THE GEOPHYSICAL OBSERVATORY AT TERRA NOVA BAY

A. MELONI1, A. DE SANTIS1, A. MORELLI1, P. PALANGIO1,
G. ROMEO1, E. BOZZO2 and G. CANEVA2

1Istituto Nazionale di Geofisica, Via di Villa Ricotti 42, 00161 Roma, Italy
2Dipartimento di Scienze della Terra, Università di Genova, Via Benedetto XV 15, 16132 Genova, Italy

Abstract: In the framework of the Italian Antarctic Project, a geophysical observatory has been installed in Terra Nova Bay, Antarctica. Two disciplines were undertaken: Geomagnetism and Seismology. The main objectives for the installation of the Geomagnetic observatory, started in 1986/87 Austral summer, were: a) to provide a data-base for the reduction of the magnetic survey measurements; b) to measure the elements of the magnetic field in order to provide absolute values and the secular variation trend for the area; c) to obtain data to investigate the time variations of the geomagnetic field; d) to supply values to World Data Center for the definition of the International Geomagnetic Reference Field (IGRF). During the Austral summer 1988/89 a high quality seismic station was installed and tested close to the Terra Nova Bay Italian Base. The sensors comply with the Very Broad Band specifications, with an instrument response flat on ground velocity in the frequency band from 8 Hz to 3 mHz, and the digitizers allow a dynamic range of 140 dB. For such a sensitive instrumentation, the installation was made inside a 8-meter tunnel in granite. Starting from the Austral summer 1990/91 the observatory starts continuous unmanned operation. Continuous power supply is provided by a new system, and data acquisition will be performed by a microVAX computer at the Base. A satellite communication links with the Base computer will allow to monitor the state of the instrumentation, as well as to view and transfer data of events of special interest.

Key words: Terra Nova Bay, geomagnetism, seismology, broadband seismograph, satellite communication

Introduction

A permanent unmanned geophysical observatory that would include seismological and geomagnetic measurements was one of the goals of the Italian Antarctic Research program.

Seismology has a strong need for a dense and uniform instrument coverage of the Earth, both for the detailed study of structure, and for the study of the earthquake source processes. A better understanding of the Earth dynamic processes requires a denser and more uniform distribution of seismographs. However, large gaps still exist in the planned distribution represented by oceanic areas and by lands where difficult environmental conditions pose difficulties in installation. Much effort is currently made all over the world to increase the instrumental coverage, by national or international projects. However, the southern polar area is still a region where seismic instrumentation is inadequate and last-generation very-broad band seismographs are almost absent.

It is well known that measurements of the Earth’s magnetic field are made continuously only at magnetic observatories. The worldwide distribution of observatory locations shows a lack of such installations in the southern hemisphere. As can clearly be understood, similarly to what happens with seismology, this arises from the objective imbalance between lands and oceans in the southern hemisphere as well as from the more recent discovery of these lands. Antarctic installations are therefore of great importance also for the study of the Earth’s magnetic field and magnetic observations have been undertaken ever since scientific expeditions began.

Following the above considerations and the IUGG suggestions, the Italian base in Antarctica was given a seismic and magnetic observatory. Since human access to the Italian Base is so far only limited to the austral summer, a permanent, unmanned Geophysical Observatory, was configured and left in operation for the first time in February 1991. This paper deals with the above mentioned installations and some of the results. The coordinates of the observatory are the followings: Latitude 74.69°S; Longitude 164.12°E, elevation 28 m a.s.l.

The Seismographic Observatory

The seismographic station has a three component set of STS1/VBB sensors and three 24-bit Quantagator A/D converters (Wielandt and Streckeisen, 1982; Wielandt and Steim, 1986). The sensors comply to the very-broad band specifications, with a frequency response to ground velocity flat between 10 Hz and 3 mHz. The 24-bit digitizers allow to fully exploit the characteristics of the sensors, with a completely linear behaviour in 140 dB of dynamic range.

This equipment is housed inside a 8 m deep tunnel, excavated in a granite wall at 1 km from the main Base (Morelli et al., 1991).

From the tunnel, a fiber optic cable transfers the digital signal to the temperature-controlled room of the Base where the computer center is located. Here, two data loggers accept data (data acquisition is managed by 68000-processor, VME-bus computers). Recording is continuous at 20 samples per second. All functions, including data compression and timetagging, are controlled by these station processors.

The data loggers are configured so as to stand failure of either of them. A rubidium atomic frequency generator provides a reliable time reference. One data logger is connected to a microVAX computer by means of a shared-memory interface, which allows to record data directly on the VAX disks.
The Geomagnetic Observatory

The Geomagnetic observatory was installed in Terra Nova Bay during the 1986/87 austral summer: in this place preliminary measurements were first carried out in order to avoid areas affected by short wavelength magnetic anomalies, which are a source of noise for magnetic measurements.

In a standard magnetic observatory absolute measurements of the total intensity, \( F \) and the angular elements \( D \) (declination) and \( I \) (inclination), are useful to ensure that the drift of any kind (i.e. thermal and clinographic) in the recording instruments is corrected. The instruments used at the observatory during the four Antarctic surveys include proton precession magnetometers (P.P.M.) for total intensity \( F \) recordings; DI magnetometers for absolute measuring of the angular elements \( D \) and \( I \), and a recording system composed of three fluxgate magnetometers for \( H \), \( D \) and \( Z \) time variation digital data acquisition. For a detailed description of such instruments refer for example to Parkinson (1983). Two non-magnetic aluminium containers, which allow a stable installation, are housing the fluxgate and proton precession magnetometers while their sensors are lodged about thirty meters away in thermally insulated boxes. The sampling rate of the magnetic field elements was averaged to 1 minute for all expedition installations; the absolute measurements independently taken, were input to a mathematical procedure in order to determine baseline values for the relative fluxgate measurements; one minute absolute values of the three elements \( H \), \( D \) and \( Z \) were finally obtained. Final data are published in the Antarctic measurement yearbooks (Azzara et al., 1989, 1990, 1991).

One of the most important aims of a magnetic observatory is to supply information for defining the IGRF (International Geomagnetic Reference Field). IGRF, adopted for the first time in 1968, is a space-time description of the geomagnetic
field including its secular variation, obtained through spherical harmonic analysis, which provides mean values of the field elements during the period of validity of IGRF itself (Barraclough, 1987).

Mean values of any geomagnetic field element, as recorded at an observatory, plotted for a number of years, undergo a steady increase or decrease for some decades. This time variation, represented by a smooth curve, is called secular variation; it is a feature of the main geomagnetic field, and the amount of its change varies smoothly with latitude.

In order to recognize whether the secular variation of the field elements from the Terra Nova Antarctic Observatory agrees with the IGRF85 and following years extrapolation, plots for the field elements were compiled. IGRF values were computed following Barraclough (1987). A reasonable fit for these trends is important for total field anomaly maps, computed by subtracting IGRF from gridded field measurements (Bozzo et al., 1988; Bozzo and Meloni, 1992). Figure 2 illustrates the comparison between IGRF values (open circles) and experimental values (stars); open squares indicate mean values from the absolute measurements only for F, H and Z. Fits are quite good for all the elements. Misfits can be ascribed to the fact that averages are made over the short operation period of the observatory, while IGRF values are intended as mean values from a full year.

**Automatic Winter Base Configuration**

The Italian Antarctic Base, located in Terra Nova Bay, is so far only limited to summer access; an automatic wintering over installation is then necessary to ensure continuous data acquisition. The basic problem to solve for continuous winter unmanned operation of a scientific base in Antarctica is power supply; our group solved it by resorting to a system composed of 6 diesel engine generators. Only one generator is active at any time, and all the engines run on rotation. During inactivity, every engine is started once a week to control its proper functioning. Fuel is Jet-Al, suitable for low temperatures.

The set of generators is controlled by a microVAX 3800, which monitors the state of health of the engines and decides when to switch to a new one for power production. Besides controlling the generators, it monitors the general working of all the instruments in acquisition (seismographic, magnetic, meteorological) and checks the general situation of the Base (temperature and humidity).

The computer room is auto-heated by all the electronics in operation. The temperature is controlled by a heat exchanger which dissipates excess heat. Through an Inmarsat satellite unit and a modem it is possible to get connected with the Base computers. The above mentioned configuration was put into operation on February 1991 at the end of the expedition. A flow chart of the Automatic winter base installation is reported in Fig. 3 (see next page).

**REFERENCES**


The Geophysical Observatory at Terra Nova Bay 587
Fig. 3. a) and b): Automatic winter station block diagram with magnetic and seismic observatory.