PROJECT TITLE:

STUDY OF THE ETNA PYROCLASTIC DEPOSITS AIMED TO LARGEST EXPLOSIVE ERUPTIONS RECONSTRUCTION AND VOLCANIC HAZARD ASSESSMENT.

RU Responsible : Luigina Vezzoli
Name-Position : Prof. Associato
Affiliation: Universita' Insubria, Como

ACTIVITY REPORT –2nd YEAR

PROJECT PARTICIPANTS

RU	AFFILIATION	RESPONSIBLE
UNICO	Universita' dell' Insubria, Como	Luigina Vezzoli
INGV CT	INGV sezione Catania	Mauro Coltelli
CNR IGM BO	CNR Ist. Geologia Marina Bologna	Luigi Vigliotti

GENERAL OBJECTIVES

TASK	**Scientific Responsible**	**Research Units**
1 **Tephrostratigraphy** 1.1 Detailed study of the Holocene to the Present pyroclastic sequences in natural outcrops, trenches and cores 1.2 Study of the deep-sea cores of the submerged part of the volcano	Luigina Vezzoli	UNICO INGV CT CNR-IGM-BO
2 **Numerical and relative chronology** 2.1 14C absolute chronology and paleomagnetism 2.2 Relative chronology with palinology and geopedology	Cesare Ravazzi	UNICO INGV-CT CNR-IGM-BO
3 **Physical characteristics of the eruptions** 3.1 Eruption physical parameters from pyroclastic deposits measures 3.2 Magma physical parameters from pyroclasts study (VSD, CSD, glass and inclusion volatiles) 3.3 Study of the basaltic magma degassing dynamics, also with laboratory simulations	Paola Del Carlo	UNICO INGV-CT
4 **Hazard assessment** 4.1 Etna explosive eruptions impact on people and land	Mauro Coltelli	UNICO INGV-CT

TASK 1 - Tephrostratigraphy

RU PARTICIPANTS: UNICO, INGV-CT, CNR-IGM-BO

2 YEAR OBJECTIVES

Trenches and cores excavation. Tephra petrographic, sedimentologic, geochemical and SEM analysis. Magnetic analysis.

2 YEAR RESULTS

Periodic surveys with the aim of mapping natural or artificial outcrops allowed us to measure and describe several new stratigraphic sections of Etna and to sample tephra, carbons and paleosols. On selected samples, thin sections for petrographic analysis have been performed. Particularly, we focused on three stratigraphic sections containing the sequence of the 122 BC plinian eruption and the 5 January 1990 (SE Crater) and 23 December 1995 (NE Crater) subplinian eruptions. The last ones produced thick lapilli and bombs deposits (2-3 m) in the proximal area and an abundant ash fall respectively on NW and SE sectors, up to 100 km of distance from the vent. In the deposits, that represent the whole eruptive sequence, we performed a very dense sampling (every 10-20 cm) to achieve detailed density, grain size and componentry (for the 122 BC eruption) analyses in order to characterize the eruptive processes. Results of the comparison between the 122 BC eruption and the 1886 Tarawera eruption (New Zealand) and their conduit processes have been discussed in Houghton et al. (2002) paper.

Magnetic properties analysis of marine cores of the submerged part of the volcanic edifice have been detailed in selected reference cores for the last 15 ka.

TASK 2 Numerical and relative chronology

RU PARTICIPANTS: UNICO, INGV-CT, CNR-IGM-BO

2 YEAR OBJECTIVES

Field sampling and analysis for 14C ages. Paleomagnetic analysis Pollen analysis on deep-sea cores. Pollen diagrams construction and sea-land comparison.

2 YEAR RESULTS

The key point of the project is the chronology during the Late Pleistocene-Holocene times of the explosive activity recorded in marine cores.

On the basis of the whole-core magnetic susceptibility profiles measured for the original data set we selected three cores (ET97-18; ET97-70 and ET99-M11) representing the best record for the interval deposited after the emplacement of the Elliptic tephra up to the recent times (last 15 ka). Quantitative micropaleontological analysis of planktic foraminifera were used to recognise the Ecozones established by Capotondi et al. (1997) with the aim to obtain an age depth-model as well as to warrant the continuity of the record. Three 14C (AMS) dating have been carried out on foraminifera tests from core ET99-M11 representing the Early Holocene in the composite section.

Two additional dating are in progress with the aim to detail the emplacement timing of the Ellittico tephra.

To improve the chronology for the interval representing the holocene we measured paleomagnetic directions on U-channels collected from cores ET97-18 and ET99-M11. The results have been compared with the secular variation curves of the earth magnetic field reconstructed from archaeomagnetic data, lava flows as well as marine and lacustrine cores (Vigliotti 2002).
Laboratory imparted magnetizations (anysteretic and isothermal) identified intervals with high magnetic content that could be representative of tephra layers. These intervals have been sampled and will be analysed by other RU of the project for the geochemical characterisation and possible correlation with events occurring on the slope of the volcano.

Concerning the absolute age of Etna's tephra layers, performed with the 14C method on paleosoils and carbons by Beta Analityc Inc. (USA) in the last 8 years, we calibrated the old dating to uniform those results with the dating performed in the last two years, obtaining calendar ages for a total of 45 data. Moreover, a study has been made on Etna historical and prehistoric activity integrating data acquired from the tephrostratigraphic studies with those deriving from the historical catalogs. It has been possible to integrate the previous knowledge with the discovery of eruptions until today unknown, to correct the age of others, etc. This investigation, that have the aim to compile the new catalog of Etna's historical eruptions, is still in progress. However, some preliminary results have been already published in Branca and Del Carlo (2002).

Geopedological and palinological study of pyroclastic successions were performed in order to increase tephrostratigraphic data, chronological definition and environmental hazard.
Geopedological study stats with field survey in the north-eastern part of the volcanic edifice (Pineta della Cubania area) for: a) mapping of areal distribution of the soils, b) study the soil-vegetation relationships, c) study the soil-tepha fall relationships. In laboratory we have analyzed about 70 samples of epiclastic and pyroclastic deposits for chemical and grain-size characteristics definition and reconnaissance of soil profiles. On the soil we have determined Al2O3/SiO2 and Al2O3/CaO+MgO+Na2O+K2O, that have pedogenetic and chronostratigraphic significance. Also the humic components and Fe and Al speciation were determined.

Palynologic study focused on marine core of the submerged part of the volcanic edifice. In the first steep we tested the presence and status of the pollen clasts in the sediments, then we individualized the appropriate laboratory methodology of the pollens extraction. This methodology consists of a set of acid and alkali attacks, heavy liquids separation, acetolisis and mounting on slides. The complete treatment for a set of 20 samples is about 1 month long. The slides were observed with an optical microscope and pollen clasts were identified and counted (from 200 to 600 pollen clasts for sample). We have selected for palinological study the core ET 99-18, in the first 100 cm from the top and the 122BC tephra, with sampling each cm. The identified and counted pollens were represented in a general distribution diagram, a synthetic distribution diagram and a synthetic concentration diagram. We have identified 73 pollen types (26 taxa of trees, 42 taxa of herbs and 5 taxa of spores) and the stratigraphic succession of the last 2000 years have been divided in 6 pollinic zones with vegetation variations.

<u>TASK 3</u> Physical characteristics of the eruptions

RU PARTICIPANTS: UNICO, INGV-CT

2 YEAR OBJECTIVES

Microprobe analysis of microliths. Vesicule SEM analysis.

FTIR volatile analysis.

2 YEAR RESULTS

To investigate the causes of Etna's high explosive volcanism that have produced plinian and subplinian eruptions in Holocene, we studied the volatile components in the melt inclusions hosted in minerals through FTIR analyses. Information on volatiles (H_2O and CO_2) indicate a rather elevated percentage in comparison to that of the other intraplate basaltic volcanoes (e.g. Kilauea) outlining, therefore, the key role of volatiles in Etna's explosive volcanism. The first results of this study are discussed in Del Carlo and Pompilio (2002) paper.

The ongoing Etna eruption, begun on 27 October 2002, have furnished a chance to study a type of explosive activity never observed directly at Etna and better interpret some Holocene tephra layers to the light of the direct observations. For instance, some black sandy deposits, sometimes mixed to soil, in the pyroclastic succession of the last 2 ka, could be previously interpreted in equivocal manner (epiclastic deposits, distal deposits of lateral strombolian cones). By the explosive activity observation during the present eruption and from the study of its deposit, we infer that the ancient black sandy deposits can be produced by a similar activity, characterized by the issue of a great deal of ash for a very long period.

TASK 4 Hazard assessment

RU PARTICIPANTS: UNICO, INGV-CT

2 YEAR OBJECTIVES

Maximum and mean eruption energy, maximum expected event, return time, probable expected event determinations.

2 YEAR RESULTS

We improved the first year results in the evaluation of hazards associated to explosive eruptions in the last 12 ka with the results of the historical activity study merged from tephrostratigrafic and historical reports. They underline that the number of the explosive historical eruptions of Etna of which we know both age and the correspondent deposit is strongly under-evaluated for the period before the XVII century. Currently, it is not possible to realize a statistic analysis of the frequency of the eruptive events occurred in historical epoch but just in the last three centuries. In this period the number of the eruptions coincides perfectly with the stratigraphic record. Besides from these data, we can affirm that in the last 25 years the frequency and size of the eruptions, both effusive and explosive, is increased notably in comparison to the previous centuries. Moreover the 2002 Etna eruption, have given important indications of the effects that this type of eruptions, characterized by the issue of a great deal of ash for a prolonged time, can produce. The ash fallout have caused damages to the persons (respiratory problems), to agriculture, to the infrastructures (roads, houses, sewerage) and above all to the commercial aviation with the long stop of the Catania and Reggio Calabria airports operations.

- RESEARCH PRODUCTS
  - n° 3 articles published on international journals
  - n° 3 articles published on national journals, proceedings, technical reports
  - n° 2 presentations at international meetings
  - Data base of tepha layers, palinological content and radiocarbon ages of Etna

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

Branca S., Del Carlo, P. (2002): Historical eruptions of Etna: chrono-stratigraphic revision of the last 3200 years. In Calvari S., Bonaccorso A., Coltelli M., Del Negro C., Falsaperla S. ed.: Etna Volcano Laboratory, AGU Geophysical Monograph, Accepted in December.

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Vigliotti L. 2002. Secular Variation Record of the Earth Magnetic Field in Italy during the Holocene. In: Quaderni di Geofisica N° 26; P. 179; L. Sagnotti & A.P. Roberts (EDS). Extended Abstract for the international Symposium on "Fundamental Rock magnetism and environmental applications. Erice 26 June-1 July 2002.

PROJECT TITLE

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RU Responsible : Luigina Vezzoli
Name-Position : Prof. Associato
Affiliation: Universita' Insubria, Como

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position		Affiliation	man/month
Vezzoli Luigina	Prof. Associato	Universita' Insubria, Como	4m/u
Rossi Sabina	Assegnista	Universita' Insubria, Como	6m/u
Ravazzi Cesare	Ricercatore	CNR Istituto Dinamica Processi Ambientali, Milano	2m/u
Previtali Franco	Prof. Associato	Università Milano Bicocca	1m/u
Comolli Roberto	Ricercatore	Università Milano Bicocca	2m/u

2nd YEAR OBJECTIVES

1 **Tephrostratigraphy:** Trenches and cores excavation. Tephra petrographic, sedimentologic, geochemical and SEM analysis.

2 **Numerical and relative chronology:** Field sampling and analysis for 14C ages. Pollen analysis on deep-sea cores. Pollen diagrams construction and sea-land comparison.

3 **Physical characteristics of the eruptions:** Microprobe analysis of microliths. Vesicule SEM analysis. FTIR volatile analysis.

4 **Hazard assessment:** Maximum and mean eruption energy, maximum expected event, return time, probable expected event determinations.

2nd YEAR RESULTS

RU activity focused non geopedological and palinological study of pyroclastic successions, in order to increase tephrostratigraphic data, chronological definition and environmental hazard. Geopedological study stats with field survey in the north-eastern part of the volcanic edifice (Pineta della Cubania area) for: a) mapping of areal distribution of the soils, b) study the soil-vegetation relationships, c) study the soil-tepha fall relationships. In laboratory we have analized about 70 samples of epiclastic and pyroclastic deposits for chemical and grain-size characteristics definition and reconnaissance of soil profiles. On the soil we have determined Al2O3/siO2 and Al2O3/CaO+MgO+Na2O+K2O, that have pedogenetic and chronostratigraphic significance. Also the humic components and Fe and Al speciation were determined.

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individualized the appropriate laboratory methodology of the pollens extraction. This methodology consists of a set of acid and alkali attacks, heavy liquids separation, acetolsis and mounting on slides. The complete treatment for a set of 20 samples is about 1 month long. The slides were observed with an optical microscope and pollen clasts were identified and counted (from 200 to 600 pollen clasts for sample). We have selected for palinological study the core ET 99-18, in the first 100 cm from the top and the 122BC tephra, with sampling each cm. The identified and counted pollens were represented in a general distribution diagram, a synthetic distribution diagram and a synthetic concentration diagram. We have identified 73 pollen types (26 taxa of trees, 42 taxa of herbs and 5 taxa of spores) and the stratigraphic succession of the last 2000 years have been divided in 6 pollinic zones with vegetation variations.

We have carried out a field survey in the area of the north-eastern part of Sicily (Monti Nebrodi) in order to measure and sample lacustrine and paleolacustrine deposits that are favorable environments to tephra deposition and conservation. Some tephra layers were sampled, petrographically examined and preliminary pollen analyses in lacustrine sediments were performed.

We have taken part of the detailed sampling of the recent pyroclastic deposits and of the discussion.

- RESEARCH PRODUCTS

  - n° 1 articles published on international journals
  - n° 1 articles published on national journals, proceedings, technical reports
  - 2 presentations at international meetings
  - Data base of tepha layers, palinological content and radiocarbon ages of Etna

PUBLICATIONS LIST

Del Carlo, P., Vezzoli, L., Coltelli, M. (2002): Last 100 ka tephrostratigraphic record of Mount Etna. In Calvari S., Bonaccorso A., Coltelli M., Del Negro C., Falsaperla S. ed.: Etna Volcano Laboratory, AGU Geophysical Monograph, submitted in June.

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PROJECT TITLE

STUDY OF THE ETNA PYROCLASTIC DEPOSITS AIMED TO LARGEST EXPLOSIVE ERUPTIONS RECONSTRUCTION AND VOLCANIC HAZARD ASSESSMENT.

RU Responsible
Name-Position: Mauro Coltelli, senior scientist
Affiliation: INGV - Sezione di Catania

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Mauro Coltelli	INGV - Sezione di Catania	3m/y
Paola Del Carlo	INGV - Sezione di Catania	11m/y
Bruce Houghton	SOEST - University of Hawaii	1m/y
Julia Sable	SOEST - University of Hawaii	2m/y
Nicole Lautze	SOEST - University of Hawaii	1m/y

2nd YEAR OBJECTIVES

1 **Tephrostratigraphy:** Trenches and cores excavation. Tephra petrographic, sedimentologic, geochemical and SEM analysis.

2 **Numerical and relative chronology:** Field sampling and analysis for 14C ages. Pollen analysis on deep-sea cores. Pollen diagrams construction and sea-land comparison.

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integrating data acquired from the tephrostratigraphic studies with those deriving from the historical catalogs. It has been possible to integrate the previous knowledge with the discovery of eruptions until today unknown, to correct the age of others, etc. This investigation, that have the aim to compile the new catalog of Etna's historical eruptions, is still in progress. However, some preliminary results have been already published in Branca and Del Carlo (2002).

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- RESEARCH PRODUCTS

  - n° 3 articles published on international journals
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RU Responsible: Luigi Vigliotti
Name-Position: Researcher
Affiliation: Istituto di Geologia Marina CNR Bologna

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Vigliotti L. - Researcher	Istituto di Geologia Marina, CNR Bologna	4
Capotondi L. - Researcher	Istituto di Geologia Marina, CNR Bologna	3
Borsetti A.M. - Collaborator	Istituto di Geologia Marina, CNR Bologna	1
Zaffagnini F. - Student	Istituto di Geologia Marina, CNR Bologna	3
Soroldoni E. - Collaborator	Dip. Scienze Geol. e Geotec. Milano Bicocca	2
Landuzzi M. - Technician	Istituto di Geologia Marina, CNR Bologna	1

2nd YEAR OBJECTIVES

1 **Tephrostratigraphy:** Magnetic analysis.

2 **Numerical and relative chronology:** Paleomagnetic analysis

2nd YEAR RESULTS

In the second year, the research of the RU-IGM-CNR of Bologna has been focused on a key point of the project: the chronology during the Late Pleistocene-Holocene times of the explosive activity recorded in marine cores.

On the basis of the whole-core magnetic susceptibility profiles measured for the original data set we selected three cores (ET97-18; ET97-70 and ET99-M11) representing the best record for the interval deposited after the emplacement of the Elliptic tephra up to the recent times (last 15 kyr.).

Quantitative micropaleontological analysis of planktic foraminifera were used to recognise the Ecozones established by Capotondi et al. (1997) with the aim to obtain an age depth-model as well as to warrant the continuity of the record. Three 14C (AMS) datings have been carried out on foraminifera tests from core ET99-M11 representing the Early Holocene in the composite section. Two additional datings are in progress with the aim to detail the emplacement timing of the Elliptic tephra.

To improve the chronology for the interval representing the holocene we measured paleomagnetic directions on U-channels collected from cores ET97-18 and ET99-M11. The results have been compared with the saecular variation curves of the earth magnetic field reconstructed from archaeomagnetic data, lava flows as well as marine and lacustrine cores (Vigliotti 2002).
Laboratory imparted magnetizations (anysteretic and isothermal) identified intervals with high magnetic content that could be representative of tephra layers. These intervals have been sampled and will be analysed by other RU of the project for the geochemical characterisation and possible correlation with events occurring on the slope of the volcano.

- RESEARCH PRODUCTS

n° 1 article published on national journals, proceedings, technical reports
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PUBLICATIONS LIST

Vigliotti L. 2002. Secular Variation Record of the Earth Magnetic Field in Italy during the Holocene. In: Quaderni di Geofisica N° 26; P. 179; L. Sagnotti & A.P. Roberts (EDS). Extended Abstract for the international Symposium on "Fundamental Rock magnetism and environmental applications. Erice 26 June-1 July 2002.