National Research Council

Final Report of the Oceanographic Survey NextData2013

Project NEXTDATA WP–1.5

Paleoclimatic Data from Marine Sediments
(CNR-DTA, URT EvK2-CNR, INGV)

Strait of Sicily - Gulf of Taranto

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Introduction, objectives and short description of NextData Project (WP 1.5)

The retrieval of series of proxy data on the past climate will serve to acquire a deeper understanding of the climate system and a more accurate prediction of its future development, as a priority task for the scientific community. In particular, the analysis of climate data of the past is an essential tool for studying the dynamics of the earth's climatic system under conditions different from those of today, and irreplaceable for testing the validity of medium- and long-term forecasting models. The determination of the influence of anthropogenic impacts on the planet’s environment is predicated on a clear understanding of the natural ways in which the earth's climate responds to the complex set of external forcings. Therefore, in recent decades, many national and international research groups have focused attention on the study of the climate evolution in late-Quaternary sediments from the Mediterranean area. By virtue of its close relationship with continental masses subject to different climatic processes, the Mediterranean basin permits the documentation of climate evolution both globally and in the Northern Hemisphere. Finally, it is worth noting that shallow sea (continental shelf) areas are natural repositories for the monitoring of short-term climate change and anthropogenic impacts on the marine system. To make available information on climate history and environment yielded by marine sediments, this WP will be dedicated to analyzing and, where possible, collecting cores of marine sediments, especially those drilled in shallow sea environments, and focusing on climate dynamics in the Mediterranean over past centuries. During its course, the project will analyse and, where possible, sample marine sediment cores in continental shelf environments and in different sectors of the Mediterranean basin. Previous studies have indicated them as key sites for the identification of major short-term climate fluctuations, due to global and local forces active during the Quaternary and particularly in the past thousand years. In fact, the possibility of enriching the databases referring to this time interval (to date, still limited to the Mediterranean) will provide new working hypotheses for the implementation of numerical models that attempt simulate how the Mediterranean, in particular the marine-coastal sector, has responded to past climate dynamics (Medieval Warm Period / Little Ice Age transition, Little Ice Age, the Industrial Age, and Modern Warming). The cores obtained will be the focus of multidisciplinary studies involving national and international research groups.

Structural and Stratigraphic Framework

According to Maldonado and Stanley (1976) the Strait of Sicily platform occupies a geologically strategic position between the deep, fault bounded basins of the Balearic, Tyrrhenian, and Ionian seas and the emerged North African and southern European regions bounding it. Most workers envision this shallow area as a prolongation of the Tunisian-Southern Sicilian land mass and as a link between the North African Atlas chain and the Sicilian-Italian Apennine chain. The different tectonic provinces of the Strait region have been defined and mapped by Burollet (1967) and Zarudzki (1972). Seismic reflection exploration has provided both deep penetration (Flexotir records of Finetti and Morelli, 1972a, b) and shallower subbottom coverage (Woods Hole Oceanographic Institution sparker and air gun profiles, Zarudzki, 1972). Flexotir records show that this zone, separating the distinct eastern and western Mediterranean geodynamic sections, consists of thick continental crust comprising a generally thin Pliocene Quaternary unconsolidated section above a thick sequence of Triassic to Miocene rock units (Finetti and Morelli, 1972a). The reduced thickness of unconsolidated Pliocene and Quaternary sediments (except in some depressions such as the Malta Graben where these exceed 1 second, penetration two-way travel time) can be contrasted with the thick sections in the Balearic Basin west of the Strait. The underlying Upper Miocene units, correlated with limestone and dolomite sequences in cores and land sections, thicken toward Tunisia (Burollet, 1967). There is ample evidence of geologically recent (post-Miocene) structural displacement, and the different morphological-tectonic sectors of the Strait can be related to major fault patterns. Magnetic and gravity studies reveal that the main structural trends are oriented west northwest - east southeast, i.e., parallel to the major orientation of the Sicily Channel (Allan and Morelli, 1971; Morelli, 1972; Colantoni and Zarudzki, 1973; and others). A northeast-southwest trend predominates at the westernmost sector of the Strait (Auzende, 1971; Auzende et al., 1974). The largely vertical structural displacement gives rise to a complex configuration of horsts (shallow tabular-shaped banks) and grabens (narrow, deep linear basins). Seismic profiles clearly display the vertical and subvertical offset of reflectors. The intensity of structural offset and seismicity (shallow earthquake epicenters), and the concentration of volcanoes (most are submarine cones) increase in the northern sector of the Strait. The islands of Linosa and Pantelleria reflect the importance of Pliocene and Quaternary eruptions in this part of the Mediterranean. Pantelleria rises from the 1300 m deep Pantelleria Basin. The position of other volcanic deposits, including some which accumulated in historic time, are reported by Zarudzki (1972) and Finetti and Morelli (1972a); these are concentrated mostly in the northern sector of the Strait. The presence of dike swarms or narrow lava streams are also suggested on the basis of magnetic anomalies and appear aligned parallel to the principal tectonic provinces. Some Mesozoic and early Tertiary intrusions also have been penetrated by petroleum exploratory wells. In terms of regional Mediterranean-Alpine tectonics, the thick crustal sections of the platform are considered part of the African Plate, which underthrusts the Euro-Asiatic plate in the Ustica-Lipari region of Sicily (Caputo et al., 1970). Finetti and Morelli (1972b) also emphasize the role of compression but prefer to relate plate motion to subduction of the African Plate below what they define as the Mediterranean Plate. Like most geophysicists, these latter authors tend to agree that much of the Mediterranean, in particular the deep basins bounding the Strait, has undergone considerable subsidence since the end of the Miocene. Benson (1972) has proposed that the Strait platform was deeper during the Pliocene than at present. The development of vertical faults with offsets to 1000 m in the upper crust is believed to reflect isostatic adjustment following the main Alpine orogeny. Additional structural offset may also be due to alternating phases of compression and distension. Zarudzki (1972) relates the gentle folding of the more than 300 m of section in the northwest end of the Pantelleria Trough, as observed in continuous seismic profiles, to the abovecited recent, postorogenic tectonic activity. The fault development, volcanism, and seismicity of this region are not unlike those postulated in some subduction models. An interpretative diagram showing the origin of this modern rift-tension relief in the Strait and associated volcanism in relation to subduction is presented by Akal (1972). These Quaternary neotectonic factors will be emphasized in the context of sedimentary processes and sedimentation rates in the Strait region.

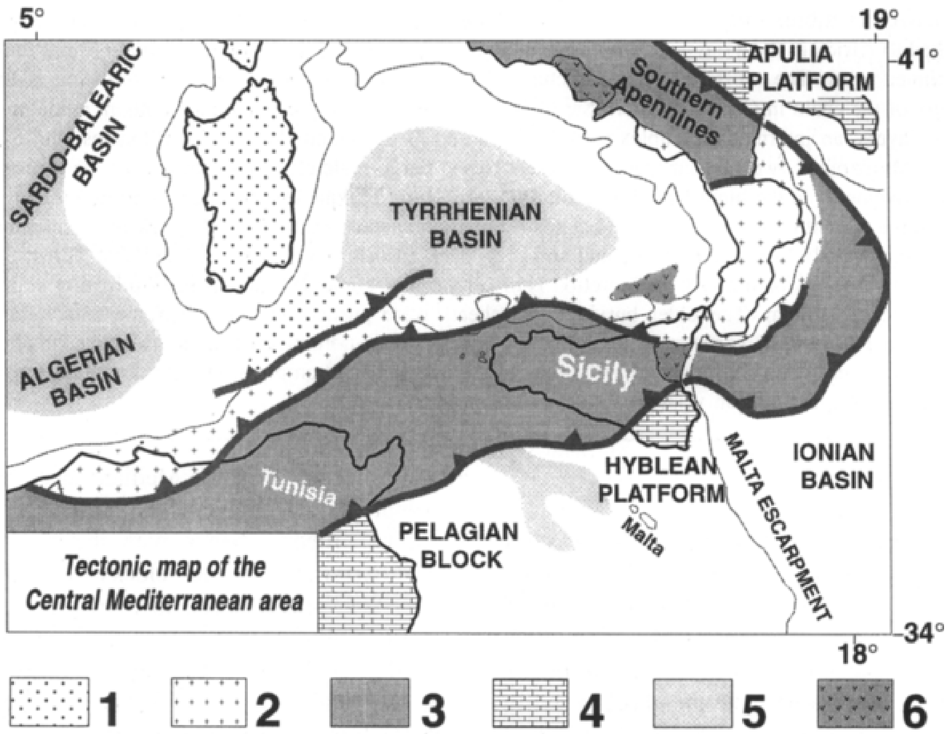

Fig. 1. Tectonic scheme of the central Mediterranean area showing: *1* = Corsica–Sardinia; *2* = Calabrian Arc, Kabylians and "Internal" Flysch sequence ophiolites; *3* = Maghrebian–Sicilian–Southern Apennine nappes and deformed foreland; *4* = foreland and mildly folded foreland (Tunisia, Hyblean plateau, Apulia); *5* = areas with superimposed extension; *6* = Plio-Quaternary volcanoes.

Fig. 1 Modified from Catalano et al., 1996

Scientific Crews

First name - Surname	Gender	Nationality	Expertise	Qualification	Role	Affiliation
1) Sergio Bonomo	M	Italian	Micropaleontology	Researcher	Co-Chief	IAMC-CNR, Naples
2) Mattia Vallefuoco	M	Italian	Micropaleontology	CTER	Coring	IAMC-CNR, Naples
3) Nicola Pelosi	M	Italian	Geophysics	Researcher	Chirp analysis	IAMC-CNR, Naples
4) Michele Punzo	M	Italian	Geophysics	CTER	Chirp analysis and coring	IAMC-CNR, Naples
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11) Giuseppe Zarcone	M	Italian	Stratigraphy	PhD	Coring	University Palermo
12) Ludovico Albano	M	Italian	Geophysics	Student	Sediment sampling	University Palermo
13) Carlotta Cappelli	F	Italian	Micropaleontology	Student	Sediment sampling	University Firenze
14) Chiara Cavallina	F	Italian	Micropaleontology	Student	Sediment sampling	University Firenze
15) Marco Castellano	M	Italian	Stratigraphy	CTER	Coring	IGAG-CNR
16) Giulia Margaritelli	F	Italian	Micropaleontology	PhD	Sediment sampling	University Perugia
17) Matteo Francesconi	M	Italian	Stratigraphy	Student	Sediment sampling	University Pisa
18) Raffaele Gazzola	M	Italian	Stratigraphy	Student	Sediment sampling	University Pisa

Sampling stations and Activities

Station	Activities	Lat. North	Long. East
ND1	Deleted	36° 21' 30.0960"	14° 49' 18.8040"
ND2	Corer SW104 + Gravity Corer	36° 33' 51.8967"	14° 52' 59.0498"
ND3	Deleted	36° 26' 17.9576"	15° 19' 13.9907"
ND4	Deleted	35° 40' 35.5552"	15° 10' 55.3721"
ND5	Corer SW104 + Gravity Corer	35° 19' 23.0463"	15° 25' 3.2569"
ND6	Corer SW104 + Gravity Corer	35° 10' 32.4234"	15° 25' 56.9151"
ND7	Deleted	34° 55' 39.9843"	15° 27' 0.9966"
ND8	Corer SW104 + Gravity Corer	38 ° 07 '45"	16 ° 53' 49"
ND9	Corer SW104 + Gravity Corer	39 ° 49 '24"	17 ° 52' 47"
ND10	Corer SW104 + Gravity Corer	40° 05' 49.8168"	17° 44' 49.9479"
ND11	Corer SW104 + Gravity Corer	37° 01' 56,28"	13° 10' 53.76"
ND12	Deleted	37° 04' 26,76"	13° 11' 56,76"
ND13	Corer SW104 + Gravity Corer	36° 35' 24.00"	14° 30' 29.88"
In yellow sites located in Maltese EEZ waters			

Timetable and activities developed during NextData2013 survey

1st day: 12th of September (Thursday, Messina).

The earlier morning was dedicated to the procedures to board the human resources and the equipment and to install the equipment on the R/V "Urania". At 11:00 a.m. we left the Messina harbour to the ND2 station.

After a general meeting, concerning the research objectives and the survey technical aspects, we established the following working groups:

WORKING GROUPS		
1st **08:00 a.m.- 12:00 a.m.** **08:00 p.m. - 12:00 p.m.**	**2nd** **12:00 a.m. - 04:00 p.m.** **12:00 p.m. - 04:00 a.m.**	**3rd** **04:00 p.m. - 08:00 p.m.** **04:00 a.m. - 08:00 a.m.**
Sergio Bonomo	Mattia Vallefuoco	Pontus Conrad Lurcock
Chiara Cavallina	Daniela Tarallo	Ludovico Albano
Carlotta Cappelli	Giulia Margaritelli	Erlisiana Anzalone
Antonio Cascella	Giuseppe Zarcone	Michele Punzo
Nicola Pelosi	Marco Castellano	Raffaele Gazzola
Matteo Francesconi	Claudia D'Oriano	Enrico Di Stefano

For the planning of the course-plotting we used a GIS map previously designed and showing the positions of all the stations within the survey area. All the samples collected during the survey refer to the GIS map numbering.

At 04:00 p.m. we participated in a "general emergency" simulation, which was followed by a meeting about safety on board.

The weather and sea conditions were good with a weak mistral wind.

At the ND2 station (arrival at 10:00 p.m.) we began to sample. We executed a core with SW104 (ND2A). At 10:55 p.m. the replica was performed (ND2B). At 11:21 p.m. we headed towards the ND1 point, the weather worsened.

2nd day: 13th of September (Friday, Strait of Sicily - Malta)

At 12:57 a.m. a core was performed with SW104 (ND1A). After a preliminary analysis of the recovered sediments, the ND1 station was deleted from the sampling program. At 01:57 a.m. we headed towards the ND6 station, the rough sea persisted. Along the way, analyzing the Chirp profile, we decided to delete the ND4 station from the sampling program.

At 09:26 a.m. a gravity core was recovered in the ND6 station (-526 m). Its replica was carried out at 10:43 a.m.; the weather conditions worsened. At 11:26 a.m. two cores were recovered with the SW104.

At 01:40 p.m. we moved to the ND7 station where we arrived at 03:05 p.m. Analysing the Chirp profile we decided to abandon the ND7 station and we went towards the ND5 station. At 06:10 p.m. a gravity core and its replica were collected in the ND5 station. Following two cores were gathered with the SW104. At 09:30 p.m. we headed towards the ND13 station, the weather conditions worsened significantly with a strong mistral.

3rd day: 14th of September (Saturday, Strait of Sicily)

At 09:00 a.m. we reached the ND13 station and a gravity core and its replica were performed. The weather conditions improved considerably. At 10:34 a.m. two cores were collected with the SW104. At 11:34 a.m. we went towards the ND2 point. At 02:00 p.m. we arrived at the ND2 point, two gravity core were performed and a core with the SW104. At 03:00 p.m. we transferred to the ND11 station. Weather conditions were excellent. We reached the ND11 point at 11:00 p.m.

4th day: 15th of September (Sunday, Strait of Sicily)
Operations began at 08:30 a.m. in correspondence to the ND11 station, two gravity cores were recovered and three cores with the SW104. The weather conditions continued to be excellent. After evaluating the time needed to reach the ND8 station, we decided to remove the ND12 station. At 12:15 p.m. the transfer towards the ND8 station (Southern Ionian Sea) started.

5th day: 16th of September (Monday, Southern Ionian Sea)
At 05:00 p.m. we arrived at the ND8 station, the Chirp profile showed an unsuitable coring substrate, we changed the ND8 station coordinates to new ones (Lat 38 ° 07 '45'' N - Long 16 ° 53' 49'' E) and we collected a gravity core. The weather conditions worsened markedly as proved by the rough sea and by the strong mistral wind. At 06:30 p.m. we began to transfer towards the ND10 station (Gulf of Taranto).

6th day: 17th of September (Tuesday, Gulf of Taranto)
At 06:56 a.m. we arrived at the ND10 station and we recovered two gravity cores. Thereafter we gathered three cores with the SW104. The sea was smooth and a light mistral wind blew. At 10:00 a.m. we headed towards the ND9 station, the weather conditions worsened with an increasing mistral wind. At 01:00 p.m. we arrived at the ND9 station. The Chirp profile showed an unsuitable substrate, consequently we changed the ND9 station’s coordinates to new ones (Lat 39 ° 49 '24'' N - Long 17 ° 52' 47'' E) and we collected two gravity cores and three cores with SW104.
At 02:00 p.m. we finished all the planned activities and proceeded to the Messina harbour.

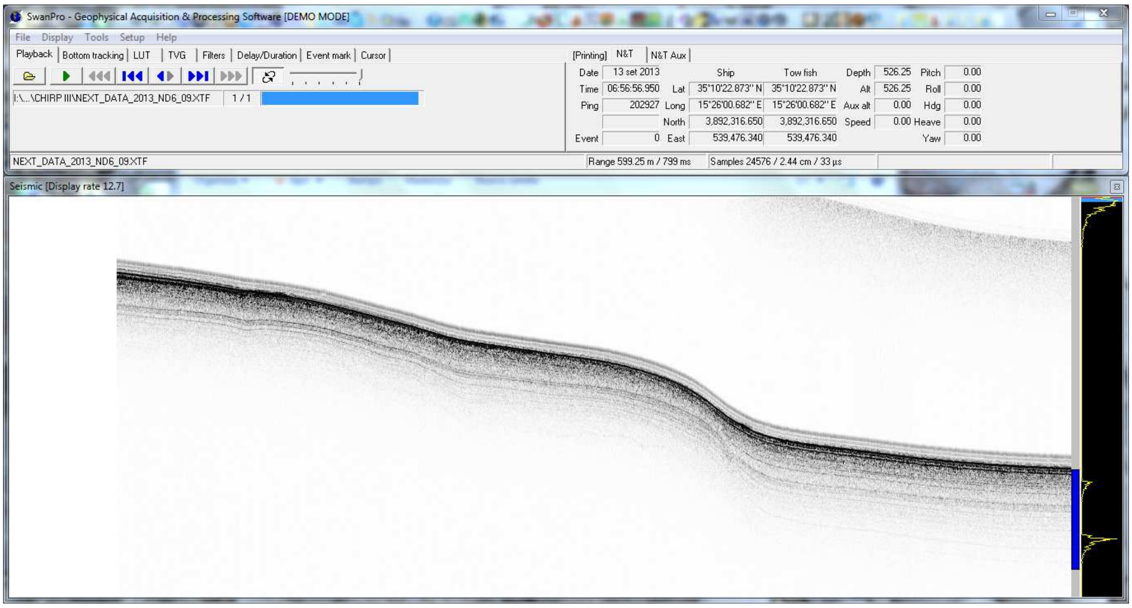
7th day: 18th of September (Tuesday, Messina harbour)
We arrived at the Messina harbour at 11:00 a.m. The NextData2013 survey ended.

Scientific and Technical activities

During the NextData2013 survey we have carried out the following scientific and technical activities:

- Sub Bottom Profiler (Chirp): a tool to determination of the depth and the trend of substrate buried by recent sedimentary cover.

Before coring bottom sediments, through gravity coring system and SW104 corer, we have performed some seismic profiles whit the Datasonics CHIRP III Acoustic Profiling System (Benthos, Inc.), parallel and perpendicular to the coastline, to verify the sediments thickness and the presence of tectonic disturbances. All data were converted into a SEG-Y format and analysed aboard with SeiSee (Rev 2.22.1).



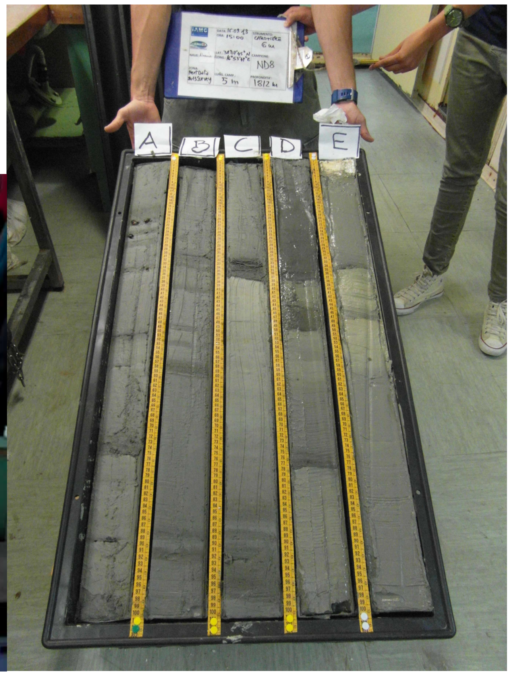
- Sediment sampling by gravity corer:

We used a gravity corer composed of the following three main parts:

1. *the head:* a cylindrical mass of 1,200 kg, capable of imparting the energy needed to penetrate the core bit through the sedimentary layers of the seabed.
2. *the tube core barrel:* a galvanized iron pipe of 105 mm (outside diameter), whose length may vary from 6 to 9 meters. Inside the tube there is a PVC liner housing (outer diameter of 90 mm, inner diameter of 84 mm), which has the function of core housing.
3. *the nose:* a full closure and tip system constituted by a stainless steel cylindrical body, which is coupled to the lower core barrel and has the function of creating the carrot. A triangular shape device, composed of four palettes and hinged in a suitable seat, represents the closure of the nose, necessary to restrain the core during the core barrel ascent. The blades closing is controlled by the same liner at the beginning of the extraction from the bottom. After bringing aboard the core barrel, the liner is extracted and divided into sections of one meter. For each section the station, the top and the bottom of the care and the section are commonly annotated.

- Gravity core splitting:

For each core the sections are immediately transferred to the cutting laboratory. Here, the sections are splitted in 2 halves by the use of a circular saw and moved towards the sedimentology laboratory for a first sedimentological and stratigraphic characterization and to sample them.



- Sediment Sampling - SW104 corer.

This corer is a lightweight core barrel (100kg max. weight) specifically made to collect clay sediments, or slightly sandy sediments. It's an ideal tool for seabed studies regarding the environmental pollution, the eutrophication and the biochemical processes occurring in the surface sediments, to analyse the nutrients flows and trace metals between the sediment and the overlying water and to assess the sedimentation rate. The corer consists of five main elements: 1) the header, 2) the tube core barrel, 3) the nose with the locking system, 4) the valve-saving water and 5) the liner.

1. *The cylinder head* is similar to a pylon including switches, crossings, a closing, an upper valve which encloses the bottom water, the annular modular masses and the core barrel junction.
2. *The tube core barrel* is made of a thin stainless steel tube (diameter: 114.3 mm, thickness: 1.5 mm, length: 2008 mm).

3. *The stainless steel nose* is composed of a very sharp conical tip, to facilitate the penetration into the seabed and the creation of the core section; the nose also represents the housing of a locking system enclosing two rings depreciated by springs and a waterproof canvas diaphragm closes the nose.
4. *The valve-saving water* is located in the upper part of the liner and represents the device which encloses and retains the water sample from the bottom. It is operated by two semi-circular lunettes set in rotation by a spring loaded an instant before the starting of the core extraction from the bottom.
5. *The liner* is a tube of transparent methacrylate, allowing us to visualize the collected core immediately, or of opaque PVC. The inner diameter is of 104 mm with a length of 1346 mm.

- Aboard Sediment Sampling:

The sediments sampling was carried out on board only in three preselected sites (ND6 - ND2 - ND10), taking samples with an equidistance of one centimetre in the gravity core and in the SW104 core. In particular the gravity core was sampled only in the half liner, while the SW104 core was extruded and sampled entirely. In both the cases, each one centimetre interval was divided into four sub-samples to study benthic and planktonic foraminifera, calcareous nannofossils, dinoflagellates and pollens.

- Magnetic Susceptibility analyses.

Measurement of bulk magnetic susceptibility is a well-established technique for quick characterization of variations in mineralogy. In marine sediment cores, high-resolution measurement of downcore variation in magnetic susceptibility is also frequently used to correlate cores drilled at different sites. Appealing features of the technique include its speed (usually under five seconds per measurement) and the compactness of the required equipment; these factors make it practical, as in this study, to make preliminary shipboard measurements as soon as a core has been retrieved and split.

When using magnetic susceptibility purely as a stratigraphic calibration tool, it is not necessary to consider the mineralogical origin of the variations in the signal: the signals from two cores are simply correlated by expansion or contraction to produce the best possible match between the curves. When the mineralogy itself is considered, magnetic susceptibility measurements can provide further data. One compelling application is in tephrastratigraphy: tephra minerals have vastly greater susceptibilities than normal marine sediments, and tephra layers are thus very easy to detect in a magnetic susceptibility record, even in cases where the layer is difficult or impossible to discern by eye. More generally, terrigenous input to a site of sedimentary deposition tends to be positively correlated with magnetic susceptibility; variations in magnetic susceptibility can thus reflect past changes in sediment provenance and supply at a coring site.

For the cores retrieved using the 9-metre corer, magnetic susceptibility was measured on split core faces at 1cm intervals shortly after retrieval, using a Bartington MS-3 magnetic susceptibility meter coupled with a handheld M2F surface probe. (For the cores obtained using the SW-104 corer, susceptibility was measured using the same equipment on individually bagged 1-centimetre slices of sediment). The MS-3 unit interfaces directly to a laboratory computer, allowing the data to be analysed immediately after its acquisition. The shipboard measurements will be repeated and confirmed at the INGV palaeomagnetic laboratory in Rome on u-channels subsampled from the cores, using a 2G Enterprises sample handler and Bartington MS-2 susceptibility meter with MS2C loop sensor.

Acknowledgments

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We also thank the Chief Vincenzo Lubrano Lavadera and all the staff aboard the R/V Urania, who has participated in all research activities actively and in synergy with our scientific staff. In particular, all the crew's members have shown a great willingness and flexibility, allowing us to achieve the NextData2013 purposes in full safety and to overcome the various contingencies.
We would like to thank the Chief and the crew also for the availability, interest and attention shown during the NextData2013 survey.

Survey Maps

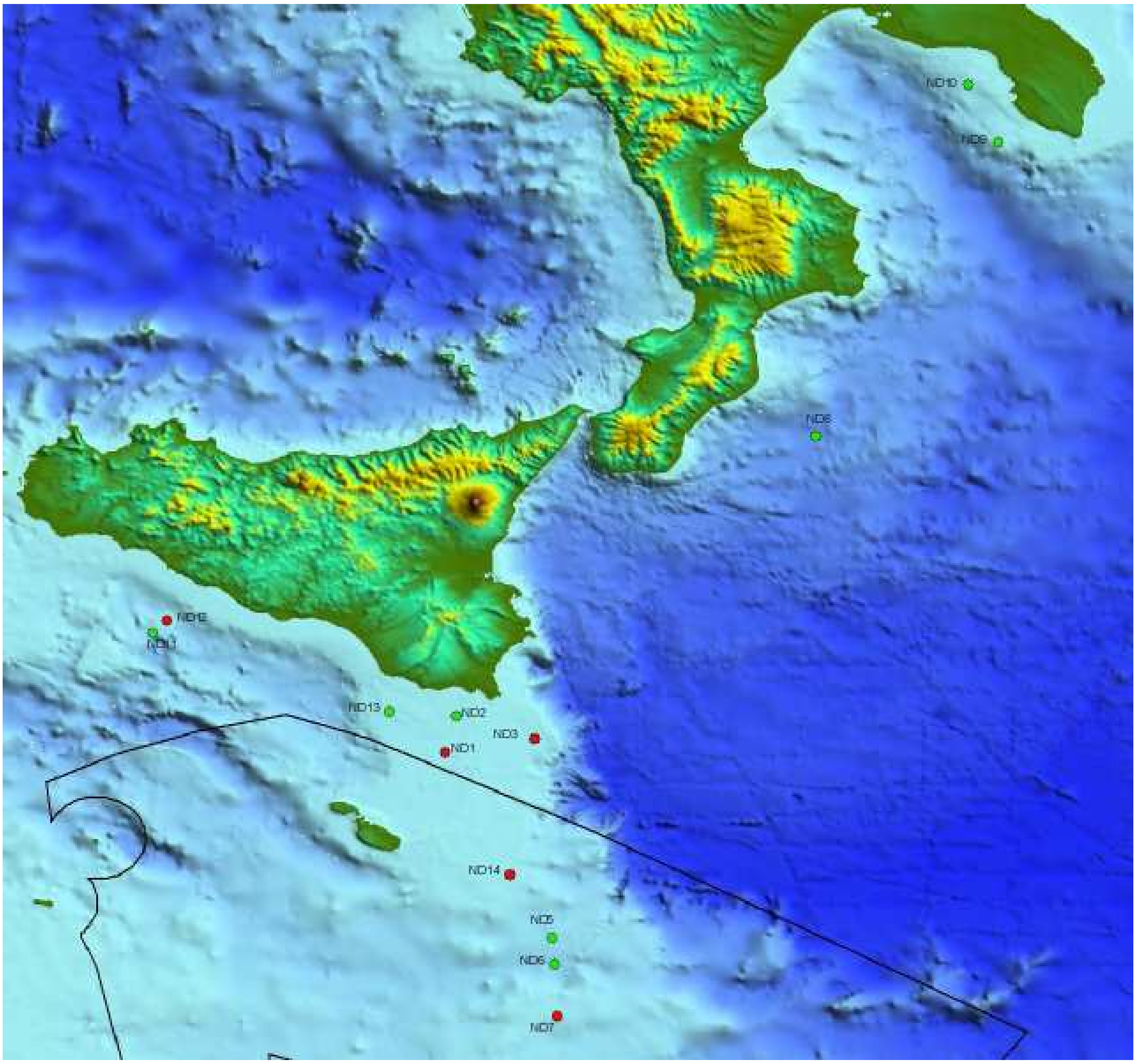

Fig. 2 Location map of the NextData2013 survey

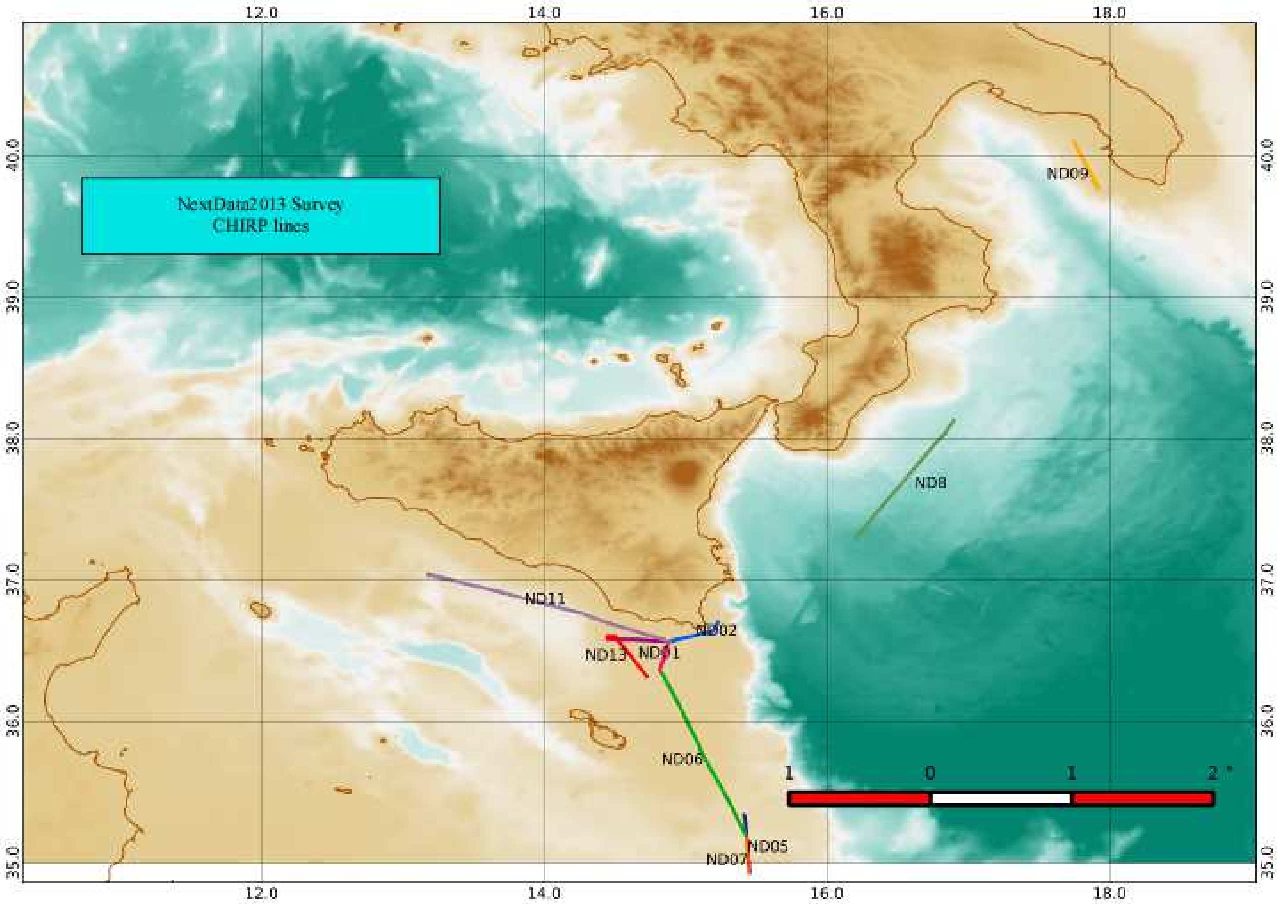

Fig. 3CHIRP lines