D-SEISMIC :A VERY FLEXIBLE LOW COST -HARDWARE/SOFTWARE-SYSTEM FOR ACQUISITION, REAL TIME AND POST PROCESSING OF SEISMIC DATA OF ROSS SEA (ARTARTICA 2002 EXPEDITION)

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ABSTRACT

Two systems called "D-Seismic", developed by "IMFA-Parthenope University" and granted by "Programma Nazionale Ricerche Antartide (PNRA) of ENEA" and by DIP.TE.RIS, have been towed on the ship Italica. These systems have been designed specifically for marine geological studies in the Antartica 2002 mission, for acquisition, storing and pre-processing of sparker and sub-bottom data. The hardware comprises an internal acquisition board with 8 channels A/D converter with 200 KHz sampling frequency, internal counter, interrupt and DMA capabilities. The software of D-seismic was developed for Windows OS and has about 10.000 lines of code. Some of the main features are a friendly user graphical interface and a programmable Real Time Varying Gain processing system for the echoes signal ; GPS navigation strings are received, decoded as Navigation FIX and are displayed and stored. Data records are stored on a slave HD that has a capacity 130 days' worth of data storage. Some innovative utilities characterize the post-processing of the data.
These systems are currently being tested with acoustical exploration techniques and characterization of the Ross Sea-bed(XVIII PNRA expedition) with a range of depth between 100-4000 m and about 60 days of uninterrupted run. Some acoustic data records, raw and processed, will be presented, along with a discussion of the results.

RECOGNITION AND CLASSIFICATION OF SEA BED AND SUB-BOTTOM WITH ACOUSTICAL DEVICES

Recognition and classification of sea-bottom surface and subsurface strata have been very important issues for geologists, engineers and biologists [1]. 25 years ago simple procedures were developed by one of the authors [2] employing analog processors for the identification of sea beds from their acoustical reflectivity. This study has been triggered by the availability of

disposable PC boards with sufficient flexibility and processing power. It has also been inspired by the development of a low cost hardware/software digital processor, Windows OS compatible, with performances for specific acoustic source and receiver.
Recently in the maps of many Geological Services and in some nautical maps, there is information about the type of sea bed relative to superficial strata.
It is very useful to construct these maps utilizing acoustical surveys, in particular on the continental platform where the morphology is quite flat and with a low gradient/slope, as steep slopes limit the efficiency of acoustical instruments.
It is clear that the data supplied by acoustical surveys must be integrated with well samples.
The acoustical impedances of sea bed types probably have values very different by than those of water(i.e. $Z = 1.5 \times 10^6 \, Kg / m^2 \sec$ *)* and thus, are sufficiently different from one another so that they can be distinguished. Bearing this in mind, some experiments were carried out in 1975, by F.Giordano [1] using an analog processor with time varying gain system and an eco-signal amplitude to time converter while utilizing a marine ecograph . The signal reflected by the sea bed was processed by the analog processor and transmitted to the stylus of the ecograph and the length of the representative bar was correspondent to sea bed typology. These modern digital technologies [3] together with sophisticated and fast data processing, therefore allow the possibility of extracting more information from the reflected sea bed signals.
Another field in which digital analysis is very useful is that of marine reflection seismology. There are various kinds of marine seismic systems (MSS) which can generate impulsive perturbations and receive echoes from sea bed as well as obtaining, elaborating and finally printing the results (wave forms) on a CRT or graphic recorder. The purposes of seismic marine exploration are very wide and include oil exploration, harbor docking systems and in general, environmental research.
The development of MSS began many years ago. Most of the original systems were extremely simplistic due to technological limitations of analog electronic devices. However, in the last twenty years, digital technologies have increased the development of signal processing.
The penetration of the impulsive *wavelet* in the sea bed strata is dependent on power.
Some examples of *high power sources are* : dinnertime, sparkers , air and water guns ,
medium energy sources :boomer, uniboom and *low energy sources* :subbottom profiler mud penetrator low frequency echo-graph, chirp sonar.
Obviously, the penetration in the sub-bottom increases according to two parameters : the power of the source and the wavelength of the wavelet signals [4],[5],[6].
In many surveys developed in the last twenty years, we have noticed that the intermediate energy systems such as boomer and modified sparker systems (mini and multidip) are a good compromise between penetration and resolution .The performances of these systems for the definition of seismo-stratigraphy for the first 40-50 meters under the sea bed, are competitive in sub-bottom low impedance contrast strata sequences [7].
Particular importance was given in designing the Time Varying Gain (TVG). The attack point is adjustable by a *graphic sliding cursor* and there is a menu of the functions and of their characteristic parameters .
For reaching the technological objective of enhancing the performances of these systems, we have developed a low cost high-speed, optimized software-hardware system ‘D-Seismic’, that we will describe in this paper.

HARDWARE

D-seismic Hardware consists of a P.C. – Pentium III with 800 MHz processor clock, internal RAM of 256 MB, 20 and 40 GB Disk ,CD Recorder and Reader, National Instruments PCI-MIO-16 E-Board [8] and some external devices ,Fig 1.
NI-Board used for acquiring and playing back on analog graphic recorders.
NI-Board advanced hardware system, which in fact integrates A/D and D/A 12 Bit converter, 16 I/O channels, 8 channel differential multiplexer and two hardware counters for triggering and delaying operation. The sample rate is programmable between 1 and 200 KHz and 8 digital output ports.
Corresponding value of the gain for each channel is programmable by software choosing the signal range in volts.

NI-Board converts input analog signals to digital data that are processed by a resident software driver and are converted to their voltage corresponding value.
The board can receive an external trigger or can generate triggering signals for external devices. This function is achieved using programmable hardware counters :the first controls the triggering of the system and the second, delays triggering and starts *acquisition*. The utility of this last feature will be highlighted during the software features description in the next Chapter .

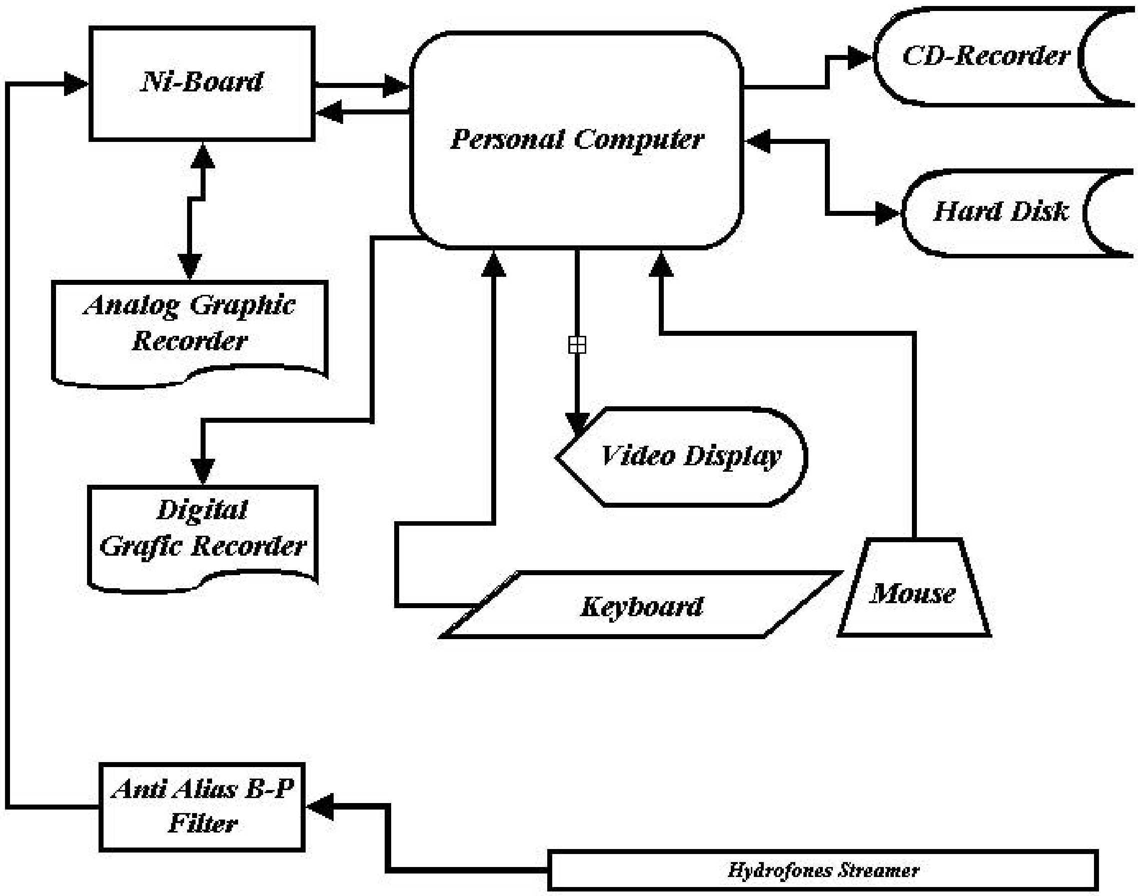

Fig.1- Hardware schematics of *digital acquisition system* controlled by D-Seismic

SOFTWARE FEATURES

D-Seismic Main Window contains 3 windows (see figure 2): the largest on the left, is "Track Scope" that allows the user to view the current digital image of seismic echoes; the slim window on the right, plots the current sweep waveform in *voltage vs. time* and the sliding cursor represents the TVG delay time. The window on bottom is the *command window* and contains all the controls related to *acquisition* or *playback*. Using the menu on the top of screen, the user can access detailed file information, display options and tools such as TVG , immediate manual fixing, GPS to PC time synchronization and analog output activation or deactivation (to analog graphic recorder) , figure 3.
Display options include :

- graphics options : minimum voltage to print, image contrast and horizontal exaggeration
- rectification control : choose to draw positive edges, negative edges or both in the "Trac Scope" window chart.
- Fix Options : choose to draw Vertical Line on each Fix and Time, Date and GPS acquired position.

TVG Settings Windows allow the user to :

- Set TVG delay time
- Set TVG slope
- Look at the TVG graphic representation

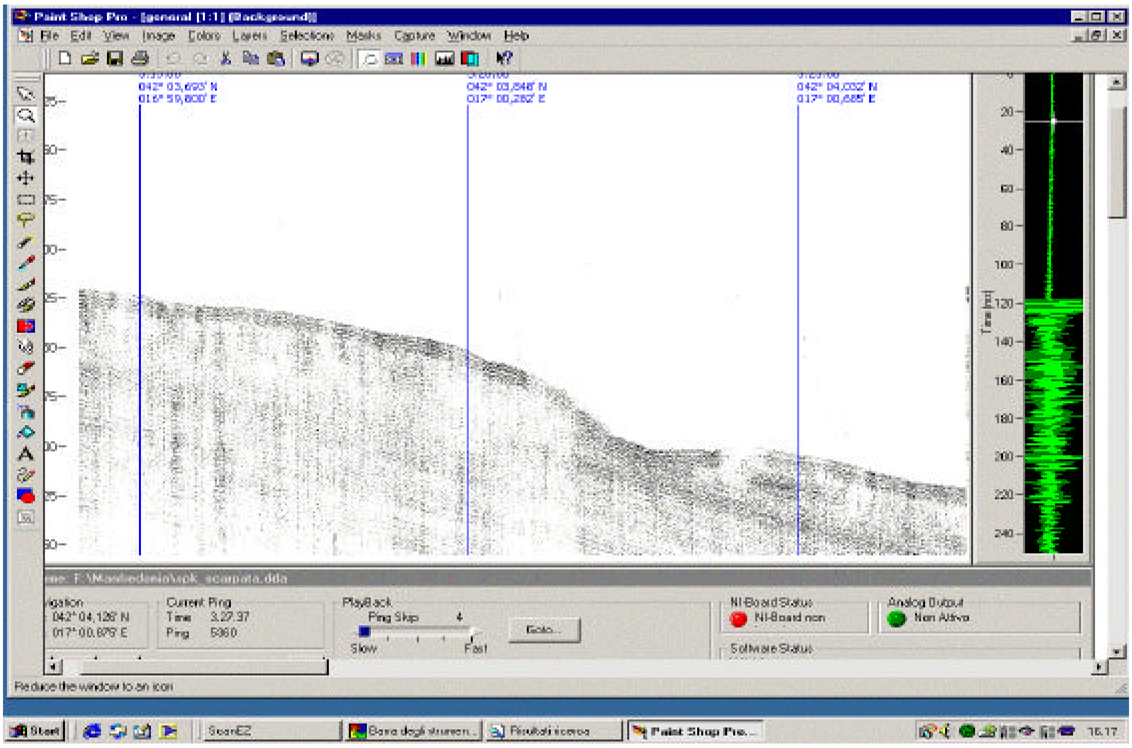

Figure 2-D-Sesmic Main Window

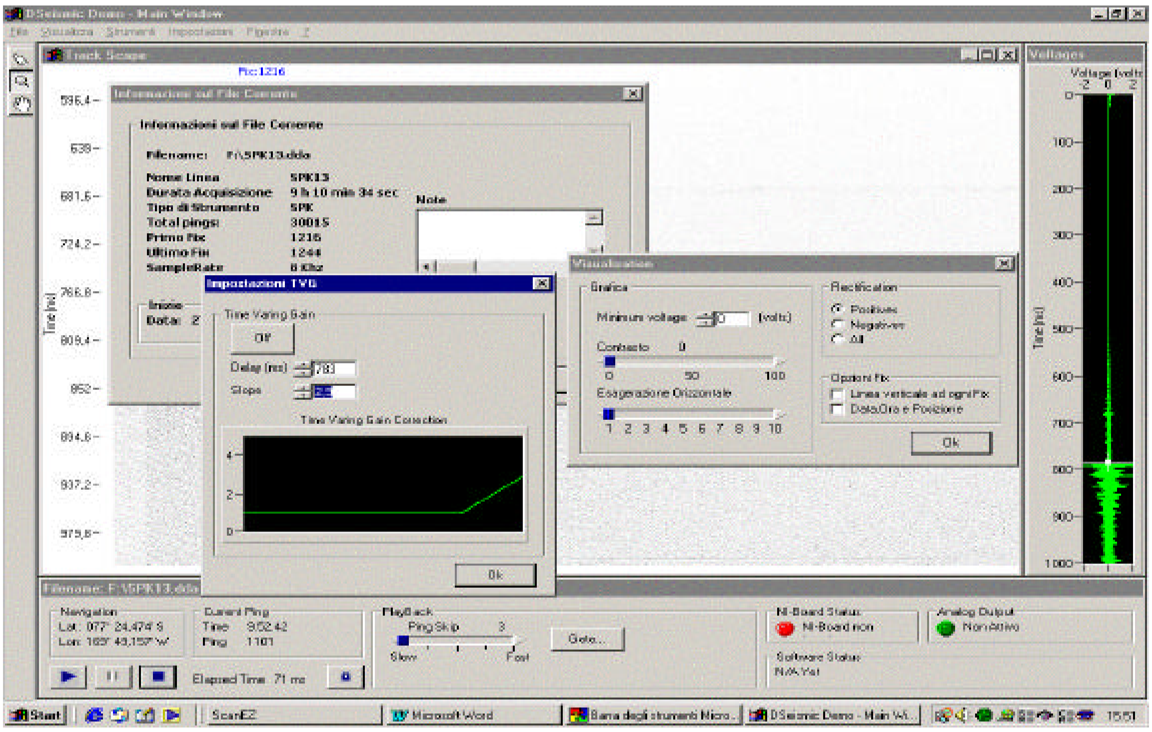

Figure 3Main Window with superimposed *File Specification* window, TVG and visualization menus.

COMMAND WINDOW

While in playback, the “Command Window” shows the standard buttons (Play/Pause/Stop) plus a button “Go to”, which is a quick way of accessing a specific Fix in the file. Indeed, “ Go to” jumps to the Fix without showing anything between the current Playback point and the Fix point. Another powerful control is “Ping Skip”, which can increase the normal playback speed several hundred times and can be modified at any time during the playback.
While in *acquisition* mode, the window shows Rec/Pause/Stop buttons, and information about *Maximum Acquiring Time* calculated according to the free space in the Hard disk.
On the left there is Navigation Data (Latitude and Longitude) and current *ping* information (time and number), on the other side you can see several information frames such as NI-Board Status (reports, if an error occurred while in *acquisition* mode), Software Status and Analog output Status (Activated/Deactivated).

ACQUISTION PARAMETERS

The analog to digital conversion is 8 or 12 bits, the sweep length is between 125 ms and 8 s , with a maximum of 128.000 samples per track .The sampling frequency is between 1 and 64 KHz. E.g. with a 8 Khz sample rate, sweep length of 1 s and a 40GB Hard Disk the *acquisition* duration is 130 days (H24).

SOME EXAMPLES OF ACQUIRED PROFILES

Following figures show the D-Seismic records of sedimentary series are characterized by several unconformities linked to advances and retreats of the ice sheet [9].

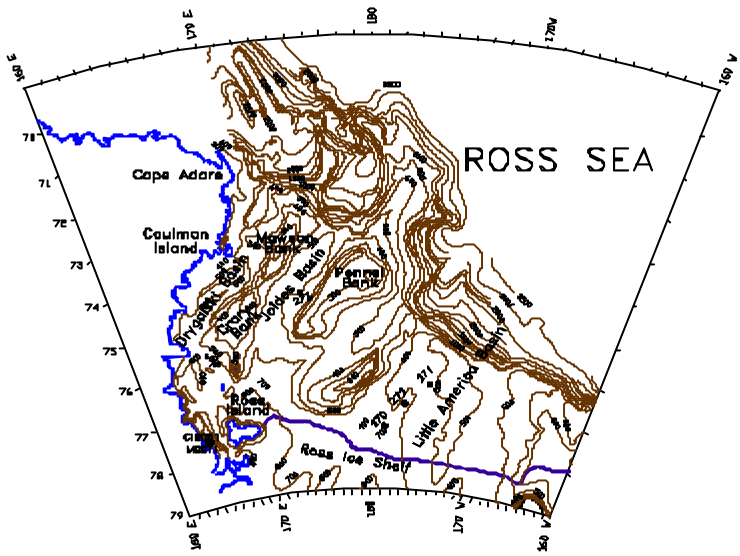

Figure 4, Map of the survey area .

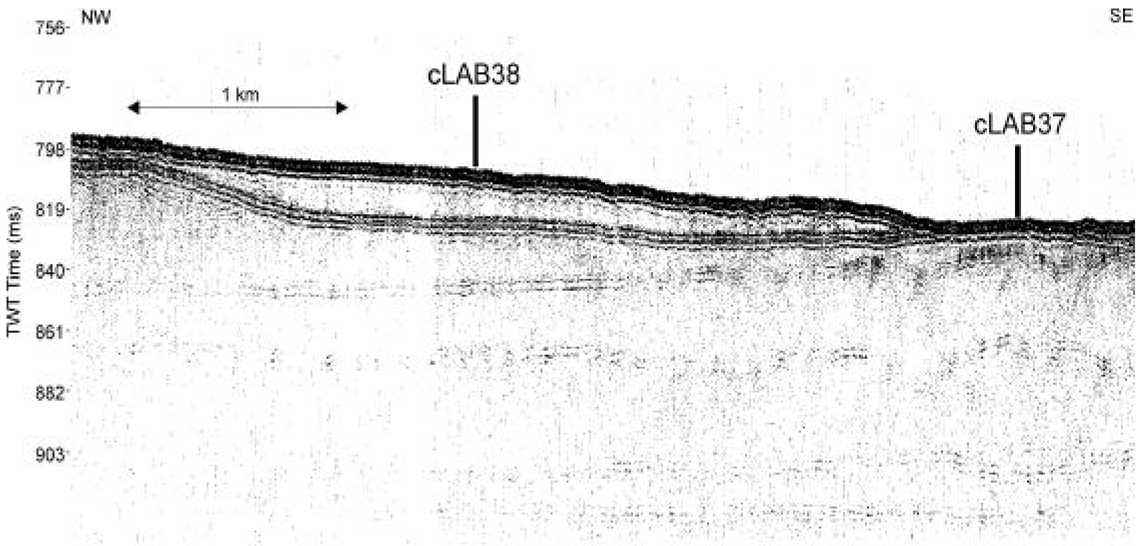

Figure 5, *Sparker* profile 400J across the Little American Basin (NW-SE). Within the layers of sediment, more glacial surfaces can be seen compared with results from the cLAB38 sampler.

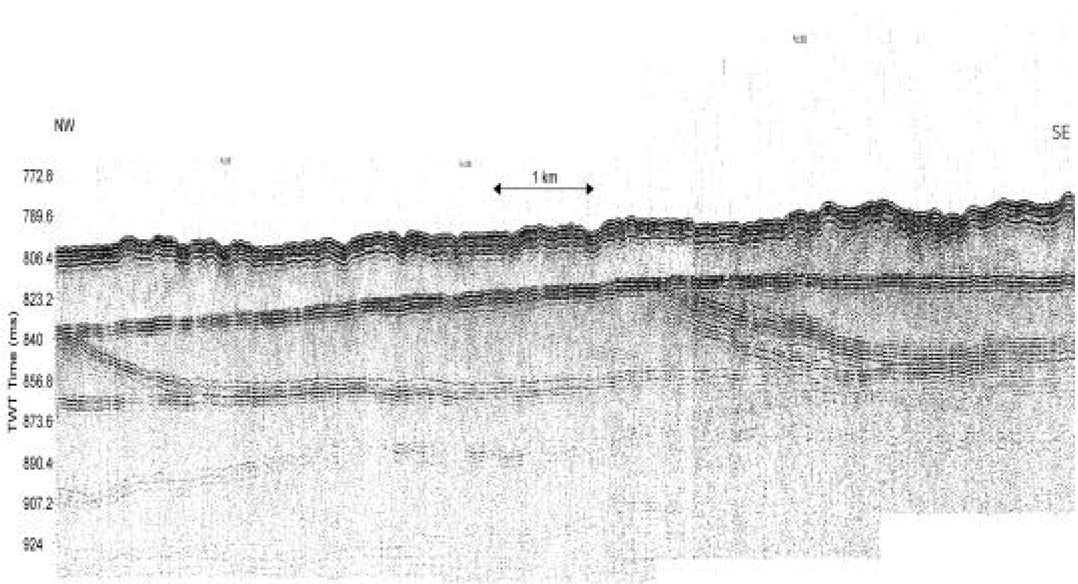

Figure 6, *Sparker* profile 400J across the Little American Basin (NW-SE). Seismic section shows numerous unconformities, which correspond with particular glacial events.

CONCLUSION

The user friendly, graphical interface together with the real time T.V.G (Time Varying Gain) and *attack point* -adjustable by a *graphic sliding cursor* and with other tools- produced positive results for seismic surveys that had never achieved before, on the Antartica 2002 expedition. The D-Seismic system, facilitated the geologist's choice of *well points* through its optimum resolving power and graphical representation of sub bottom soil characteristics.

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