with filter on the vertical channel, at a sampling frequency of 20 sps. The time was controlled by a GPS and, after due to the WNRO (week number roll over) failure in August 1999; the inner real time clock has been used. The electric support was provided with an UPS (uninterrupted power supply) connected to the local electric power. This unit allows us autonomy of 20 hours. An auxiliary 486 PC for operational purposes was installed.

A 3-m-deep hole was dug in the ground and a vault with brick walls of 0.20 m and a lightly reinforced concrete roof composed of two layers separated by a 20 mm polystyrene foam for thermal insulation was built inside it. The inner dimensions of the vault are 1.90 m x 1.20 m x 1.40 m. The floor was left untouched so that possible rain

leakage can be absorbed. The vault was covered with waterproof foil and the access is possible by means of an aperture of 0.6 m x 0.6 m, which is kept covered with a concrete flat stone that is hidden with 0.3m of soil to avoid vandalism (Fig.1).

A 0.9 m x 0.9 m x 0.6 m pier of concrete was built, using a 50% portland cement and sand mix well vibrated, so that it does not contain air bubbles. It was left forging during a month. No steel reinforcements were used in order to prevent the possible production of seismic noise due to the different dilatation coefficients. The pier juts out 0.2m and its superior surface is 2.0m under the ground level.

After the three sensors were installed on the pier, they were covered with a thermal insulation box made with 40 mm “Polyfan” laminated polystyrene foam, with a density of 32 kg/m³, and were also covered with aluminium foil. Two-inch PVC tubes (60 m long) for the signal and power cables join the vault with the control house.

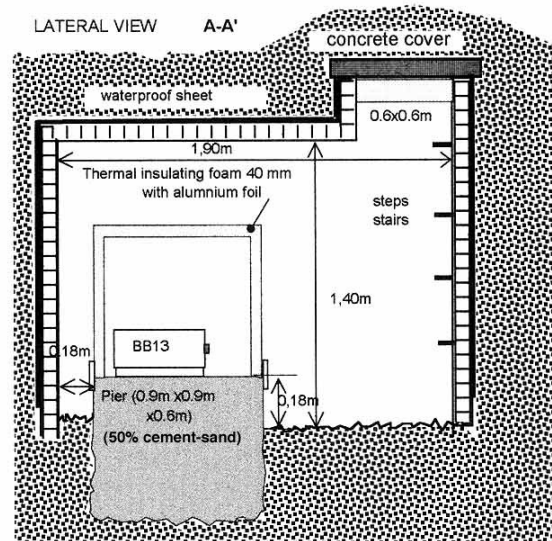
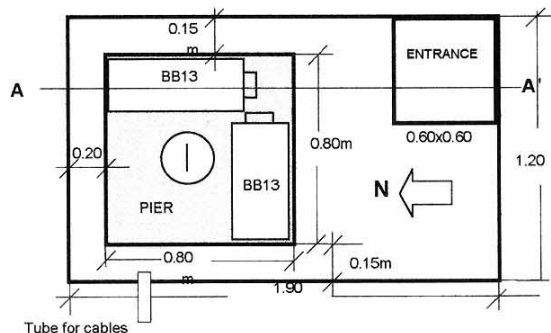
Two temperature sensors were installed for studying the position of the mass; one stuck to the BB13 cover, and the other for sensing air temperature during spring and summer seasons. It is evident that the vault sensor and the mass position accompany the season’s temperatures. Moreover, it is possible to observe the diurnal thermal signature. The mass position has a direct correlation with the fluctuations of the BB13 cover sensor which are phase shift and smaller than those of the air temperature. This results from the thermal insulation and the sensor’s mass that behave as a low pass filter. Because of the inner circuits power (3 x 0.8 W), the cover temperatures are bigger than those of the air.

In order to minimise the diurnal mass fluctuations is necessary to increase the thermal constant of the assembly. There are two possible solutions to this: the first one, and the easiest, is to add thermal mass with another masonry vault on the pier that covers the sensors and, the second one, is to increment the thermal insulation.

A value of $Kt=320 \pm 20 \mu\text{m/s}^2/\text{°C}$, not provided by the manufacturer, was determined for the vertical sensor thermal drift coefficient.

Rio Grande station is equipped with a LE-3Dlite

Fig. 1 - Details of the sensors housing. Left: a front view, right: AA' section view.



Lennartz Electronic, three directional 1 Hz geophones (Germany, 1993) and a three-channel data acquisition with DAC of 16 bits and a sampling frequency of 25 sps with a RS485/RS420 serial output. The acquisition software runs on a PC notebook 486 with 200-Mb hard disk for operation and data storage; the registration is continuous. The time has been controlled with a GPS Trimble ACE II receptor since December 1999. The power is obtained with 12V batteries and solar panel (50 W), which allows the equipment 36 hours autonomy. The sensor is situated inside a wooden box without a base. Thermal insulation is provided by a 40 mm polystyrene foam. A 2.5 W heater is used for warming, approximately 5 °C over the ambient temperature. The control house, together with the converter RS485/RS232, Laptop, batteries, AC power generator (from the farm) and solar panel, is located at a distance of 500 m.

Background Seismic Noise

Patagonia and Tierra del Fuego are regions characterised by low temperatures and strong winds so it was convenient to study the seismic noise at the stations. For this purpose, 10 minutes records free of seism, using visual inspection, later checked against NEIC (USGS) listings were considered.

Trelew station: the site has a thick sedimentary layer, an ancient marine floor and is situated 30 km from the coastline. Using particular records and pre-event pieces obtained from the event-triggered registration, acceleration noise spectra were calculated. The spectra were smoothed applying 20-point moving average.

From the analysis that was done is possible to distinguish three zones:

- a) 0.07 - 1 Hz: is a portion with variable amplitudes and appearances, due to the oceanic activity. Is frequent to observe two maximums, at 0.2 Hz. and 0.4 Hz., the first one due to the action of oceanic waves on coasts and the second one due to standing waves travelling in opposite directions, or only one centred maximum.
- b) 0.8 - 1.8 Hz: strong winds near the station act upon this frequency band as was studied using meteorological satellite information. At the horizontal components this effect is notorious with amplitudes 4 and 5 times greater than the ones at the vertical component, this remarkable feature may be the consequence of the

limited chamber depth (Fig. 2).

- c) 2 - 10 Hz: the city proximity and the winds explain the shape and amplitude of this portion. Frequently is possible to observe a signal at 3.6 Hz, that sometimes presents its harmonic at 7.2 Hz. As this effect was found with other seismographs located on other sites of the Observatory, is possible to assume that the source is neither the instrument nor the vault, so a soil or nearer wooden construction resonance probably occasions it.

Rio Grande: the sensor is located on a conglomerate outcrop, 40 km from the coastline. The records used for the seismic noise study were chosen from the visualisation of 1-hour records, instrumental response correction was applied to them and a set of meteorological data between July and October 1999 was provided by the owner's farm to do the correlation of effects.

A typical spectrum shows a similar feature for the three components of this station, in windy or calmly days (Fig. 3). The wind produces raising at the band frequency studied, especially between 1 Hz and 4 Hz that influence the local seismicity recorded.

Use of the Stations

Is a fact that the seismic structure of the crust and upper mantle underlying South America remains rather poorly characterised as a whole, particularly in comparison with other regions, such as North America and Eurasia. The quantity of continental seismicity is significantly lower than the regions mentioned and South America remains more poorly instrumented than they do. The lack of instrumentation lead to an underestimate of seismicity in a region. With a good distribution of stations source mechanism can be determined for an event above certain fixed magnitude threshold anywhere. Obviously, the larger the number of stations, the smaller the events that can be detected and analysed.

50 stations perform the National Network of Seismological Stations in Argentina. At the North-West there are 17 stations, at the Centre and West 27 stations, at the North-East 3 stations and at Patagonia and Tierra del Fuego 1 station. Among the stations mentioned, there are 5 broad-band stations. The deployment of two new seismological stations in Patagonia and Tierra del Fuego, will allow us a better distribution.

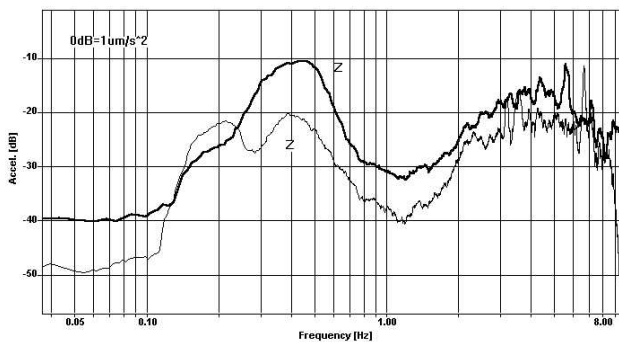


Fig. 2 - Vertical component background seismic noise at Trelew. Typical spectra is shown with two maximum at 0.2 and 0.4 Hz (thin line) and with only one (bold line).

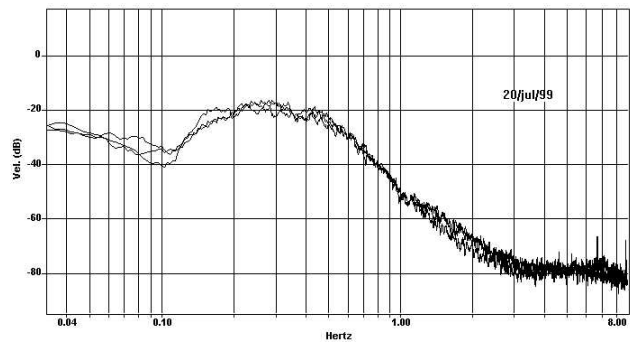


Fig. 3 - Typical feature of smoothed noise spectra for the three components at Rio Grande applying instrument response correction.

Clearly, the siting of the seismic stations is as critical a design parameter as is the instrumentation itself. The chief technical criterion for a good site is low seismic noise. This is usually determined by measurements made at a prospective site with portable equipment. In some cases the low noise criteria must be relaxed in order to assure adequate coverage. Other important factors in site selection are accessibility, power availability, local support, the last being the most important non-technical specification. It has been demonstrated, many times over, that the best of stations are those with a dedicated local staff and that while all other criteria for a good station may

be met, the lack of local support almost always spells disaster.

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