Symposium on the Mediterranean region in PEP III

Paleoclimate in the Mediterranean region: a contribution to the Afro-European Paleoclimatic Transect (PEP III) Milano, 22 June 1998

PROGRAMME

10.00 - 10.20. Introduction by G. Orombelli and F. Oldfield

Holocene variability:

10.20-10.45 Renzo Motta - From past to future: climate reconstruction and CO_2 doubling scenario in the Mediterranean region.

10.45-11.10 Dario Camuffo - Winter severity and instability phenomena in Italy during the last millennium.

11.10-11.35 Jose S. Carrion - Overview on the Holocene evolution with special emphasis on abrupt climatic events.

Coffee break: 11.35-12.05

12.05-12.30 Fekri A. Hassan - Late Holocene climatic fluctuations in North-Eastern Africa.

Long term fluctuations:

12.30-12.55 Donatella Magri - Palynological record from the Italian crater lakes.

Lunch and posters: 12.55 -14.55

14.55-15.20 Fabio Trincardi - Paleoenvironmental change during the last 20,000 years: global and local factors recorded in the Central Adriatic Basin.

15.20-15.45 Tony Stevenson - PEP III – Focus 3. Palaeoecological potential of Mediterranean endoreic lakes – climate and human aspects.

15.45 - 16.10 Biancamaria Narcisi - Tephrochronology and past global changes in the Mediterranean.

16.10-16.35 Steve Juggins - Multi-proxy databases and PEP III.

16.35-17.00 Rick Battarbee - Human impact on lake ecosystems

General discussion: 17.00-18.00

Introduction

FOREWORD

Frank Oldfield

PAGES – IGBP, Barenplatz 2,Berna 3011,Switzerland

PAGES works to identify and understand those aspects of past global change that are of the greatest significance for the future of human societies. It seeks to promote and co-ordinate the broad and diverse area of research that extends knowledge of our changing environment back beyond the short, recent period for which we have instrumental records. By so doing, it provides essential knowledge about the natural variabilityof processes driving changes in the earth system and the impacts of past climate change on other environmental systems. If we are to make a realistic appraisal of future global change and its implications for human societies, these are key themes demanding urgent attention.

One of the principal strategies of PAGES is to take a first major step towards a high resolution reconstruction of past global climate variability by co-ordinating research along a series of three Pole-Equator-Pole (PEP) Transects. The scientific rationale for these transects is set out in an earlier publication (Paleoclimates of the Northern and Southern Hemispheres) which can be consulted on the PAGES Web site (http://www.pages.unibe.ch/pages.html).

PEP III passes though Europe and Africa and is the focus concern of the present Symposium. The PEP III Activity was initiated in December 1993. Community workshops held in Sfax, Tunisia (April, 1995) and Bierville (September, 1996) further refined the PEP III objectives and established the background for PEP III organization.

The primary PEP III goals are to document how records from the major climatic regions are inter-related, and to provide the paleoclimatic proxy data required for evaluating the performance of climate models under changing boundary conditions. In these respects, the Mediterranean region is of vital importance. It lies at the heart of the Transect. The marine realm itself provides a rich sedimentary archive that is surrounded by other, diverse records of past environmental change represented by the range of themes covered in the meeting. The 'Mediterranean' is also a region of long and intensive human impact with many areas of high environmental vulnerability. This poses distinctive challenges and adds a direct relevance to the work presented during the meeting.

THE MEDITERRANEAN IN THE AFRO-EUROPEAN PALEOCLIMATIC TRANSECT: AN INTRODUCTION

Giuseppe Orombelli

DISAT - University of Milano, Via Emanueli 15, 20126 Milano, Italy

The Mediterranean region, with Italy in a central position, is of particular importance for paleoclimatic studies along the Afro-European pole-equator-pole transect, being located at the boundary between the subtropical high-pressure dominated climates and the mid-latitude climates, governed by cyclones moving within the belt of the westerlies and by the associated polar front.

The variety of geographical and geologic settings, together with a long human presence that has left a rich archaeological and historic record, makes the Mediterranean a particularly favourable area for paleoclimatic and paleoenvironmental studies. Historical data, archaeological remains, lacustrine and marine sequences, glacial, periglacial, alluvial, littoral and eolian sediments, peat bogs, speleothems, geomorphological evidence, soils and paleosols, tephra, and cold glaciers of the highest parts of the Alps, make a complex of man-made and natural archives, offering multi-proxy records of climatic and environmental variations and of the human impact on the environment.

Instrumental meteorological records started in Italy in the 17th century, and several multisecular meteorological series are available in the Mediterranean area. The historical archives preserve a great wealth of paleoclimatic, paleohydrological and paleoenvironmental information, spanning over two millennia. Classic and medieval archaeology supplements such information, particularly concerning the human impact on the environment. Biological and geological detailed archives can also contribute to the study of the last 2000 years of environmental and climatic history.

On a longer time scale, continuous long lacustrine sequences are present in volcanic, karst and tectonic lakes. Present and Pleistocene mountain glaciers have left a discontinuous record of their fluctuations, along a transect stretching from the Alps to Mt. Etna. Paleobiological and geochemical records, from pollen sequences to stable isotopes of carbonates, integrates with other paleoenvironmental data, such as lake level and hydrologic variations, and periglacial slope activity. Peculiar to the Mediterranean coasts is the rich documentation of sea level fluctuations, associated with well preserved and easily accessible Quaternary marine deposits, while deep sea sediments record important episodes of paleoceanographic changes since the Messinian desiccation. Because of the presence of many active volcanoes, tephra layers provide firm correlation between marine and continental records.

All of these Mediterranean records provide an opportunity to reconstruct N-S and E-W past climatic gradients, together with changes of seasonality, and precipitation and hydrologic budget variations. Armed with these paleoclimatic and paleoenvironmental knowledge, we should be able to assess the reaction of one of the Earth's most beautiful, culturally and historically rich regions to possible future climatic changes.

Invited Speakers Section

HUMAN IMPACT ON LAKE ECOSYSTEMS

Richard W. Battarbee

Environmental Change Research Centre, University College London

The importance of conserving lake and other aquatic ecosystems and managing water resources in a sustainable way is widely recognised. The EU Science Plan WAtER (European Commission EUR 17452) highlights the importance of a coordinated plan for water research, and the IGBP is currently developing a cross-cutting theme on Continental Aquatic Systems that proposes to bring together expertise from all IGBP core projects, including PAGES. A proposed new project within PAGES on "Human Impact on Lake Ecosystems" will enable palaeolimnologists to take a fuller role in these EU and IGBP programmes.

Although on a global scale lakes play only a minor role in the hydrological cycle they have special importance owing to:

(i) their dominance in the landscape of many, especially glaciated regions;
(ii) their value as a resource for water supply, hydropower, irrigation and amenity;
(iii) their value as natural ecosystems and centres of biodiversity;
(iv) their role in sensing environmental pollution;
(v) their sediment records as unsurpassed archives of recent environmental change.

However, lakes are under increasing threat due to the separate, but often combined impact of:

(i) climate change from greenhouse gases;
(ii) nutrient (N and P) enrichment from domestic and agricultural sources;
(iii) acid deposition (S and N) from fossil fuel combustion;
(iv) salinisation from over extraction of freshwater;
(v) pollution from toxic metals (Pb, Hg, Cd etc), organic compounds (PAH, PCBs etc) and radionuclides;
(vi) accelerated infill from catchment soil erosion;
(vii) habitat disturbance from engineering projects;
(viii) ecological disruption from species introductions and invasions.

These multiple threats have different histories (although most post-date 1800 AD), operate on different space-scales (catchment, local, regional and global) and involve different pathways (land, water, atmosphere). Moreover, many, but not all cause changes and involve substances and processes that are similar or identical to those that occur naturally.

In this presentation I will demonstrate how the lake sediment record can be used to understand these issues more fully, using examples from different parts of the world, including the Mediterranean basin.

WINTER SEVERITY AND INSTABILITY PHENOMENA IN ITALY DURING THE LAST MILLENNIUM

D. Camuffo, S. Enzi & C. Cocheo

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Climate changes may occur either with inadvertent, progressive changes or with an increased frequency of extreme phenomena. The latter can be found analysing old written sources, e.g. annals, chronicles, diaries. In documentary sources, the winter severity can be recognised in an objective way from the effects: during great winters all the large water bodies (and the Venice lagoon) were completely frozen over, supporting people and chariots crossing them; also the wine and the wells were frozen, and plants and a number of animals were killed by the cold; also severe winters can be easily found for the large water bodies frozen but not supporting people and chariots, and the dangerous effects on plants and animals. Cold and 'normal' winters are not clearly distinguishable for the subjective complaints about chilly weather in the absence of objective spectacular effects, taken as a useful severity index. Mild winters can be recognised from the flowering of plants and birds nest-buildings.

A research made on the great and severe winters in Northern Italy has shown that in the early 1500s, during the Spörer minimum of solar activity, there was an important increased frequency of great winters, but in the following period their frequency was nearly the same, either during the Little Ice Age and the Present Day Warming. In the majority of the extreme winters, the cold was not limited on the local scale, but was found also in Switzerland and was extended at least to central Europe.

In Northern Italy, instability phenomena such as hailfall and thunderstorms are mainly associated with the penetration of Atlantic disturbances, especially cold fronts, or pre-frontal squall lines in the mid seasons, and with the thermal convection of hot and moist air in the summertime. Also the penetration of cold air masses forced by the sea or mountain breeze may generate hail and thunderstorms in the hot season. Although these effects are associated with the growth of cumulus clouds and the formation of cumulonimbus, their seasonality is not strictly the same. Seasonal changes may be considered as an index of anomaly in the synoptic pressure pattern which determines the general circulation over Europe. Two types of meteorological data were analysed: (1) historical, non specialist descriptions, taken from chronicles, annals or diaries after 1300; (2) regular daily observations made by trained meteorologists after 1740.

The historical descriptions shown that in the Po Valley the thunderstorms frequency was highest in the summertime, between June and August, but in the 1500s the distribution was anomalous. In this particular century, a broad maximum was found between March and August, and a secondary maximum was found in December.

In the early period of observations made by trained meteorological personnel, i.e. 1740-1799, a summer maximum of thunderstorm frequency was found, almost equally distributed from June to August, but with an elevated number of occurrences also in May and, secondarily, April and September. In the most recent period, i.e. 1940-1989, the seasonal distribution was very regular for three decades (1940 to 1969) with the mode in June, followed by July and August, and then changed with more late peaks.

The historical written sources show that the hailfall seasonal distribution was more homogeneous than thunderstorms. The hailfall was especially frequent in the summer, from June to August, except in the 1500s (which is always the most anomalous century), when the seasonal distribution was practically one month earlier. In the early period of regular meteorological observations, hailfall was seasonally distributed less regularly than thunderstorms, more skew and earlier. The maximum frequency was in June, followed by April, May, July and August. In the most recent period, the distribution was still irregular, with marked fluctuations, the distribution being practically displaced later in the season.

OVERVIEW ON THE HOLOCENE EVOLUTION WITH SPECIAL EMPHASIS ON ABRUPT CLIMATIC EVENTS.

Jose S. Carrion

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A critical approach is presented about the potential of Mediterranean sites for palaeoclimatological studies, with emphasis on Holocene pollen records and abrupt events. Published literature shows a bulk of palaeoecological information from which becomes difficult to document overall tendencies. This fact appears related to not only poor chronological control but also the physiographic complexity of the region and the influence of site-specific historical factors. A few selected sequences from the Iberian Peninsula and North Africa are compared with other extra-regional sequences and some global signals can be noticed. Suggestions are given for future research stressing the importance of more adequate site selection, chronological assessment and higher temporal and taxonomic resolution.

LATE HOLOCENE CLIMATIC FLUCTUATIONS IN NORTHEASTERN AFRICA

F. A. Hassan

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The Eastern Sahara in northeastern Africa, south of the Mediterranean Coast, witnessed dramatic changes in the amount and seasonal distribution of rainfall during the Quaternary period. Climatic fluctuations during the Late Holocene suggest moist intervals at ca. 3600 bp, 2700 bp, and 2100-1600 bp (all dates are in uncalibrated radiocarbon years before present). These moist interval correlate with increased rainfall in Equatorial and Eastern Africa, the Congo (where forest expansion is recorded during the interval from 2600 to 1600 bp), and the Sudan where mollusks and lake deposits indicate a wetter interval ca. 1900-1700 bp.

The climate from 1800 to 950 bp was dry in Ethiopia with a return to wetter conditions ca. 800-700 bp. In the Eastern Sahara, radiocarbon dates on dried grasses in dunes from 470 bp to less than 30 yr bp indicate that four or five rain events occurred within the past few centuries (ca. AD 1350-1515, 1395-1950, 1490-1950, 1660-1950, 1955-1958). The probable mid-points for these events are approximately AD 1350-1470, 1700, 1775, and 1955-58. Hyperarid conditions at Siwa and in the Sudan at ca. AD 1580 and 1350 bracket the AD 1350-1515 moist episode.

The late Holocene wet/moist intervals were interrupted with drier conditions ca. 3300-3000 bp, 2500-2200 bp, and 1800-950/800 bp. The sequence of climatic variations may be summarized as follows:

Climate	Range (^{14}C BP)	Duration (^{14}C yrs)	Midpoint (^{14}C BP)
Moist	3800-3450*	350?	3600
Dry	3300-3000	300	3150
Moist	2950-2300	650	2680
Dry	2500-2200	300	2500
Moist	2100-1600	500	1800
Dry	1800-950/800	1000	(1300)
Moist	800-?350	450	600

* possibly two subphases (3800-3700 bp and 3500-3300 bp) with a brief hyperarid interval at ca. 3700 BP or from 3700 to 3500 bp).

Transregional coherence of climatic variations in Africa are manifest in the historical period. In general, increased rainfall in northeastern Africa is associated with the northward of the intertropical convergence zone, which appear to be correlated with warm summer conditions in Europe.

MULTI-PROXY DATABASES AND PEP III.

S. Juggins

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Majority PAGES and PEP science goals require the integration and analysis of multi-proxy data from regional or continent-wide site networks. Central to this task is the need to develop an effective data management strategy based around an integrated multi-proxy database.

This talk will present current work on a PEPIII multi-proxy database, and illustrated its potential using examples from the PALICLAS project.

PALYNOLOGICAL RECORD FROM THE ITALIAN CRATER LAKES

Donatella Magri

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Several Italian crater lakes have shown high potential for palaeoenvironmental investigations, as they generally provide sequences with relatively undisturbed sedimentation in which pollen is well preserved and abundant. In many cases the formation of the lakes is much older than the Holocene and sediment accumulation took place also during the glacial periods. Twelve crater lakes, of variable age from a quarter of million of years to few thousands of years, have been the subject of pollen analysis by different authors; some records are still in course of study. They show a significant diversity of vegetational phases in the couse of time, which may be partly due to local situations, but certainly demonstrate that the Italian peninsula, in the heart of the Mediterranean, is a very sensitive area to climatic changes.

FROM PAST TO FUTURE: CLIMATE RECONSTRUCTION AND CO_2 DOUBLING SCENARIO IN THE MEDITERRANEAN REGION (FORMAT EU PROJECT).

R. Motta[1], M. Carrer[2], P. Nola[3] & C. Urbinati[2]

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The aim of the project **FORMAT** (EU, ENV4-CT97-0641) is to assess the sensitivity of tree-growth to climate change in different ecological and geographical situations in forest ecosystems of southern Europe, both in its past variability and in the future as predicted by climate models for a CO_2 doubling scenario. The project **FORMAT** is focused in the mediterranean region.

Forecasting impact of future climate change on ecosystems requires plenty information about the past. Instrumental data are not sufficient because they are contemporaneous with industrial activities that are held responsible for the present climate change. The study of past climates and environment distribution and variations at any time scale, and in particular the inter-annual variations enables a better understanding of the present climate and environment variability beyond any human intervention. Such information makes possible to understand more accurately possible changes in future and so, to mitigate the consequences on environment.

The general circulation models simulate climate at a global scale; they are now refined using mesoscale models whom outputs are more compatible with spatial variation of ecosystems. Nested to tree-growth models they can provide predictive models of tree-growth. On large area it became possible to approach through radial growth the wood production for the main tree-species and the different forest ecosystems in the hypothesis of the climate change predicted by climate models.

The project **FORMAT** responds to requirements of different International research programmes on climate change. In particular, it links up with the **I.G.B.P. PAGES** project organisation, mainly in Focus 1, Global Paleoclimate and Environmental Variability, the **PANASH** *(Paleoclimates of the Northern and Southern Hemispheres*) Project, the **P.E.P. III** (***Pole Equator to Pole***), providing the Afro-European transect.

TEPHROCHRONOLOGY AND PAST GLOBAL CHANGES IN THE MEDITERRANEAN

Biancamaria Narcisi

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By virtue of both the huge explosive character of its volcanic activity and the quite diverse composition of the products from province to province, the Mediterranean is an ideal region for tephrochronological studies.

While the tephrostratigraphy of the Eastern sector is defined well and has been developed in conjunction with detailed biostratigraphy, sedimentation in the Central Mediterranean is influenced by the proximity of the source volcanoes and hence primary tephras frequently exhibit evidence for reworking and post-depositional phenomena. In contrast to the long marine tephrostratigraphy there are still only a few studies reporting continental tephra deposits.

Tephra markers of the Mediterranean have been employed to date palaeoclimatic and palaeoenvironmental records. Besides, they can be used to define both the climatic impact of past explosive eruptions and the influence of global environmental change on local volcanism. For these purposes, further stratigraphic and chronological investigations are needed to improve the completeness and reliability of the tephra records.

PEP III – FOCUS 3 - PALAEOECOLOGICAL POTENTIAL OF MEDITERRANEAN ENDOREIC LAKES – CLIMATE AND HUMAN ASPECTS.

Tony Stevenson

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The palaeoecological potential of mediterranean endoreic lakes to provide both records of climate change and human modifications of landscapes is emphasised. Examples will be drawn from a range of sites from the Iberian peninsula illustrating i) linkages between recent lake sediment records and historical lake level and rainfall regimes; ii) variations in the strength of lake level response across the Iberian peninsula during the Iron age; iii) the role and relative significance of climate and human modifications of mediterranean ecosystems on a Holocene time scale; iv) the importance of longer historical perspectives provided by palaeoenvironmental records in informing debates on desertification and environmental restoration.

PALEOENVIRONMENTAL CHANGE DURING THE LAST 20,000 YEARS: GLOBAL AND LOCAL FACTORS RECORDED IN THE CENTRAL ADRIATIC BASIN.

Fabio Trincardi

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This presentation uses the data produced by several colleagues under the PALICLAS EU project to illustrate the potential of continental-margin sedimentary sequences for resolving short-term paleoenvironmental fluctuations during the late-Quaternary; the extraction of multiproxy data from shelf and slope-basin sequences with high sediment accumulation rates may complement other kinds of marine and terrestrial stratigraphic records such as deep-sea sediments, corals, ice cores, lake sediments and loess deposits. However, when studying sequences accumulated in continental-margin settings or enclosed seas, such as the Mediterranean, it is critical to disentangle global climatic factors from local factors or amplifiers. Local factors include changes in basin size and morphology, driven by sea level fluctuations; changes in oceanographic regime, with reduced or enhanced connection to the rest of the global ocean; changes in the hydrologic balance; and changes in fluvial regime and sediment yield.

The ceanographic circulation in the Mediterranean basin is controlled by the water exchange with the Atlantic and by the occurrence of several sills that define distinct subbasins. The surface inflow of less saline watrs from the North Atlantic, called Mediterranean Surface Waters (traced as far as the eastern Mediterranean), is balanced by a concurrent subsurface outflow of relativelly more saline Mediterranean waters (mostly from the Levantine concentration basin), in a two-layer flow regime through the Strait of Gibraltar. During the last glacial maximum (LGM) sea level was about 120 m below its modern position and extensive shelf areas were emergent in the North of the basin and in the area of the Sicily Channel. Paleoenvironmental and paleoclimatic reconstructions in the Mediterranean region relied on micropaleontologic, palinological, geochemical and isotopic studies, documenting the potential for this area to resolve millennial-scale changes. Most of these reconstructions, however, did not exploit the areas where potential stratigraphic resolution is highest and have limited chronologic control. Within the Mediterranean, the Adriatic is one of the broadest shelf area and a site where deep waters form during winter in response to heat loss to the atmosphere. Because of its semi-enclosed nature, the basin underwent substantial changes in morphology, extent and degree of connection to the Mediterranean, since LGM. The central portion of the Adriatc was in the order of 120 m deep and poorly connected to the Southern Adriatic through the Pelagosa sill that was shallower than 30 m. Several proxies indicate that circulation was substantially different from today: planktonic foraminifera were extremely rare because of the sluggish connection to the deeper waters to the South while TOC fluxes and pollen concentrations record the increased influence of the Po fresh waters on the hydrology of the basin. Complementary shelf and basin multiproxy data and a refined ^{14}C chronology help defining century-scale paleoenvironmental change during and following the last glacial maximum.

Certainly paleoenvironmental change in the Adriatic basin was affected by local factors and biases driven ultimately by the timing of deglaciation in the Alps and by sea level rising in a semi-enclosed area: changes in basin size, morphology, mean water depth, hydrologic connection to the rest of the Mediterranean (onset of anticlockwise gyre, entrance of levantine waters). Despite their significance, local factors, nevertheless, do not hamper the good correlation potential of the Adriatic record to other paleoclimatic records in the Northern Hemisphere (e.g.: North Atlantic and Greenland). This climate-change link to the Northern Hemisphere is supported by the duration, number and gross chronology of several oscillations that affected the late-glacial interval, between Terminations 1a and 1b. The overal <u>structure,</u> shown by all proxies in the Central Adriatic basin, during the late-glacial (abrupt warming at the onset of the Bølling interval, followed by an overall oscillatory cooling trend culminating in the Younger Dryas interval), is remarkably similar to other records in the Northern Hemisphere; the <u>amplitude</u> and <u>number</u> of oscillations superposed on an overall cooling trend from the base of Bølling to the YD: namely the Older Dryas and the Amphi-Atlantic, respectively at the base and within the Allerod; the <u>chronology</u> of events reconstructed in the Adriatic basin is in tune with records coming from other sites. The Adriatic shelf is also ideal to attempt stratigraphic correlations shelf (expanded but discontinuous) records. Although deposited during a short interval, the late-Quaternary record reveals great geometric and facies variability on two adjacent shelf domains: the low-gradient shelf to the north, a sediment-starved setting where drowned barrier-lagoon deposits have a patchy distribution; and the steeper southwestern shelf, where a muddy transgressive record includes an "out-of-sequence" regressive unit that reflects unsteady sediment flux during the late glacial. Comparable shelf successions can be exploited also in other mediterranean margins, where mud supply is dominant, to extract paleoenvironmental informations on critical time intervals.

Poster Section

HOLOCENE SEA SURFACE TEMPERATURE TREND IN THE MEDITERRANEAN RECONSTRUCTED FROM MARINE OVERGROWTHS ON SUBMERGED STALAGMITES

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The Holocene temperature history is crucial to understand the natural variability of climate and quantify anthropic disturbance. High-resolution isotope, alkenone and Sr/Ca palaeothermometry records extracted from ice cores, deep sea sediments, tropical corals and continental speleothems yielded amplitudes of the deglacial warming temperatures which differ considerably for the high and low latitude records and little is known for the mid latitude. A clearer picture of the Holocene temperature trends needs mid-latitude marine records which can be tied to absolute calendar timescale. Holocene sea surface temperature and sea level fluctuation in a key mid-latitude sea, the Mediterranean, are scarce have been obtained through the stable isotope composition and radiocarbon dating of eight Serpulid overgrowths on submerged speleothems which were collected at different depths in submarine caves located on tectonically stable Italian coasts (Argentario and Palinuro). Study of calcitic Polycaeta serpulid overgrowths allowed the simultaneous reconstruction of sea surface temperature and timing of sea-level rise from 9.5 kyr BP to the Present, because worm tubes can be precisely dated by ^{14}C, because the Polycaetae colonized the stalagmites at the time of sea level rise, and because the d18O of their calcite likely formed in isotopic equilibrium with seawater. The radiocarbon ages for serpulids were obtained by both mass spectrometry and accelerator mass spectrometry (AMS), and the dates are comparable. The AMS ^{14}C dates were converted to calendar ages using the CALIBRA program. Serpulid overgrowths on submerged speleothems at Argentarola commenced to grow at 6590±185 yr cal BP at -6 m, 6770±190 yr cal BP at -9.5 m, 7360±200 yr cal BP at -14.5 m, 8300±150 yr cal BP at -16 m, 9590±120 yr cal BP at -19.0 m, 9430±170 yr cal BP at -21.0 m. The marine overgrowths at Palinuro commenced to grow 8223±71 yr cal BP (AMS) at -27 m and 8680±65 yr cal BP (AMS) at -41.5 m. All the submerged speleothems overgrowths exhibit similar $\partial^{18}O$ trend that are characterized by $\partial^{18}O$ enrichment through the Middle and Late Holocene. By plotting in the same graph all the **ninetysix** $\partial^{18}O$ datapoints, the resulting curve shows a continuos positive trend since ~ 8.2 kyr cal BP up to the Present. There is no correlation between sampling depths and $\partial^{18}O$ values, as indicated by the $\partial^{18}O$ values of twelve living Serpulid tubes collected at various depth, which indicate that the $\partial^{18}O$ fluctuations do not depend on this parameter. The inferred SST decrease at ~ 8.2 kyr BP corresponds to the maximum rate of sea level rise for the Mediterranean, and with the temperature trend inferred from deep sea core records for the same region. The Mediterranean Mid and Late Holocene cooling is in phase with high and low latitude SST Middle Holocene cooling, but the onset of the cooling trend was not synchronous. Some parallel Mediterranean continental records are characterized by an overall warming trend in the last 8 kyr, which is marked for the last century. This finding, along with the results from the correlation of high and low latitude high-resolution climate proxies, strongly supports the inferred idea that global SST trends respond to the dynamics of distribution of water vapour in the atmosphere, whereas the parallel continental record is more sensitive to summer insolation as predicted by orbital changes. The thermal inertia of the oceans hampers their capacity to record short-lived climate changes and the modern anthropogenic global warming.

CENTRAL MEDITERRANEAN SEA SURFACE TEMPERATURE TRENDS IN THE LAST FOUR CENTURIES RECONSTRUCTED FROM VERMETID REEFS

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It is important to acquire paleoclimate data for the Mediterranean sea with a resolution that allows to distinguish between natural variations and the effects of anthropogenic forcing on climate changes. The reconstruction of recent climate changes from proxy paleoclimate indicators extracted from the geologic record depends on the continuity of the record and on the precision of dating. The $\delta^{18}O$ record from vermetid reef carbonates, the age of which can be precisely obtained through calibrated ^{14}C ages on the organic components of the reefs, provide parallel information on sea level fluctuations and sea surface temperature (SST) at decennial scale.

Vermetid reefs colonize Southern and Central Mediterranean coasts. The present study focuses on reefs from North West Sicily, which consist of an outer, living part, and an inner core dated 450 cal. years BP. These bioconstructions, which seem to be thermophilic, are the result of the activity of the gastropod *Dendropoma petraeum*, which dwells at zero sea-level. Consequently, vermetid reefs are commonly used to reconstruct sea-level fluctuations.

In the present work, vermetid reefs, which have been continuously growing for the past 450 years have been used to reconstruct sea surface temperature changes (SST). The studied reefs preserve fossil parts which can be found down to a depth of -40 cm below present day sea level. By taking into consideration that the area is tectonically stable, this depth should mark the ancient Mediterranean sea level. Two colonies have been sampled along the Cape Gallo coast (Palermo, north-west Sicily). The microcores used for $\delta^{18}O$ mass-spectrometry analyses were drilled parallel to the growth direction of each colony, from the innermost part, attached to the host rock, up to the outer, living part of the colony. Isotopic equilibrium fractionation was tested by analysing a statistically significant number of living gastropods sampled in adjacent areas.

The $\delta^{18}O$ fluctuations recorded in marine, biogenic carbonates are commonly related to changes in sea surface temperature. The isotopic curves obtained from vermetid reefs record a shift towards more positive values between 1600 AD and 1850 AD. This shift indicates a SST cooling, probably related to the Little Ice Age cooling event. The subsequent trend records a temperature rise throughout the 20th century. The isotope values of living *vermetids* from both specimens are very similar.

Vermetid reefs are valuable palaeoclimatic indicators for the temperate regions and allow to reconstruct Holocene SST fluctuations with a ten-year scale resolution, which should allow to recognise the effects of anthropogenic forcing on climate changes.

WHERE DID SEA LEVEL REACH DURING TERMINATION IA?

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Changes in continental ice volume during the last deglaciation induced a world-wide sea level rise from about 120 m below its modern position. This sea-level rise occurred at very high rates between about 16,000 and 5,000 years BP and was not monotonic. Maximum melting rates occurred during two distinct time intervals from 14,000 to 12,000 years BP and from 10,000 to 7,000 years BP separated by a mid-deglacial interval; this interval was characterised either by a pause in deglaciation, with no ice volume loss, or by a significant ice growth. Many independent and complementary geologic indicators on several continental margins inicate that the late-Quaternary sea level rise was stepwise: carbonate platforms, siliciclastic shelves and mixed environments. These data are consistent with reconstructions of the ice sheet dynamics.

We discuss detailed bathymetric, seismic-stratigraphic, sedimentologic and biostratigraphic data in a refined chronostratigraphic framework from the Northern Adriatic shelf, a shallow epicontinental sea that was subaerially exposed during the last glacial maximum. In this area the transgressive record has clear bathymetric expression and is accessible to coring. Thanks to its extremely low axial gradient, the Adriatic shelf records each increment of sea level rise with large landward shifts of the shoreline and is an ideal site to test the timing of the late-Quaternary sea level rise. The sequence stratigraphic arrangement of a series of shoreline and back-barrier lithosomes shows that they belong to a low-supply transgressive systems tract resting on low-stand alluvial plain deposits. The degree of erosion and reworking of these transgressive coastal deposits varied during the transgression and basin widening.

A set of 35 ^{14}C dates from peat layers within the transgressive record from 50 to 25 m water depth defines the chronostratigraphic framework for the North Adriatic shelf. We selected peat layers where molluscs, benthic foraminifera and Sr Isotope ratios (a paleosalinity proxy) indicate a brackish-water backbarrier coastal environment close to sea level at the time of deposition; ^{14}C dates from these layers range in age from 11,000 to 9000 calibrated years between 48 and 25 m water depth and fall on the eustatic curve of Fairbanks (1990), indicating that the area remained stable during the Holocene. The area also shows that between 46 and 42 m a set of dates on back-barrier peats (11,900 and 12,400 calibrated years, corresponding to the Younger Dryas cold episode) are 10-15 m above the published global sea level curve. If correct, these data show evidence of a greater sea level rise during Termination Ia; the superposition of Younger Dryas brackish-water peats on slightly older open lagoon or lower shoreface deposits may imply a small sea level fall during this cold episode.

PALEOENVIRONMENTAL RECONSTRUCTION OF THE CENTRAL ADRIATIC SEA DURING THE LAST 70 KA

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The modern Adriatic is a broad epicontinental shelf that surrounds a small slope basin 250 m deep, where a continuous marine section has deposited during the last glacial-interglacial cycle. During the last 6 ka the bas has been characterized by dysoxic bottom waters and oligotrophic surface waters. A composite record obtained from several cores allowed a high resolution paleoenvironmental reconstruction using different and independent proxies (O and C stable isotopes, Uk^{37}, foraminifera, pollen, TOC). Physical correlation between complementary sites relied on high-resolution seismic stratigraphy and magnetic susceptibility. Chronology is provided by ^{14}C AMS dates, oxygen isotope stratigraphy and tephrachronology.

The oldest part of the record can be ralated to Isotopic Stage 4: the dominance of the subpolar species *Globigerina bulloides* indicates cold and productive surface waters while high concentrations of *Artemisia* indicate relatively dry conditions onland. Aabove this interval, the lower part of Isotopic Stage 3, warmer conditions characterize both the surrounding mainland areas (with a significant increase of *Quercus* in the pollen spectra) and the water masses (increase of *Globigerinoides ex gr. ruber* and *Globorotalia inflata*). The interval immediately upsection is interpreted as the equivalent of "Sapropel 2" in the Eastern Mediterranean based on increased TOC content, a foraminifera assemblage indicative of cold water (with *Neogloboquadrinidae* up to 50%) and a concurrent strong depletion of $\delta^{18}O$.

A prolonged cold interval lasted until ca. 13 ka BP and was punctuated by a major warm oscillation between 42 and 35ka (Hengelo?) indicated by all biological and chemical proxies. Following the last glacial maximum, the first pronounced warming is recorded at 13 ka and can be related to the base of the Bolling/Allerod interval. During this interval, an overall cooling trend shows two short-term colder oscillations characterised by differentiated foraminiferal assemblages and visible in other marine sequences of the central Mediterranean: based on our age-depth modelling, these oscillations seem to correlate to the Older Dryas and Anphi-Atlantic oscillations, respectively. The Younger Dryas cold episode is well detected by different proxies (e.g., total disappearance of warm planktonic foraminifera, decrease of broad-leave trees accompanied by a peak of *Artemisia* and *Chenopodiaceae*, heavier values of $\delta^{18}O$ record and low surface-water temperatures derived from UK^{37} measurements). The boundary between Younger Dryas and the Holocene is recognized by a strong shift of the $\delta^{18}O$ curve towards light values and by the reoccurrence of warm species (*G. ex gr. ruber*) and *Quercus*. In cores where the record is particularly expanded, several small oscillations characterize the pre-Boreal interval. Upsection, geochemical proxies show two episodes of water stratification, centered at 9 and 7 ka. These are considered as equivalent of Sapropel 1 in the rest of the Mediterranean.

PALEOCLIMATIC DATA FROM LACUSTRINE BASINS OF SOUTHERN ITALY

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In the last years one of the main research interests of our group has been the stratigraphical evolution of the Quaternary continental successions of Southern Italy. These works let us to identify the most suitable sites for paleoclimatic investigations which are mainly represented by lacustrine successions ranging in age from lower Pleistocene to Holocene. Because of the complex tectonic history of the Southern Apennines chain, a lacustrine succession covering the entire Quaternary does not exist and only partial paleoclimatical curves can be reconstructed. The geomorphological and stratigraphical analysis help in the identification of the relative chronological position of each lacustrine basin.

Until now, with different research projects supported by CNR and MURST, three continuous cores in lacustrine basins of different age have been drilled, namely the Camerota, Vallo di Diano and Acerno basins. These lacustrine successions partially cover the Lower and the Middle Pleistocene.

The pollen analysis allowed the duration and rates of the lacustrine sedimentation in each basin to be evaluated and palaeoclimatic curves to be reconstructed. Tephrostratigraphy, when possible associated with absolute dating, allowed the chronostratigraphical position to be better defined and correlated with the $\delta^{18}O$ isotopic marine record.

In the Camerota basin, the 50 metre thick succession was drilled in two different sites in order to obtain the entire record. The diffuse barrennes did not allow the reconstruction of continuous pollen curves and thus the count of the climatic cycles recorded in lacustrine sediments. The pollen floral composition, rich of subtropical elements, as well as the occurrence of vegetation changes, from interglacial to transitional types, lead to ascribe the Camerota lacustrine succession to the period characterized by the 40kyrs cyclicity. Moreover, a position close to P-P boundary can be proposed on the basis of the presence of Santernian marine sediments covering the paleo-lake sediments.

For the 200 metre thick succession drilled in the Vallo di Diano basin, pollen analysis pointed out the alternation of steppic and forested phases suggesting the occurrence of three glacial-interglacial cycles. Tephrostratigraphy, isotope stratigraphy and an Ar/Ar dating allowed the correlation of the lacustrine deposits with the isotopic stages 16 to 11.

In the Acerno basin, pollen analysis of the 100 metres cored succession revealed the occurrence of one climatic cycle through the alternation of steppe and forested phases. Tephrostratigraphy allowed the chronological position to be better defined through the identification of the WTT marker level (which is dated 300 ka) and the climatic cycle to be correlated with the isotopic stages 9 and 8.

In conclusion, the Vallo di Diano and Acerno deposits represent important records of the Middle Pleistocene climatic history of the Mediterranean area. Our future attention will be focused on the last climatic cycle, by means of analysis of younger lacustrine sequences of southern Apennines.

EVIDENCES OF PRECESSION AND OBLIQUITY ORBITAL FORCING IN ^{18}O ISOTOPE COMPOSITION OF MONTALBANO JONICO SECTION (BASILICATA)

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Quantitative signal processing methods have been applied to a geologic record. The data analyzed are a profile of oxygen-18 isotopes extending from the upper part of Lower Pleistocene to the lower part of Middle Pleistocene for a land-based stratigraphic section. It is a well exposed , continuous succession of muds and muddy silts, about 400 metres thick, located in the southernmost part of Bradano Trough, near Montalbano Jonico in Basilicata (South Italy) (Ciaranfi *et al*., 1997). The sampled part of the section is about 240 metres thick, in which a foram benthic species is continously available (*Cassidulina Carinata*) for oxygen isotope ratio measuraments. The aim of our data treatment is to discover how much of the Earth's orbital periodic movements, precession and obliquity, which represent the dominant periodicities in paleoclimatic variations during Pleistocene until 0.735 Myr B.P., is responsible for the oscillations observed in the oxygen-18 record of the Montalbano Jonico section.

A time framework of the section was already constructed on the basis of calcareous nannofossil biostratigraphic analyses, preliminary magnetostratigraphic results and oxygen isotope correlation with the record from DSDP s607 (isotope data collected in the NOAA World Data Center, most of which was published originally in Ruddiman *et. al*., 1989). The resulting time-scale extends from 1.15 Myr to 0.74 Myr, and on that has been performed quantitative data treatments. Power spectum analysis is performed on the isotope data to illuminate the most important periodicity components of the Montalbano Jonico record. The periodic components of 41,000 and 21,000 years are present in this record; the former associated with periodic changes in the tilt of Earth's axis and the latter with periodic changes with the precession of the equinoxes, as predicted by the astronomical theory of the ice ages (Imbrie & Imbrie 1978). They are, however, not the most important components of the power spectrum, in which a lower frequency component contains most of the variance. This low-frequency component is centered at a period around 208,000 years. To all appearances, this periodicity cannot be attributed to any known astronomical or paleoclimatic phenomenon. We have made an attempt to verify if this periodicity was due to the composite effect of precession and obliquity signals together at different frequencies from their forcing frequencies. In order to investigate this effect, a function of isotope data D(t) has been parametrized in terms of a sum of simple functions of precession and obliquity signals [Sp(t),So(t)], of unknown coefficents α,β, and I(t) representative of noise. These coefficients are estimated from the time series with the assumption that the best coefficients are those which minimize the difference between the data function and the precession and obliquity functions:

$$[D(t)-\alpha Sp(t)-\beta So(t)=I(t)] \qquad (1).$$

Cross-spectra analyses are also performed on the data and the precession signal and on the data and the obliquity signal. The power spectrum of the "I" function, calculated from (1), and the cross-spectra have demonstrated that precession and obliquity signals are not in phase at their forcing frequencies and damp each other. Then we shifted the precession and obliquity signals towards lower frequency of equally spaced lags, plotting the resultant "I" power spectra for every combinations of lags of precession and obliquity. The results of this data processing demonstrated that it is possible to have a combination of precession and obliquity cyclicity that could be responsible for the signal with 208 kyr periodicity.

PERMAFROST AND GLOBAL CHANGE
AN INTRODUCTION TO PACE PROJECT

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The significance of permafrost as indicator of global climate change has been highlighted (Lachenbruch et al., 1988; Osterkamp and Gosink, 1991; Haeberli, 1993; Guglielmin et al., 1994). The permafrost can be used as climatic changes indicator in different ways and at different timing scales:

a) analysis and monitoring of active layer thickness variations (seasonal-annual);
b) analysis of thermal profile of the upper part of permafrost (decades-centuries);
c) monitoring of permafrost thickness and analysis of thermal profile of the deeper part of permafrost (millennia).

Also the features linked with permafrost distribution as rock glaciers, ice-wedges, stone lobes etc. can be used as climate indicator (Kerschner, 1983; Guglielmin et al., 1994). In permafrost environment can be preserved also ground ice and buried ice which can be useful to reconstruct climate evolution in the past (Sudgen et al., 1995). The climate signal recorded by permafrost is the response of the ground at different energy balance and depends mainly from snow cover, solar radiation, air temperature and type of vegetation cover (Williams and Smith, 1989). These kind of signal focus on the role of snow cover and solar radiation changes in the alpine environment and of air temperature and vegetation cover in the polar environment.

The aging of permafrost features is possible with 14C of paleosoils buried by features and with indirect methods, as lower altitude of active and inactive rock glacier (Kerschner, 1983). On the contrary, the datation of the same landforms through their kind vegetation cover (Evin, 199) appears by recently studies (Cannone, 1998) not possible, even if sometimes vegetation patterns can be useful to reconstruct the spatial relationships between glacial and periglacial systems.

The Project PACE (Permafrost And Climate in Europe), leaded by Prof. Charles Harris of Cardiff University and founded by U.E. with ENV4-CT97-0492 contract, is the first project that purposes to detect changes in permafrost ground temperatures and to model the relationships between climate and permafrost.

This project included 7 countries that will make a network of study sites along a latitudinal transect N-S from Svalbard Island (Norway) to Sierra Nevada (Spain) through the Alps. Among the main goals of this project it is important to point out the providing of new process-based methods for assessing environmental and geotechnical hazards associated with mountain permafrost degradation, the analysis of the response of vegetation ecosystems to climate changes, the monitoring of permafrost changes using biotic indicators and the influence of these variations of cover on permafrost evolution.

LATE QUATERNARY CENTRAL MEDITERRANEAN BIOSTRATIGRAPHY

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The Quaternary climatic record is characterized by significant fluctuations from glacial to interglacial conditions that affected the global marine plankton distribution. Because of this, the statistical analysis of foraminiferal assemblages can provide a reliable and detailed record for paleoclimatic reconstruction.

The foraminiferal content identified in several cores from the central Mediterranean Sea allowed to establish a detailed biochronological subdivision (millenary scale) of the Late Quaternary time. The quantitative and qualitative analysis of planktic distribution from the Last Glacial Maximum to the Present evidences a succession of microfaunal assemblages (ecozones) related to the paleoceanographic changes. Each ecozone is characterized by several bioevents that are defined by frequency peaks and/or local (re-)occurrences or (temporary) disappearances of some taxa .

We identified ten ecozones for the last 23 Ka in the Tyrrhenian Sea and eight ecozones in the Adriatic Sea for the last 15 Ka. The ecozones boundaries have been calibrated by ^{14}C AMS radiometric dates and by the stable oxygen isotope record. Therefore, each ecozone corresponds to a well-defined time interval.

The distributional pattern of the most significant taxa shows the same trends in both basins and suggests that the major changes in planktic foraminifera assemblages occurred rather synchronously in the Tyrrhenian and in the Adriatic Sea.

LATE PLEISTOCENE AND HOLOCENE CLIMATIC CHANGES IN CENTRAL SAHARA

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Systematic surveys and archaeological excavations recently carried out, shed new light on the climatic changes occurred during Late Pleistocene and Holocene in the western Fezzan (Libya, Central Sahara).

The area studied is approximately circumscribed by the co-ordinates Lat. 24° 30' and 26° - Long. E 10° and 12° and includes the central Tadrart Acacus massif, the Messak Settafet plateau and two sand seas (Erg Uan Kasa, Edeyen of Murzuq). The present day climate of the region is hyperarid: annual rainfall ranges from 0 to 10 mm, the mean annual temperature is 30°C, with a mean annual relative humidity of 32%; nevertheless sporadic rainstorms are recorded in the winter season.

In this area, evidence of wetter phases occurred since Late Pleistocene, was found in a wide range of sources: alluvial deposits, fill of caves and shelters, travertine, paleosols in the mountain ranges; lacustrine and marsh deposits, archaeological sites, paleosols in the ergs. Dating and correlation of such evidences allow a palaeoclimatic reconstruction which shows a slow progressive change, from a very wet period at the boundary between Late Pleistocene and Holocene, toward progressively drier conditions.

Travertine sedimentation in the mountain ranges dates from 14.000 to 9.000 BP (calendar age), as a consequence of a sharp increase of precipitation at the end of the Late Pleistocene and at the very beginning of the Holocene. No date younger of 9.000 BP (calendar age) exist for the travertine, indicating decreasing wetness in the mountain range. During this phase, enhanced fluvial activity, rubification and clay translocation in soils were also recorded.

n the erg areas the rise of the water table and the consequent formation of lakes is almost synchronous: lakes and ponds covered a very large surface from 9.600 BP (calibrated) up to about 6.300 BP (calibrated), with a first cycle of high stand dated up to the 10th millennium BP. It is contemporaneous to the older phase of deposition of the anthropogenic fill in the caves of the Tadrart Acacus, which also is indicative of wet conditions.

Both, lake and shelter fills, display a sedimentary gap, related to dry environment at about the half of the 9th millennium BP. It may be interpreted as the local effect of the «Middle Holocene» dry period, showing some overlap with the dry event recorded by windblown chemical indicators and decrease in methane in Greenland ice-core proxy.

The 8th millennium BP is one more period of high stand of the lakes and of wet climate in the mountains, as indicated by the humified deposits inside caves and shelters and further supported by wet savannah pollen record. However, the main crisis leading to the onset of dry conditions happened around the 5.800 BP (calibrated): lakes and swamps turned into sebkhas, shelter roofs often collapsed and many shelters were emptied by wind erosion.

The results justify a scenario of wet savannah landscape in the mountain and a continuous belt of pond and lakes in the ergs, connecting the Sahelian area to the Northern fringe of Sahara, further supporting the idea of dissolution of the desert during the Holocene «Interglacial».

SAPROPELS AND PALEOCEANOGRAPHY (SAP)

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Mediterranean Sea is an semienclosed marginal sea; it has a negative hydrological budget and it is an unstable biogeochemical palaeo-environment. The geographical position of the Mediterranean Sea is unique: at present it is surrounded by arid regions to the south and east and by more humid regions in the north. The individual basins (Alboran Sea, Balearic Basin, Tyrrhenian Sea, Eastern Mediterranean, Aegean Sea) have a different evolution during the major climatic change: i.e. the transition from a glacial stage to a interglacial stage. During this time the Eastern Mediterranean remained a marine environment where regional and global variation in climatic signals were recorded in the sediments. The deep sea pelagic record in the Eastern Mediterranean in notable for the existence of numerous layers of dark coloured pelagic sediments rich in organic carbon, known as sapropels. Bottom water anoxia due to stagnation, and/or enhanced productivity have been put forward as possible explanations. All models are related to global climatic variations that have occurred such as those referred to as "astronomical forcing" models. These climatic variation may have resulted in distinct changes in the physical water mass circulation, and/or chemical fluxes to the water column.

The overall aim of SAP is to better understand the (paleo)functioning of the Eastern Mediterranean and to determine the role in the global environment by studying the characteristic biogeochemical processes. Mediterranean sediments are ideal for high resolution studies, because of the excellent control on stratigraphic time (due to ash layers and sapropels, most of which have been extensively dated). This, in combination with palaeomagnetic, isotopic, micropalaeontological, and geochemical markers, tuned with astronomical parameters, gives an unprecedented precision for chronostratigraphy over the last few million years. Such high precision allowes the accurate comparison, in high detail, of identical time intervals in the sedimentary record of different cores.

CLIMATE CHANGE IMPACT ON FREQUENCY AND DISTRIBUTION OF NATURAL EXTREME EVENTS: AN OVERVIEW

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The link between climate change and occurrence of extreme events represents a very debated topic especially since the 'greenhouse effect' detection and in general the anthropogenic activity are to be investigated in order to understand whether human influence on climate can be considered a cause or simply a factor of climate variability. The response is still likely far to be provided by scientists since climate future trend is a very difficult topic to be assessed due to the complexity of the Earth's system and the great number of variables which may influence the atmospheric circulation system. In addition, the methods in the assessment of maximum discharge expected for a water course or time returns of extreme meteorological events are based, as a rule, on historical instrumental records that, for most territories, date back to a time window which cannot be exhaustive of long-term trends (i.e. for precipitation and temperature almost 150-200 years of observation). The historical outline of some case studies carried out by ENEA - Geological Dynamics and Territory Section, highlights the importance of the memorialistic tradition (archives, chronicles, scientific literature) produced at the time of the events. The lack of numerical parameterisation of descriptive information and data hampers, at present the applicative use: their importance is fundamental for the correct reconstruction of the meteo-climatic scenarios that lead to the occurrence of events. Otherwise, the value and the reliability of meteo-climatic forecastings and the appraisal of their impact on the territory strictly depend on the degree of acquired knowledge of meteo-climatic changes which occurred in the past and of the natural and human reactions to climatic fluctuations. For this reason, there is a clear need to extend our knowledge as far as possible in the past, regarding both climatic features and their impact on the natural and anthropized environments, in a so-called 'historical monitoring of the territory', since the lack of understanding of climatic trends may compromise the reconstruction of numerical modelling for planning and management of the territory. In particular investigation on short-term impacts of meteo-climatic factors on landslides shows that flows (i.e. mud-flows, debris-flows) are mainly triggered by extreme precipitation occurred in the hours prior to the events; slides are often triggered by extreme rainfall due to the increasing of water table as a consequence of cumulated precipitation during previous months; falls seems to be linked to meteo-climatic factors only when triggered by frost-thawn cycles and, in some cases, for thermo-clastic mechanisms. Other parameters play a role in landslide triggering but their contribution seems to be relevant only when meteo-climatic factors do not exhibit a fondamental role (i.e. falls). Medium-term evolution of floods and droughts investigated since 1000 A.D. for some major basins of the Italian territory shows a scarce correlation with solar anomalies; Fast Fourier Transform (FFT) estimates of power spectra for floods demonstates periodicities of 10, 13, 21 years and as well weaker long-term periodicities (32, 38, 53, 68 years), while the same technique applied for droughts shows periodicities of 19, 34, 48 and 95 years; the periodicity of 19 years for both seems to be the most representative and may be correlated with the 18.6-year lunar nodal forcing whose influence has been detected in other floods and drought cycles all over the world. The same periodicity for floods and droughts and their occurrence in opposite phases seems to confirm that both are connected to the same meteo-climatic 'engine' so that droughts events are a direct consequence of precipitation affluxes rather than of temperature fluctuations. Anyway, the impact of climate change have to be investigated in the contemporary socio-economic context in order to reconstruct not only the occurrence of extreme events but also the contribution of anthropogenetic system (i.e. land-use, defforestation, artificial change on hydraulic streams) to the time/geographic events distribution: this is in order to avoid false interpretation in terms of climate impact instead of human interference on hydrological cycle. A model of relationships among different socio-economic and meteo-climatic factors has been developed for the Po Plain in the period 1450-1650 showing the complexity of the different elements and then the need of an integrated historical, socio-economic, geological and climatological approach.

NON-STATIONARITY OF HYDROCLIMATIC DATA: THE CASE STUDY OF THE TIBER RIVER BASIN

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The paper reports the first conclusion related to the hydroclimatic scenario of the Tiber river basin where historical researches on climatic and meteorological features of the last 1000 years have been carried out in the context of the CEC Project "Meteorological Factors Influencing Slope Stability and Slope Movement Types: evaluation of hazard prone areas" (MeFISSt).

The analysis on meteo-climatic data has been mainly undertaken for geomorphological purposes, as a general attempt to correlate a temporal occurrence of landslide with well detected climatic periods or fluctuations. Anyway, other important observations may be done. In fact, studies carried out at basin-scale can assume a great significance to understand the behaviour of climatic parameters, especially when local information is not sufficient due to partial or total lack of data; the present research has permitted to better understand the geomorphological evolution of single test areas in the upper part of the Tiber river basin through the meteorologic and hydrologic data recorded in Rome, as a situation which may be considered an 'integral' of the whole territory.

The historical records of meteorological and hydrological data in Rome highlight a well detected non-stationarity in precipitation pattern and, consequently, in the regime of the Tiber river discharge. In the early past, namely from the end of the 19th century up to 1920, the precipitation amount was higher than today (over 40%), responding to a near one-hundred fluctuation wave detected in many other historical records of the world. After a wet period, the curve fall down abruptly, determining a drier situation. This long time trend should be taken into account since in Italy as a matter of fact a systematic record of meteorological and hydrological data for the whole territory starts in 1921. Very often the calculation of the return time of floods or heavy precipitation, by hydrologist and water engineers, is performed on the general assumption of stationarity of climate often in temporal windows not completely exhaustive of the long-term fluctuation wave, or, worst, based on observations of a completely arid period like the 1921-1951 one, like in some Global Circulation Models.

The study of discharge in the Tiber river basin has been an useful tool to determine the detection of arid and humid periods and to understand the role of anthropisation in the last decades. The regimation of discharge, carried out for industrial, agricultural and civil use, has determined a regimation of floods in the city of Rome in the last decades. Anyway, before the industrialisation, all the floods in Rome and in the basin of the Tiber, occurred in a strict correspondance of humid periods. This consideration induces to a deep reflection in the light of possible wetter future trends which can rule heavy consequences even into basins where the role of the anthropisation seems to be marginal (i.e. the flooding in Versilia in 1996).

MINERAL DUST ANALYSIS OF THE FIRST COLLE DEL LYS ICE CORE

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In June of 1996 a 80 m ice core was drilled at Colle del Lys on Monte Rosa (4250 m a.s.l.). Colle del Lys is important because it is one of the few cold ice sites in the Alps where ice cores can be taken that are suitable for paleoclimatic research. Analysis of tritium, alpha and beta radioactivity and visual stratigraphy, together with a simple linear flow model, have provided a provisional age-depth relationship. This shows a mean annual accumulation rate of approximately 1.5 m w.e. The analysis of mineral dust combined with meteorological observations, which are presented here, provides both a high resolution record of mineral dust concentration and a detailed picture of the annual stratigraphy.

About 550 samples were cut in a cold room and analysed for their insoluble dust content in a clean room class 10000 by means of a COULTER COUNTER©, using both 100 μm and a 50 μm orifice tubes. Measurements of grain size, volume and concentration of particles have been obtained.

The meteorological situation of the site is quite particular. In the spring and summer, air masses principally come from the heavily polluted adjacent Po Plain of northern Italy. This contrasts with the relatively clean air masses of the winter months that are westerlies of the free troposphere. This situation is interrupted by sporadic, non-periodic arrivals of warm air masses from remote areas of North Africa, transporting huge quantities of terrigenous dust to the Alps.

From the comparison of the mineral dust concentration and results of the analysis of the meteorological data the principal dust transport events recorded and preserved in the ice core have been identified. By removing the identifiable North African transport events from the mineral dust record, the seasonal variability of the background conditions at the drilling site has been investigated, characterised by high accumulation in spring and autumn. This record is of a high resolution because of the relatively large snow accumulation rate at the site, although the influence of wind erosion, especially in the winter season, has to be taken into account.

Although Colle del Lys is a cold glacier, very occasionally in summer months high temperatures can produce melting at the surface. Down to the point of transition of firn to glacier ice, at a depth of about 40 m, a dozen clearly visible ice lenses have been identified. These have probably been generated during the episodes of strong positive thermal anomalies. In addition, warm summer seasons are also characterised by the presence of numerous thin recrystallization lenses in distinct layers, whilst wind crusts are sometimes visible in early spring.

SURFACE REDUCTION AND EQUILIBRIUM LINE ALTITUDE RISE FROM THE LITTLE ICE AGE TO THE PRESENT IN THE ITALIAN ALPS

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The Alpine glaciers are good indicators of climatic and environmental changes. In fact every variation in climatic conditions affects the Equilibrium Line Altitude (ELA) and the mass balance, causing a dynamic response and a readjustment of the glacier size. The Little Ice Age (LIA) was a period of glacial advance that, in the Italian Alps, peacked between the early 17th and middle 19th century. The majority of the Italian glaciers reached the LIA maximum extent during the first half of the past century.

Present glaciers on the Italian Alps area more than 1000 and they cover a total area of about 607 km^2. They are mainly concentrated in the Western and Central Alps. Data regarding the area reduction and ELA rise, from the LIA maximum to the present are summarised in this research for glaciers located in Valtellina (Central Alps) and in Valle d'Aosta (Western Alps). In Valtellina the studied glaciers are situated in the Bernina-Disgrazia Group (43) and in the Ortles-Cevedale Group (39). In Valle d'Aosta 143 glaciers were studied, located in the Gran Paradiso, Gran Sassiere, Rutor, Monte Bianco, Dent d'Herens, Cervino and Rosa mountain groups.

The ELA rise from the LIA maximum advance to present is 102 m in the Ortles-Cevedale Group, 100 m in the Bernina-Disgrazia Group and 139 in Valle d'Aosta.

In the Ortles-Cevedale Group the glacierized area was 65 km^2 in the LIA and decreased to 34 km^2 at present, with an ice surface reduction of 48%. The glaciers located in the Bernina-Disgrazia Group shrank from 61 km^2 in the LIA to 36 km^2 at present, with an area reduction of 42%. The total area of the glaciers studied in Valle d'Aosta was 271 in the LIA and now is 158 km^2, with a surface reduction of 42%. The average surface reduction for all the glaciers studied is 42.6%.

For a few glaciers in valle d'Aosta and in the Bernina Group it has been possible to reconstruct the surface reduction in different time intervals, showing an increased retreat in 1930-1960 and in the last decade.

The studied glaciers confirm the general trend observed in all temperate glaciers and particularly the sensitivity of Alpine glaciers to the atmospheric warming that, according to the ELA rise, can be evaluated in 0,5/0,7°C from the mid 19th century to present.

HOLOCENE ALPINE CLIMATE FLUCTUATIONS RECONSTRUCTED FROM A STALAGMITE

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Holocene climate changes have been reconstructed through stable isotope, trace element and calcite texture time-series extracted from the axial slab of one stalagmite removed from Grotta di Ernesto (Valsugana valley, Trento province, 1167 m a.s.l.), where water temperature is stable throughout the year at 6.5 ± 0.1°C. High precision dating was obtained by using thermal ionisation mass spectrometry (U-series) and annual lamina counting. The stalagmite commenced to develop 8,581 ± 120 years B.P., and has grown almost uninterruptedly up to the year of removal. By counting annual laminae, several minor hiati have been recognized in the interval between 3,000 and ~1,000 years B.P.. These hiati have been interpreted as indicative of relativel cool and dry conditions.

The Mg/Ca ratio of the calcite yields information about water availability changes. A rise in Mg/Ca in calcite commonly indicates dry conditions. On the contrary, lower Mg/Ca ratio in calcite is indicative of humid periods. The Mg/Ca ratio fluctuations identify three periods: humid before ~5,400 years B.P., dry between ~5,400 and ~1,000 years B.P, and humid between ~1,000 years and present-day.

By combining the effects of the temperature dependence of $\delta^{18}O$ in rainfall and the temperature-dependence between $\delta^{18}O$ calcite and $\delta^{18}O$ water, we should expect a $\delta^{18}O$ shift of about +0.36 ‰ per °C temperature increase. This relationship holds true for humid periods, as in dry periods the $\delta^{18}O$ of cave water can be modified by evaporation processes in the soil. During the humid 8,500 to 5,400 years B.P. period, positive shifts of $\delta^{18}O$ values are recorded at 8,450 B.P., between 8,000 and 8,150 B.P., and between 7,850 and 7,950 B.P.. Between 7,750 and 7,100 years B.P., the $\delta^{18}O$ curve is characterized by more depleted values, indicative of cooling. The $\delta^{18}O$ curve shifts to more positive values between 6,500 and 5,800 years B.P., a second mid-Holocene warm phase. By using the present-day $\delta^{18}O$ calcite-temperature relationship, we infer that the Middle Holocene hypsithermal was characterised by mean T° only slightly higher than the Present (0.5 to 1°C). During the cooler, 7750 to 7100 years B.P. phase, mean T°C was probably 1.5° to 2°C lower than today.

The $\delta^{13}C$ of speleothems depends on the $\delta^{13}C$ of the dripwater which is related to both the $\delta^{13}C$ signal of the atmospheric carbon and on the $\delta^{13}C$ signal of soil CO_2, which is controlled by the vegetation cover. Between 8,500 and 7,750 years B.P., the $\delta^{13}C$ signal reaches values of about -8 ‰, indicative of the colonisation of the soil above the cave by broadleaf vegetation, followed by a shift towards more positive values which correlates with the dry 7,900 years B.P. episode. The period between 7,750 and 5,400 years B.P. is characterised by mean values of speleothem calcite $\delta^{13}C$ of about -8‰. This value is similar to the present-day value. We infer that most of the soil CO_2 derived from the degradation of beech-derived organic matter, in analogy to present-day.

LATE PLEISTOCENE AND HOLOCENE LAKE LEVEL VARIATIONS IN FUCINO LAKE (ABRUZZO - CENTRAL ITALY) INFERRED FROM GEOLOGICAL, ARCHAEOLOGICAL AND HISTORICAL DATA

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Fucino Lake was completely drained in the second half of the 1800's. Fluctuations in the level of Fucino Lake have been studied using geological data, archaeological and historical data. Examination of sediments exposed in trench walls extending many kilometers, and excavations and surveys done along the banks of drainage canals, have resulted in the collection of a large quantity of stratigraphic and chronological information. A detailed chronological framework is provided by ^{14}C, thermoluminescence and archaeological dating methods. The most recent lake level fluctuations have been deduced from historical sources. Fucino Lake is a very complex environment. It has therefore been necessary to consider the problems connected to the feeding, to the general characteristics of the hydrologic basin, to tectonics, to the evaluation of the karst drainage entity and to the ancient artifical drainage works. Except for the drainage works, non-climatic factors can be excluded as having a determinant influence on the fluctuations of Fucino Lake. The study of the variations in level of the lake appear, therefore, reliable and of extreme utility for palaeoclimatic purposes.

The strong phases of increasing lake level between 27,000 and ca. 21,000 B.P. is synchronous with the expansion of mountain glaciers in Central Italy. The increasing lake level between ca. 16,000 and 15,000 B.P. is synchronous with a minor expansion of mountain glaciers in Central Italy. A drop in lake level started before 14,170±260 B.P.; at the same time in Central Italy the environment was cold: above 1800 m on the surroundings mountains, were developing various rock glaciers, showing the presence of discontinuous permafrost.

The minimum Upper Pleistocene level was reached around 10,990±120 years ago. The environment was cold and very dry: on the slopes and on the mountains surrounding Lake Fucino the sedimentation of stratified slope deposits began, ephemeral lakes dried, an aeolian phase was developing, and new rock glaciers above 1950 m were forming. The drop in lake level occurred, therefore, in a period contemporary with the Younger Dryas: during no other period younger than 14,000 years B.P. was the temperature so low in Central Italy. Between ca. 7000 and 6000, ca.2800 and 2400, ca.1400 and 1100 years ago, when the lake level was high in some caves, on the border of the Fucino Plain, speleothems were formed. The curve of the fluctuations of the Fucino Lake in the period 1783-1862 appears to be well correlated with the curve of the variations of the major Alpine glaciers: the phases of increasing lake level are practically synchronous with glacial advance. In the same way, a noteworthy period of growth of the lake, which reached its peak around 1600 A.D., coincides with the strong advance of the Alpine glaciers.

The strong rise in level which took place in the period 1783-1787, could have been linked also to the presence of volcanic aerosols in the atmosphere. A remarkable eruption of the Laki Volcano in Iceland took place in 1783 and even in Italy were registered atmospheric phenomena similar to dry fog; moreover in 1783 there was the eruption of the Asama Volcano in Japan and in 1785 the Vesuvio Volcano (Campania, Italy) was active for many months. The extremely high lake level reached in 1816 might also have been caused by the climatic impact produced by the eruption of the Mayon (1814 - Philippines) and Tambora (1815 - Indonesia) Volcanoes. Fucino Lake level fluctuations need to be considered a palaeoclimatic indicator not directly correlated to a single parameter or a single cause: the causes that induced variations in the hydrologic balance of the lake must therefore be analyzed taking into consideration other palaeoclimatic data.

LATE PLEISTOCENE GLACIAL EVENTS IN THE CENTRAL APENNINES, ITALY

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Investigation of the glacial phases has been carried out on the Gran Sasso Massif. This massif, consisting mainly of carbonate rocks, is situated at 42° 30'N in the central portion of the Italian peninsula. The Corno Grande, the highest peak of the massif (2912 m), is the highest point in the Apennines. Calderone Glacier (2700 - 2840 m), the only glacier today in peninsular Italy and the southernmost in Europe, is located on the Corno Grande and covers just a few hectares. It survives because of the morphology of its cirque, which has very steep walls, and a NE exposure, even though it lies below the regional snowline. Campo Imperatore is a closed tectonic-karst basin situated south of the Corno Grande and Mount Aquila, between 1850 and 1450 m altitude, and is ca. 18 km long and 1 to 4 km wide. The main glacier during the last maximum advance at Campo Imperatore was the largest in the Central-Southern Apennines. Due to the geographical position of the Gran Sasso Massif, the study of the glacial phases recorded there provides a paleoclimatic record that may be representative of the whole of the Apennines, and also the central Mediterranean region. The study of glacial evidence at Campo Imperatore has resulted in information on the last maximum advance, its retreat phases and its stadial readvances. A fairly complete chronological framework has been obtained by correlating the glacial phases with the climatic evolution of the surrounding areas. The glaciers reached their maximum advance probably ca. 22,680 ± 630 yr B.P. (Campo Imperatore Stade), and then started to retreat ca. 21,000 yr B.P. leaving behind three recessional moraines. After a first interstade (Fornaca Interstade), which started after 17,840 ± 200 yr B.P. and ended ca. 16,000 yr B.P., the Fontari Stade occurred, starting shortly after 16,000 yr B.P. Ca. 15,000 years ago the glacier started retreating, leaving behind four more recessional moraines. Another interstade (Venacquaro Interstade), starting shortly after 12,850±200 B.P., preceded the Mount Aquila Stade, which can be dated ca. 11,000 yr B.P. At the beginning of the Holocene, with the exception of the Calderone Glacier, the glaciers must have disappeared. The presence of rock glaciers concurrent with glacial oscillations has made it possible to compare temperatures from those periods with present ones. Furthermore, snowfall at earlier times can be calculated from paleotemperatures and ELA changes. The data show that during the Campo Imperatore Stade the mean annual temperatures were 7.3 to 8.3 °C lower than at present, and snowfall was similar to present rates. Under fully glacial conditions, in the Mediterranean area, the lower temperature reached values between those recorded in Greenland (10-13 °C) and in the tropics (5-6 °C). The correlation between the glacial phases at Campo Imperatore and the isotopic variations in the Tyrrhenian Sea cores has been made possible by two tephra, showing an excellent coincidence between glacial phases and $\delta^{18}O$ peaks. Reconstruction of the climatic variations that occurred between 30,000 and 10,000 yr B.P. (^{14}C) has shown clearcut climatic signals corresponding to the Younger Dryas, indicating cooling and drying of the climate. A relation between climatic oscillations at ca. 14,000 and 21,000 yr B.P. and Heinrich Events H1 and H2 is suggested; according to Watts *et al.* (1996), Heinrich Events H1 - H6 are recorded in a pollen sequence based on a lacustrine core taken from the Lago Grande di Monticchio, in southern Italy. Our data, at least for the Campo Imperatore Stade, confirm the hypothesis of a climate characterized by wet winters and dry summers. For example, lower temperatures imply an extension of the snowfall period; hence snowfall, as determined here, represented an appreciably higher percentage of the annual precipitation than is the case today. During the course of the Campo Imperatore Stade the amount of snowfall was comparable with that of today, whereas the mean annual precipitation could have been appreciably lower.

THE LATE PLEISTOCENE OSCILLATIONS IN THE BIOLOGICAL RECORDS FROM THE SEDIMENTS OF LAGO DI ALBANO (CENTRAL ITALY).

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We report the results of a comparative analysis of algal and photosynthetic bacteria pigments, diatoms and invertebrate fossil remains (ostracods, cladocerans, chironomids) in two late Pleistocene cores from Lago di Albano, a crater lake in Central Italy (Guilizzoni & Oldfield, 1996). Core PALB 94-1E, hereafter 1E (13.875 m long, taken at a depth of 70 m) covers the last *ca* 28 kyr years, but we refer to the record from the basal 3.5 m of it (24-28 kyr). PALB 94-6B, hereafter 6B, (8.40 m long taken at 30 m depth) spans from *ca* 17 to 24 kyr BP.
Within the above time window considered, different lithological types were distinguished: massive silts, dominated by moss remains, alternate distinctly with laminated silts and carbonates (Chondrogianni *et al*., 1996). The laminated sediment sections imply deposition in a relatively deep, stratified lake with stagnant bottom water, whereas the bioturbated silts and moss layers indicate shallower water levels. These distinct lithological changes are also reflected in the geochemical indicators
Several AMS ^{14}C determinations, tephra and palaeomagnetic chronologies, varve counting and pollen-based correlations were used to construct depth/age curves. The depth profiles obtained for the different biological fossils, made it possible the reconstruction of the environmental changes that occurred in the lake. Water level fluctuations, as well as pulses of increased lake productivity, were detected during the Full Glacial. In core 1E oscillating littoral-sublittoral conditions prevailed in the time interval between 28 to 24kyr BP.
A considerable rise in the water level at *ca* 24 kyr BP allowed the beginning of deposition of lacustrine sediments at Site 6, which in modern Lago di Albano is 40 m shallower than Site 1. Thus, all the oscillations recorded in the sediments from Site 6 occur in an enlarged lake compared to that within which the oscillations at the base of core 1E occur.
The analysis of core 6B and 1E, entirely deposited during the Full Glacial, allows the reconstruction of eight main cycles of productivity and water level oscillations during a *ca* 11 kyr, which resemble those found in marine and ice cores form the North Atlantic and Greenland. Within these major cycles, the two cores reveal the existence of other cyclical water level and productivity oscillations spanning short duration, especially in the laminated intervals.

PRELIMINARY RESULTS FROM A HIGH ALTITUDE ICE CORING CAMPAIGN IN THE ITALIAN ALPS

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In contrast to the global palaeoclimate record from ice cores at polar sites, mid-lattitude locations offer a record of regional palaeoclimatic conditions, although with a relatively much shorter time scale. To obtain meaningful information, drilling site locations need cold ice, on average considerably below freezing, with little or no melting season. In the Alps, one of the limited number of sites that meet these requirement is Monte Rosa, with a location that potentially provides a record of anthropogenic effects from the recent industrial past.

A new ice core has been drilled at the high altitude site of Colle del Lys (4238 m a.s.l.), on the Italian side of Monte Rosa. The ice core was the first exploratory drilling in a field campaign to be undertaken over the next few years. The high accumulation rate at the site provides a high resolution record of climate covering recent time. The work forms part of a new EEC funded project on the environmental and climate records from high elevation Alpine glaciers (ALPCLIM). Some of the initial results from the analysis of the first ice core are presented here.

This includes measurements of density, tritium, alpha and beta radioactivity, electrical conductivity and mineral dust, as well as with observations on visual stratigraphy. Major events recorded in the core, together with a linear flow model have been used to establish an initial age-depth relationship for the core.

Although the time record is certainly not as extensive as that for the polar ice cores, the Colle del Lys site provides a valuable high resolution record of regional and recent anthropogenic influences on climate change, with particular emphasis on regional source apportionment of the last 50 years. This is of particular importance in the Alps, with a high incidence of anthropogenic pollution.

UPSLOPE TURBIDITES FROM THE AFRICAN CONTINENTAL MARGIN

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Upper turbidites have been reported from different areas of the outer flank of the Mediterranean Ridge (Eastern Mediterranean). Detailed sedimentological studies have been carried out on deposits from cores collected in two transects acrosses the deformation front of the Mediterranean Ridge accretionary complex: one across the southwestern flank in the Sirte Abyssal Plain and the other on the southeastern flank in the Herodotus Abyssal Plain. The turbidites have originated from the north African margin, as it is suggested by the sand fraction composition, and have been correlated up to 800 m above the adjacent abyssal plains, implying the up slope flow of the turbidity currents on the flank of the Ridge. The deposits from the two areas up to seven meters thick, have been compared in their textural and structural characters. The common feature of all this deposits is down core oscillations of the sand distribution that correlates inversely with the silt fractions. Two differents depositional models are proposed to explain these oscillations: 1) quasi-contemporaneous differential failure at the source area that produced a sequence of turbidity currents that generate a Mega-event; 2) splitting of the main flow into minor sub-flows scattered by topographic obstacles.

THE EUROPEAN POLLEN MONITORING PROGRAMME (EPMP): A HELP FOR THE INTERPRETATION OF PAST VEGETATION AND CLIMATE

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Pollen analysis is often the main technique for the reconstruction of past vegetation communities. Obviously, the more detailed and accurated a reconstruction is, the more detailed and accurated will be the deduction of other environmental variables such as climate, edaphic conditions and the extent of anthropogenic disturbance. In order to refine the interpretation of pollen data, in the attempt of determining not only the broad regional trends in vegetational development, the examination of the vegetational changes at a more local level is required.

As pollen production and pollen dispersal vary so widely from species to species, is often very important to know whether a species, whose pollen was preserved inside a sediment, was growing in the immediate vicinity of the sampling site or only at a distance of some kilometers. As the pollen influx of a species to a sediment is very closely related to the distance of that species from the site, this method gives us a more objective basis for the interpretation of these data rather than percentage values (Davis 1976, Davis et al. 1980). All these data will let the interpretation of pollen diagrams to be much more precise, consequently also the palaeovegetational reconstructions will mirror this precision that will affect the paleoclimatic reconstructions.

For this purpose, the EPMP (European Pollen Monitoring Programme) is trying to build up a body of data about the influx values of the major tree species and the ecologically significant shrub and herb species of Europe using pollen traps (organized into transects) to monitor pollen deposition across vegetation transitions from closed forest to open situations. This is required, since another aim of the EPMP is to acquire more data for the investigation of those periods or situations where there is a change from unforested to forested conditions (or *vice versa*) as the forest limit, both altitudinally and latitudinally.

The EPMP is a Working Group of the Holocene Commission of INQUA (International Quaternary Association): it was launched, for the first time, at a meeting held in Kuusamo and Hailuoto (Finland) in July 1996. The second meeting of the EPMP took place in Tallinn (Estonia) in May 1998. This Programme involves representatives from 17 countries, building up a transect across the whole Europe from the Mediterranean (Greece, Italy, France, Portugal) to the North European countries.

In Italy, the two places where the pollen traps have been placed are the Pian di Gembro peat-bog (near the Aprica pass, North Italy) and the area just before the Forni Glacier. For the first place we have already collected the first year of data while for the second place the first set of data will be available next October.

ABRUPT LAKE-LEVEL FLUCTUATIONS OF LAKE GENEVA IN RESPONSE TO A SHORT CLIMATIC CHANGE DURING THE SUBBOREAL

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Sedimentological investigations on the western shore and lake-bottom of the Geneva Bay have revealed the presence of unconsolidated surface sediments mainly consisting of homogeneous ooidal sands. Their nature suggests deposition on a shoreface during a wave-dominated transgression phase reaching about 375 m a.s.l.. Sedimentological evidence indicates that the lake-level rise was strictly related to a climate modification characterized by persistent strong storm winds. Moreover, deposits interpreted as mud flows suggest that high magnitude rainfalls must have occurred frequently. Chronological data from both ooidal sands and archaeological remains indicate a Late-Bronze Age for these event, about 2,800 ^{14}C yr. BP. Such unfavourable natural conditions finally forced the prehistorical lake-dwellers to move landwards to higher ground.

PALAEOENVIRONMENTAL SIGNATURES FROM THE MINERALOGY AND GEOCHEMSTRY OF THE GLACIAL AND POST-GLACIAL SEDIMENTS OF LAKE GENEVA (SWITZERLAND)

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Investigations on mineralogy and geochemistry of the Geneva Bay lacustrine sediments provide evidence of significant change in sediment composition from the last advance of the Rhone glacier until the lacustrine establishment.

Glacigenic deposit are dominated by detrital minerals mainly derived from the Alpine region. They consist of calcite, quartz, feldspars, phyllosilicates and subordinated heavy minerals. Overall clay mineralogy (<2µm fraction) suggests important erosive processes of the Foreland bedrock. At the base of the sequence, unit A shows significant affinities with the local Tertiary Molasse (illite, chlorite, chlorite/smectite and pyrite) and with the weathered overlying terrains (smectite). An increase in carbonates and clay minerals (i.e. kaolinite and smectite) is recorded soon after the glacier withdrawal (unit D) as the result of the exposure of molasse and carbonate terraines surrounding the lake (Jura and Calcareous Prealps) The progressive vanishing of the glacier from the lake induced a strong reduction in sediment input so that only fine particles accumulated: phyllosilicates and clay minerals content increased at that time (subunit D2). Quartz and calcite increase is moreover recorded during the early Late glacial period (Oldest Dryas) thanks to considerable aeolian supply.

A significant change in sediment composition occurs at the glaciolacustrine/lacustrine transition corresponding to the Oldest Dryas/Bølling-Allerød transition. A further strong decrease in detrital inputs, together with the amelioration of limnic conditions (water warm up, organism development), occurred at that time as a consequence of palaeoclimatic and palaeoenvironmental changes. This change is indicated by the endogenic calcite precipitation onset. This transition is however marked by minor amplitude oscillations characterized by increased allogenic supply (clay minerals) corresponding to the Younger Dryas climate reversal and to the Preboreal oscillation.

Biogenic and endogenic sedimentation was finally established since the Boreal time period, attaining the maximum during the Atlantic. Increased allochthonous organic matter supply is due to the development of vegetation in the catchment area. Low values of TOC throughout the Post glacial sequence suggest the persistence of well-oxygenated and well-mixed waters at the lake bottom.

The deterioration of the environmental conditions during the Subboreal and Subatlantic time periods, probably related to the human impact on vegetation and soils, is underlined by a slight decrease in allochthonous organic matter supply and the increase in soil erosion indicators (i.e. heavy metals).

SEDIMENTARY PROCESSES AND ENVIRONMENTS SINCE THE LAST GLACIAL CYCLE IN THE GENEVA BAY, LAKE GENEVA, (SWITZERLAND)

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The Quaternary filling preserved in the Geneva Bay provides the complete sedimentary sequence of the last glacial cycle and the subsequent lake establishment.

Stratigraphical and sedimentological investigations on six deep geotechnical cores allowed the identification of five lithostratigraphic units laying on the bedrock. The lowermost (unit A), directly overlying the bedrock, consists of fine-grained sediments accumulated in a distal part of a sublacustrine fan in a proglacial lake. Coarse mud-free gravels related to unit A, fill the deepest part of the Lake Geneva valley. They were transported in a subglacial tunnel which was active during the glacier advance. A deep and wide valley on the older deposits, several km in length downstream from Geneva, was grooved at that time. The wet based advancing glacier overrode and glaciotectonized unit A, partly mixing it with englacial debris (deformation till). The overlying unit B consists of three different types of till. The lowermost lodgement till (subunit B1) formed during local freezing-on processes at the inner Alpine catchment area about 150 km from the Geneva. Thick mud-rich lodgement till (subunit B2) originated from incorporation of lacustrine muds by the advancing glacier over the proglacial lake, whereas sand/silt-rich melt-out basal till (subunit B3) formed where older lacustrine sediments had been previously removed by sublacustrine proglacial streams. Coarse-grained outwash deposits (unit C) then occurred. They accumulated in the proglacial lake during ice retreat (18.900 ^{14}C y BP) both by subglacial and supraglacial streams and by gravity flows involving melt-out till. Soon after the detachment of the glacier ice from the lake bottom, the deposition of ice-rafted sediments began (subunit D1). Adjustments of the lake to the expanding lacustrine environment induced intense gravity processes on the lake slope. The complete glacier vanishing induced the stabilization of the lake bed and distal turbidites and glacial varves formed (subunit D2 and D3). Owing to the post glacial environmental and climatic modifications in the catchment area, sediment-laden river discharge strongly decreased and endogenic carbonate precipitation and lacustrine organism development (unit E) took place. Sedimentary processes were therefore dominated by fine particles settling out and sediment reworking induced by local erosional processes (lake-level fluctuation, wave action).

INFLUENCE OF LARGE SCALE VOLCANIC ERUPTIONS ON LACUSTRINE SEDIMENTATION: THE LAACHER SEE TEPHRA (LST) AND THE LAKE GENEVA SEDIMENTS

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Microstratigraphical analysis of Late glacial lacustrine sediments from Geneva Bay provided evidence of a tephra layer within the upper Allerød biozone. The layer consists of alkali feldspar, quartz, plagioclase, amphibole, pyroxene, opaques, titanite and glass shards. Electron microprobe analyses and morphological study of glass shards allowed correlation with the upper part of the Laacher See Tephra of the Laacher See volcano (Eifel Mountains, Germany). Sedimentological features of enclosing lacustrine sediments suggest that a momentary decrease in precipitation occurred in the catchment area and consequent reduction in detrital supply in the lake, immediately before the ash fall-out. This has been interpreted as the environmental response to a momentary cooling following the Laacher See Tephra aerosols emission. Comparison with sedimentological features characterizing the Allerød-Younger Dryas transition highlights the sensitivity of Lake Geneva system in recording both short and long-terms climate-induced environmental changes.

A LONG VARVED LACUSTRINE SUCCESSION IN THE MIDDLE-LATE PLEISTOCENE BASIN OF PIANICO-SELLERE (N-ITALY)

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The Pianico Basin in the Lombardian Pre-Alps (N-Italy) has been known since the last century as an important site documenting the Middle-Late Pleistocene environmental and climatic variations at the southern margin of the Alps.
This sequence of glacial, fluvioglacial and lacustrine deposits (Casati, 1968), has been investigated for the richness in fossils, like vegetable macroremains, pollen, woods, fishes, mammals, molluscs, diatoms and insects. Several studies were carried out on the leaf associations (e.g. Sordelli, 1896; Emmert-Straubinger, 1992) providing a rich documentation of an interglacial traditionally related to the "Riss-Wurm".

In fact, several times, glacial advances have dammed the basin and formed deep lakes filled during the subsequent climatic stages. The best known lacustrine phase is documented by a silty-clay, 50 m thick succession, including a unit of 10 m thick, continuously varved, chalk deposits. Its favourable exposure conditions and the fairly good vertical continuity provide unique conditions that allow a high resolution chronological study of these deposits. The sedimentological, palynological, mineralogical (XRD) and geochemical (stable isotope) analyses, now in progress, will provide detailed information on palaeoenvironmental history recorded at list over about 25,000 years.

A preliminary pollen analysis of the varved unit shows a continuous forest vegetation cover, including warm-cool temperate oscillations. The vegetation history and the taxa composition suggest a Late Middle to Late Pleistocene age.
High resolution chronology (varve counting), compared with the pollen record, will allow the reconstruction of the evolution of the sedimentary basin in response to local and/or regional climate conditions. In particular, an estimate of periodicity and recurrence of debris flows, that characterise the final phase of the varved infilling of the lake, will be addressed. This will provide important information concerning the environmental response (slope instability, evolution of the vegetation) to the climate changes occurring at the transition between the last interglacial (Eemian, Auct.) and the 'Wurmian' stage.

EVIDENCE OF THE YOUNGER DRYAS REVERSE CLIMATE AND PREBOREAL OSCILATION IN LAKE GENEVA SEDIMENTS (SWITZERLAND)

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Detailed interdisciplinary investigations demonstrate that Geneva Bay (Lake Geneva) sediments clearly record important palaeoenvironmental and palaeoclimatic changes occurred during the Late Glacial and early Holocene. Sediments are in fact differentiated by changes in texture, mineralogical and geochemical composition. Distal turbidite and glacial rhythmite deposition associated with wind-transported sediment supply dominate during the Oldest Dryas. These were replaced during the Allerød by detrital settling from turbid water and by endogenic calcite sedimentation. The Younger Dryas climate reversal (for the first time in Lake Geneva well defined by a pollen record) was characterized by an increase in detrital supply owing to increased run-off from the Bay slopes surrounding and within the catchment area, favoured by the thinning of the vegetal cover. A brief pause in endogenic precipitation related to decreased productivity occurs at that time. Endogenic carbonate sedimentation began abruptly at the start of the Preboreal biozone in response to the rapid global climatic warming. In the middle Preboreal, a new pulse of detrital sedimentation is interpreted as the sedimentological response of increased erosion in the high altitude region of the catchment area, owing to a minor early Holocene cooling phase (Preboreal oscillation) and interrupts the trend towards increasing endogenic calcite precipitation. Favourable limnic conditions are reached during the upper Preboreal, when diatom-calcite rhythmites formed. Stable isotopes analysis ($\delta^{18}O$, $\delta^{13}C$) in bulk sediment highlight the transition from clastic-dominated to endogenic-dominated sedimentation. Endogenic calcite deposition continues throughout the Holocene, alternating with local high energy sedimentary processes (wave-induced erosion and reworking of littoral deposits) enhanced by progressive lake-level lowering.

Geneva Bay proved to be an important site for recording the Late glacial-Holocene climate and environmental changes. The comparison with other Swiss Plateau lacustrine systems allowed us to emphasize the role played by the particular geographical and morphological setting of the investigated site and by links with climate-sensitive regions in the catchment area.

DENDROGEOMORPHOLOGY TO RECONTRUCT THE EARLY GLACIER ADVANCES OF THE LITTLE ICE AGE: THE EXAMPLE OF THE MADACCIO GLACIER (ORTLES-CEVEDALE GROUP, CENTRAL ITALIAN ALPS)

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In the Italian Alps the maximum advance of the whole Holocene usually coincided with the Little Ice Age (LIA), which reached a climax for most glaciers during the first two decades of the 19th century. The reconstruction of glacier advances preceding the LIA climax is rather problematic. In fact the moraines deposited during the peak of the LIA have usually obliterated the glacial deposits resulting from previous advances, apart from rare cases in which some remnants of lateral moraines have been preserved.

The phases marking the worsening of climate which caused the advance of glacier fronts are however recorded in paleoclimatic evidence, such as growth variations of tree-trunk rings. The analysis of dendrochronological curves combined with the dating of tree trunks buried by moraines and the age of living trees growing on glacial deposits, has permitted the reconstruction of the glacial events preceding the LIA climax as well as the most recent climatic history of the Madaccio Glacier (South Tyrolean sector of the Ortles-Cevedale Group, Italy).

The Madaccio Glacier, over time has modified the shape and position of its tongue. During the 17th century the glacier advanced occuping also the Eastern portion of the present proglacial plain while in more recent times the front has remained only in the mid-portion of the valley trough, although it has reached lower altitudes. For this reasons it was possible for one terminal moraine (in the east lobe) preceding the climax of the Little Ice Age to be preserved. A larch growing on the edge of the terminal moraine of the East lobe gives a minimum age of 1624 for the moraine. A larch still living on the great East lateral moraine, born in 1538, shows a fall in growth-rate between 1597 and 1612, with two particularly pronounced minima in 1605 and 1608. These evidences allow to identify an advance that took place in the first two decades of the 17th century. This advance is one of the several advance phases documented from the end of the 16th century and the beginning of the 17th in the Alps.

The vegetation of the Madaccio Valley also shows a critical phase between 1633 and 1652 with a more pronounced low in 1642. In this case, though, no glacial deposit was found that might indicate an advance phase for this time interval.

At the end of the 17th century a critical interval started for the tree vegetation of the Madaccio Valley, which ended only after the climax of the LIA. Larches show how in the period 1670-1823 there was a sensible decrease in the ring width. The peak of the Madaccio advance took place around 1770. The front of the glacier nevertheless remained in a rather advanced position until the end of the 18th century, with possible positive pulsations in the last decade of the century. The dendrochronological curves of the Madaccio Valley show that an attenuation of the cold phase took place at the end of the 18th century. A marked worsening definitely occurred from the beginning of the 19th century; already in 1809 more than half of the mean curves show a net negative peak. The climax of the advance which followed this cold phase shown in the dendrochronological curves was only reached in 1820-1821, which is also supported by historical evidence.

EVALUATION OF THE RESPONSE TIMES OF ALPINE GLACIERS THROUGH DENDROGEOMORPHOLOGY

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In the Alps, at the front of present glaciers, recently deglaciated areas are found with moraines either bare or poorly covered by vegetation, arranged in a nearly concentric pattern. Landscape features are of paramount importance in interpreting glaciers' past behaviour. Among landscape elements, not only glacial deposits should be considered, but also plants and other kinds of vegetation since they allow a proper interpretation of both the present landscape and past glacial dynamics.

It is well known that the frontal glacier fluctuations are thr last ring of a chain that start with a climatic input and end with the frontal response. So between the time of a climatic change and the shifting of the front, there is some delay. The response time for Alpine glaciers is often estimated using methods based on a linear correlation between front variations and the patterns revealed by several climatic parameters such as temperature and precipitation. Unfortunately adequate series of meteorologial data are not available but many glaciers during the LIA penetrated deep into the forest and trees represent very good recorders of climatic events and so tree data series are available everywere. Even in areas where glaciers did not reach wooded areas during the Little Ice Age and thereby directly influencing tree vegetation growth, as in the cases of smaller glaciers, the trees still recorded the same climatic fluctuations that were responsible for the glacier advances. Therefore, the use of dendrogeomorphological studies could become a useful instrument for investigations in many situations.

The Lys Glacier, in the Gressoney Valley, a tributary of Aosta valley is one of the most important italian glaciers that entered in the forest during the 19° century; so it was chosen to test dendrochronology as a method to calculate the response time of the alpine glaciers

Four mean dendrochronological curves were plotted from data collected from the analysis of 216 larch trees. The curves correspond to areas from which the glacier retreated in time intervals that gradually reach more recent periods. The curves were then correlated with the glacier front variation data. The linear correlations were repeated by progressively breaking down the data into time periods differing by one year. In other words, first the immediate effect of climate on the trees and thus on the glacier was analyzed, and then analyzed again, based on time delays gradually increased by one year at a time, based on the supposition that the impact of climate on the glacier occurs in that year, or in the following years. The correlation coefficient r tends to drop after the year 0, corresponding to an initial immediate response of the glacier, to then increase the time period until the maximum point is reached, corresponding to a delay in glacier response to the climatic variations (an absolute value). This maximum is reached in the 5^{th} year, which represents the delay between the two curves and thus the response time for the Lys Glacier. The results obtained by correlating the mean dendrochronological data curves with the front variation data curves for the Lys Glacier, were similar to those obtained from the correlation between the temperature data and front variation data. The reliability of the utilization of vegetation to evaluate the response times of Alpine glaciers was also confirmed by the fact that there was no delay between the climatic input and tree response. The trees that are most suited to this type of investigation are those located outside the area of the maximum Holocene expansion of the glacier. Such trees probably are effected by the climate of the valley head without, however, being disturbed by their extreme closeness to the glacier mass.

HIGH-FREQUENCY CLIMATIC CYCLES AT THE BEGINNING OF QUATERNARY FROM A LONG POLLEN RECORD IN THE LEFFE BASIN (N-ITALY)

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The Leffe Basin (500 m a.s.l., Lombardian Pre-Alps, Northern Italy) is located in a small valley cut through Triassic carbonate, surrounded by 1000-1600 m high mountains, and is filled by a 200 m thick sequence, including a middle, continuous succession of lacustrine-palustrine deposits (the 'biogenic unit' and 'upper unit' of the Leffe Formation).

According to paleomagnetic studies and mammal assemblages, the biogenic unit shortly postdates the end of the Olduvai Subchron (e.g. 1.7 Ma) and extends up to the Latest Villafranchian, e.g. 1-1.2 Ma.

We present here a pollen record from part of the biogenic unit of the Leffe Fm., showing five cycles of vegetation succession. Each cycle is characterized by a phase of deciduous mesophytic arboreal communities, from dry to wet temperate climate, followed by a cooling leading to a long phase of wet coniferous forests. At the end of some cycles, the forest succession is interrupted by a brief period of open vegetation, indicating drier and colder, continental climate. Correlation of the cold phases with major glacial advances of the southern Alps, as previously proposed, is excluded. Instead, this pollen record and the sedimentary evolution consistently suggest a prevalent temperate and humid type climate, with moderate oscillations.

Finely laminated intervals, consisting of alternations of carbonate-rich and organic matter/diatoms-rich layers, have been recognized within lacustrine marl intervals. They have been interpreted as original diatom-calcite rhytmites accumulated in a temperate lacustrine environment where endogenic sedimentation was strongly controlled by annual seasonality. Calculation of sedimentation rates for such intervals (0.048-0.1 mm/years) and lamination counting provided a reliable estimation of time duration of the respective pollen zones. Compaction degree of brown coals, estimated by measuring wood deformation, was useful to estimate the time span covered by organic layers.

A rough estimation of time duration of 22-32 ka has been provided for the main vegetational phases composing each cycle. A possible astronomical forcing of obliquity and precession is in agreement both with the inferred climatic evolution and the calculated time duration.

LATE-HOLOCENE EVOLUTION OF DELTAIC AND COASTAL DEPOSITIONAL SYSTEMS OF THE NORTHERN ADRIATIC BASIN

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The late-Holocene highstand wedge of the Adriatic basin is a muddy sedimentary body, elongated parallel to the Italian shoreline; its formation is related to the slow progradation of deltaic and coastal depositional systems started around 5000 years B.P., at the end of the rapid post-glacial sea-level rise.

Thickness distribution shows that the evolution of this sedimentary body is controlled by both the Po plain and Apennine rivers sediment input and the geostrophic circulation pattern within the Adriatic sea; the latter distributes sediments against the western (Italian) shoreline limiting the dispersion toward the basin center; depocenters are localized along the shoreline and particularly near the main deltas (25 m of highstand sediments in the Scardovari 1 well - a continuous coring well drilled in the Sacca di Scardovari, Po delta).

The progradation was not a continuous and homogenous process; on the contrary it was characterized by phases of rapid outbuilding and successive abandonment of deltaic and coastal systems as a response to high-frequency climatic changes, anthropogenic and autocyclic factors.

Anthropogenic factor is particularly important in this area that in the last 3/4000 years has been characterized by the presence of several important civilizations, whose main efforts were devoted to the control of river courses in order to enhance their social and commercial development.

The late-Holocene highstand wedge as a whole offers the most expanded and complete record in a shallow-marine setting of the climatic events and the environmental and anthropic changes occurred at different time scales (10^3-10^2-10^1 years) during the last 5000 years.

The use of ultra-high-resolution seismic tools allows the study of internal geometries of the wedge; integration with sedimentological data from cores leads to the reconstruction of a physical-stratigraphic framework cronostratigraphically calibrated with several methodologies ((AMS ^{14}C, d^{18}O, biostratigraphy, magnetostratigraphy, tephrocronology and palinology).

This kind of interdisciplinary approach allows the recognition within the late-Holocene wedge of a hyerarchy of minor sedimentary bodies with a clear genetic and cronostratigraphical meaning; for this reason they can be easily correlated on basin scale. Thickness maps clearly show their deltaic origin; in particular the Po di Primaro and Fiumi Uniti old deltaic systems and the modern Po Delta have been recognized and mapped.

The availability of expanded sedimentary sections of short time-intervals (<1000 years) and their correct definition within a physical-stratigraphic scheme is the first and fundamental step for any attempt of palaeoclimatic and palaeonvironmental reconstruction. The detailed study of well-constrained sedimentary units leads to the resolution of very short-lived and high-frequency events (tens to hundreds years), allowing the comprehension of the sedimentary response of a basin or of a single depositional system to high-frequency and variable scale cyclic phenomena. This is of fundamental importance to understand the contribution that such kind of study can offer to the scientific debate on the rapid, global-scale environmental changes.

AREA, EQUILIBRIUM LINE ALTITUDE AND VOLUME VARIATIONS OF 143 GLACIERS IN VALLE D'AOSTA (WESTERN ALPS, ITALY), FROM THE LITTLE ICE AGE TO THE SECOND HALF OF THE TWENTIETH CENTURY.

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This research is concerned with the glacial and climatic history of Valle d'Aosta (western Alps, Italy), from the Little Ice Age to the second half of the twentieth century (1975). One hundred and forty three glaciers were studied and for each glacier the maximum Holocene expansion, reached during the Little Ice Age, was reconstructed.

The area reduction, the Equilibrium Line Altitude (ELA) rise and the volume contraction have been determinated. The mean ELA rise was then used as a proxy measure of a temperature increase.
The glaciers studied in this research covered a surface area of 270.6 km^2 during their maximum Holocene expansion phase, and 158.4 km^2 in 1975. The reduction was therefore 112.2 km^2 equal to 41.5% of the total. The mean ELA at the maximum of the Little Ice Age was 2845 +/-165 m and in 1975 was 3015 +/-197 m. However, there is a wide spread in the values of the ELA rise, with individual values ranging from –71 to +467 m, and a mean rise of 139+/-106 m. The values of ELA also depend on aspect, they show that glaciers exposed in the southern quadrants have values of the rise of the ELA that are greater than those exposed on the northern quadrants.

Using 3D models for 17 glaciers located in upper Valpelline and Valtournenche a mean value of the thickness of ice lost of 24 m from the maximum of the Little Ice Age to 1975 was found. This datum was then used to calculate the mean volume reduction of the 143 glaciers studied in Valle d'Aosta. For an area reduction of 112.2 km^2 the volume reduction was found to be of 2.7 km^3.

The ELA of a glaciers is a response to the prevailing climatic conditions.Variations in the ELA can therefore provide information about variations in temperature and precipitation. The mean value of ELA rise of 139 m for the glaciers in this study was transformed into a temperature variation using an annual mean lapse rate of 0.62 °C/100 m. This gave a mean annual increase of temperature from the Little Ice Age to the present of 0.8°C.

TEPHROCHRONOLOGY: FROM SOURCE AREA STUDIES TO STRATIGRAPHIC AND PALEOENVIRONMENT PERSPECTIVES, AN EXAMPLE OF ETNA VOLCANO (ITALY).

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As tephra layers are excellent tools to stratigraphy and chronology of Quaternary sequences, the crucial problems are their sure recognition and age determination. These purposes can be gained with the identification of the corresponding event in the source volcano.
Beetween 6 to 25 km from the active summit vents, the flanks of Etna volcano are locally mantled by a pile of volcaniclastic deposits, represented by yellowish volcanogenic silts and sands interbedded with paleosols and scoria and pumice lapilli layers. Tephrostratigraphy and tephrochronology on these Etna volcaniclastic deposits allowed to reconstruct a continuous sequence of tephra layers and to establish the detailed explosive history of the volcano in the last 100 ka.

More than 80 tephra layers have been identified, most of them have been correlated and 7 tephra layers are marker beds all around the volcano.These marker beds are well dated and identified. Two benmoreitic pumice layers are related to plinian eruption occurred at 100 ka BP and 15 ka BP. In the post-13 ka BP activity we recognized the products of one basaltic plinian eruption at 2180 a BP (122 BC event) and 4 basaltic sub-plinian eruptions at 5340 a BP, 3930 a BP, 3150 a BP and in 44 BC. The isopach maps of the products allow the reconstruction of the dispersal area of the tephra layer.

The Etna marker beds can be related to Late Pleistocene tephra layers recovered in the Mediterranean deep-sea sequences and seeked in continental sequences. We propose the correlation of the benmoreitic pumice layers dated at 100 ka BP and 15 ka BP to east-mediterranean tephra layers X4 and Y1 respectively. A tephra layer correlable to the 122 BC event have been recovered in three deep-sea box cores sampled on the Malta Rise, 400 km SE from the Etna'summit.

Moreover, the well dated and continuous stratigraphic sections of Etna volcaniclastic sequences are potentially reference sections for paleoenvironment studies. In fact, pedologic and palynologic analyses are planed on a stratigraphic section that represent the interval from 9400 a BP to the present.

BIOGENIC FLUXES IN BANNOCK BASIN FROM A SEDIMENT TRAP INVESTIGATION

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The eastern Mediterranean is a reliable recorder of global climatic variation. In this area the particle fluxes can be compared between oxic and anoxic condition in order to understand the conditions related to climate variation recorded in sediment composition/preservation. We present here the results obtained in a sediment trap investigation carried out within the MAST-Marflux and -Paleoflux European programs. Two time-series sediment traps have been deployed at 2900dbar and 3700dbar in the south western Bannock Basin, a central eastern Mediterranean anoxic basin, to allow comparison under oxic and anoxic conditions. The trap collection period was 3 years (November 1991- August 1994), with a sampling interval of approximately 10 days. The purpose of our work was to determine the nature and magnitude of the major biogenic components in an oligotrophic environment in both oxic and anoxic conditions. The biogenic particle fluxes recorded at 2900dbar originate in the upper water column. In contrast, the particle fluxes in the deeper trap from the brine lake, are mostly related to resedimentation and preservation. The general particle seasonal trend recorded at 2900dbar was characterized by higher late winter-early spring export production. In the trap positioned in the brine lake, the particle fluxes were consistently 2/4 times higher and the seasonal signal was obscured by the suspended matter sliding from the step side walls of the basin. Coccolitophores are the major contributor to the biogenic carbonate flux in the basin and also the dominant phytoplankton group. There is a major difference in the biogenic opal flux between the upper and lower traps such the siliceous biogenic fluxes are consistently higher in the lower trap.

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