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Opening Session

Preparing for Catastrophes: Insights Provided by the Tsunami of December 26, 2004

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The tsunami triggered by the giant Sumatran earthquake of December 26, 2004, claimed the lives of more than 200,000 people in 14 countries in South Asia. It was, by far, the most devastating tsunami in recorded human history, killing six times as many people as the Krakatau tsunami in 1883. The catastrophe came as a complete surprise to almost everyone, and it highlighted the woeful lack of preparedness of states bordering the Indian Ocean for such a rare event. The lack of awareness and preparedness seem surprising, given that several tsunamis occurred in the eastern Indian Ocean in the 19th and 20th centuries. Further, prior to December 2004, geologists had previously warned that a great earthquakes would occur at the subduction zone west of Sumatra. Along the same lines, the 1995 Great Hanshin earthquake, which caused more than US 200 billion dollars damage and killed more than 5500 people in Kobe, was unexpected and came as a shock to a country that is arguably the best prepared in the world to deal with an earthquake.

Why do natural disasters continue to take such a terrible toll, when scientists know that they are not 'acts of God,' but rather natural phenomena that will surely recur in the future? The answer is complex and lies outside the domain of science, within the realms of human and social behaviour. The crux of the problem is that natural catastrophes are rare events. And the larger the event, the rarer it is. Someone living in a country with high exposure to earthquakes, tsunamis, floods, or cyclonic storms is unlikely to be injured or killed by such an event and, therefore, will likely ignore or discount the risk. This reaction is understandable, considering the number of more pressing hazards that an individual faces in daily life, for example disease and the danger of driving. Society and governments, however, should not take the position of the individual. They must consider natural hazards in timeframes of hundreds of years, not the span of a single person's life. Our cities and infrastructure will exist, in fact they will be larger and more complex, when a disaster event of the scale of the South Asia tsunami or the Great Hanshin earthquake next strikes. Governments have a responsibility to be ever vigilant and to prepare for possible natural catastrophes. Preparation involves (1) education, (2) investment of public money in infrastructure to make it more resistant to earthquakes, tsunamis, storms, and floods, and (3) building and continually testing emergency preparedness and response systems. Over the next decade or two, new technologies and advances in science may enable timely advance warnings of earthquakes, tsunamis, floods, and other catastrophic natural events However, a complete reliance on technology, as seems to be happening in South Asia in the aftermath of the December 2004 tsunami, is a mistake. The best technology in the world will be of little value without effective communication systems, an educated populace, and a resilient society. Finally, it is no coincidence that most loss of life from natural disasters has occurred, and continues to happen, in the developing world. Disasters disproportionately affect the poor, and will continue to do so until poverty and social injustice are eliminated. The developed world should address these issues as a priority, rather than relying on well intentioned, but misguided "techno fixes" to natural disasters.

Mega-floods in Africa: Report from the Dark Nature Workshop in Mozambique, November 2004

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Mega-floods are among the most common environmental catastrophes, and are of particular importantce for societies, because such a large part of the World's population live on floodplains. They are, however, often difficult to identify shortly after they have occurred. In contrast to some other kinds of climate-controlled catastrophes, they are not all caused by the same climatic situation. In African countries modern mega-floods have resulted in diseases and caused very large damages in cities and rural areas. Warning systems are often lacking. Historical and pre-historic data records are sparse, and the mechanisms that result in mega-floods are often poorly understood. This paper shows examples of mega-floods in East Africa, and focus on the need of data for pre-historic flood records.

Natural Disasters in the Past and in our Super-Vulnerable Present-to-Future

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The global warming scenario has put the focus on artificial computer worries instead of real natural disasters. The recent M 9.3 earthquake off Sumatra and its disastrous tsunami event brutally took us back to reality.

Flooding, draught, volcanism and seismic events with related effects like tsunamis, slides and mudflow are natural disasters that have seriously affected not only individuals but also whole cultures. With a remarkable stubbornness people have moved back and re-started their work, only soon again to suffer a new disaster (the slope of Mt. Etna, high-seismic risk areas, etc).

Our hazard prediction must be anchored in paleo-records; seismicity in paleoseismicity, tsunamis in paleo-tsunamis, etc. The Kozani earthquake in Greece and Kobe earthquake in Japan may have come as a surprise on the basis of instrumental records, in paleoseismology, however, there was no surprise (the records of paleo-events being plentiful). The new INQUA intensity scale is a powerful tool for the bridging of the gap between seismology and paleoseismology.

Some areas have strongly discontinuous hazard from deglacial to present day conditions. Areas of strong glacial isostatic uplift (Fennoscandia, Scotland, Canada, etc) experienced a very high seismic activity at the time of deglaciation, whilst they, today, have a low to moderately low seismic activity. This novel understanding has to be incorporated in long-term hazard predictions like in the case of the stability of high-level nuclear waste storage sites.

Tsunamis are frequently reported from the Pacific. They must, however, also be expected for the Indian Ocean, the Atlantic and other water bodies, too. The December 26 event is by now a notorious example. Both in Sri Lanka and in the Maldives, we have records of past tsunami events. In Sweden, I have dug up, at least, 15 tsunami events in the last 13,000 years. The famous Lisbon 1755 earthquake and tsunami was not a single event. There are records of previous events, too, implying that the likelihood of new events is high.

Today, however, we have built a new world, which is exceptionally vulnerable to disasters. Our cities have grown to mega-cities. The communications systems are overloaded. Our shores are full of houses and our beaches full of people. A new Lisbon event would, today, have terrible effects. Our preparations are minimal, still the event will come "sooner or later".

Our Planet Earth is full of "ticking-down" bombs. Our attention must concentrate on these issues. We must not allow for further distraction on the political elephantiasis of "global warming". I urge for an immediate return "to the real World".

What was terrible disasters in the past, will re-occur in the present-to-future. It will, however, hit us stronger and worse now because we have built our society and culture in ways that are so much more vulnerable to disasters than they were before.

Rapid Changes in Landscape Dynamics: Separating Natural from Human-Induced Causes in Order to Develop Mitigation Strategies for Landscape Degradation

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Complex sets of geologic, hydrologic, and biologic conditions and interactions give rise to earth system services[1] that act collectively to sustain productive terrestrial landscapes and to support human livelihood. Increasing human interaction of these earth system services leads to rapid changes in the magnitude, frequency, and extent of landscape processes that may threaten environmental sustainability through degradation. The Holocene geologic record of landscapes provides critical information on rapid environmental changes that existed prior to significant human-induced degradation. A thorough assessment of the geologic history of landscape changes provides critical indicators on the range of these natural landscape changes. Such assessments yield information that allows degradation caused by human intervention to be separated from that resulting from natural causes. Distinguishing natural from human-induced changes is critical in the development of strategies for mitigating degraded landscapes. In this paper, we provide examples from western North America of the recent (i.e., late Holocene) history of landscape degradation that predates human activity and that results from arroyo cutting (entrenching of fluvial channels), wildfire activity, and climate change, with implications for environmental assessments and strategies for mitigating landscape degradation.

The geologic record of selected alluvial valley floors in the southwestern USA reveals alternations between periods of channel erosion (arroyo cutting), widespread aggradation, and stabilization with soil formation. In many valleys, these periods of erosion are regionally synchronous (ca. 400 yrs B.P., 1000 yrs B.P., 2800 B.P., and 4200 B.P.), indicating natural climatic variability as the driving force. Geomorphic comparison of Holocene-age arroyos shows that arroyos existing in the present landscape are similar in size, and thus regional conditions causing erosion have not changed significantly within these study areas. In these areas, the energy driving arroyo development (cutting and extension) originates from runoff within bedrock uplands and not from base-level changes or runoff generated on the valley floors where human activity typically has the most significant impacts. Such studies establish indicators that can be used to differentiate between human-driven arroyo incision and periods of arroyo cutting driven by Holocene climatic variability. The late Holocene geologic records of Yellowstone National Park in the western USA show that periods of intense fires and concomitant erosion were episodic and were related to millennial-scale climatic variations. Fire-related events cluster within the intervals of 3300–2900, 2600–2400, 2200–1800, and 1400–800 yr B.P., with a major pulse of fire-related debris-flow activity between 950 and 800 yr B.P. (i.e., Medieval Warm Period). Because land managers have been challenged with wildfire management for generations, such histories have significant implications for strategies of fire management and sustainable environments in the western North America. This geologic record demonstrates that periods of extensive wildfires have occurred episodically for thousands of years and supports the conclusion of W.A. Patterson (2000) that “we are going to have to accept what history has shown us—that there will always be some fires burning on the landscapes.”

Although the geologic studies demonstrate that natural periods of widespread degradation have dominated the landscapes, human alteration of the terrestrial landscapes and their functionality threaten the sustainability of the earth systems services in rural regions of the western USA. Any assessment of arid landscape sustainability should involve long-term experiments to predict

[1]Earth system services is defined by the National Academy of Sciences Board of Earth Sciences and Resources (2004, unpublished) as biogeochemical and hydrogeologic states and flows that give rise to and sustain the biosphere, the thin layer of the earth system in which life can exist.

future differences in magnitude, frequency, and extent between the natural and human-induced consequences. An example of this predictive approach involves research underway at the Nevada Desert FACE Facility (a large scale, elevated CO2 experiment in the Mojave Desert). This research suggests profound ecosystem changes associated with stochastically high moisture periods will be exacerbated under elevated CO2 regimes expected during the next half century. Over time, these impacts will influence the vegetation community composition, structure, and function. These changes may have significant impacts on the socio-economics of arid rural areas, leading to desertification through decreased productivity of rangelands by invasive species and significantly increased fire cycles in landscapes previously dominated by fewer wildfires.

It is crucial in developing strategies that mitigate the often-negative impacts of rapid environmental change to distinguish among changes (a) that occur naturally, (b) that are caused by humans, and (c) where natural factors exacerbate those that are human. If the erosional, fire, and climate changes are predominately natural in specific regions, we need to consider how to live with these variations. If, however, rapid changes are human or largely human, then the choice is clear: understand how the system operates and work to change the human factor. Desertification, which results in reduced biodiversity and productivity within human systems, threatens the livelihoods of one billion people. The examples that we give—erosion, fire, and climate change—are all factors that impact human use systems. Policy decisions and individual human choices must recognize how the landscape responds to both the natural and the human system. It is because landscape processes can change so rapidly that we must understand the causes of change.

Rapid Climatic Change, Palaeoenvironmental Studies and Cultural Response A

Invertebrate Remains from Lago Di Vico

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Invertebrate remains of Cladocera (Crustacea) and Chironomidae (Diptera) were studied on lacustrine sediments from a composed sequence of three cores taken at the littoral of the Vico Lake (Latium, Italy). The sequences reached 16 m depth and were sectioned at intervals of 0,50 m. The time span covers a period from 95,000 to 10,000 years B.P. The Chydoridae dominated the zooplankton remains, reflecting the dominance of a littoral community. The Chironomidae assemblage indicates that the lake has been mesotrophic during that interval. Along the sequence, there were many fluctuations in the relative abundance of invertebrate remains and species replacements, which can be associated to changes on the water level of the lake and temperature variation. In general, invertebrate remains were less abundant during periods of glacial climate, with the occurrence of coldstenotermic genera and presented major diversity on periods of climatic melioration, inferred by pollen stratigraphy.

Study of Recent Sediments in the City of Como (Northern Italy): Multidisciplinary Analysis and Implication for the Environmental Evolution of the Area

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The purpose of this work is to provide a reconstruction of the recent environmental evolution, after the Last Glacial Maximum (LGM, about 20000 years ago) throughout the Holocene, for the Lake Lario sector where the city of Como is located.

This aim is achieved through a multidisciplinary approach and analysis conducted on urban subsurface sediments. A more detailed knowledge of the Holocene stratigraphy of Como can lead to a more accurate territorial and urban planning, for the improvement of environmental management of a city like Como.

Como provides a privileged point of view for understanding the post glacial evolution because it conserves a continuous, datable and high resolution archive of environmental data. In fact this area was occupied by a closed branch of Lake Lario after the LGM, with a high sedimentation rate of deposits rich in organic matter and with limited erosion phenomena.

Since 2001 the University of Insubria, in collaboration with Como Administration, APAT (Italian Agency for Environmental Protection and Technical Services) and IMONT (National Institute for the Mountain) is carrying out a multidisciplinary research to investigate in detail the stratigraphy of the urban subsurface.

Firstly, we collected and interpretated about 100 boreholes stratigraphy located in the entire urban area. Then we conducted a detailed analysis in 3 zones of the city (S. Abbondio site, Ticosa's area and Valleggio street). In particular, we drilled three new shallow boreholes for the site of S. Abbondio in 2003. For these sites we collected samples for sedimentologic, stratigraphic, palynologic, mineralogic and radiocarbon dating analyses. Combining litostratigraphic, mineralogic and palynologic data we proposed a model of climatic and environmental evolution for the area after the LGM. Previous data (Comune di Como, 1980; Castelletti and Orombelli, 1986; Apuani et al., 2000) and our new analyses allowed us to work out a 3D geological model describing the spatial geometry of deposits and then to interpret the stratigraphic succession of Como subsurface from the palaeoenvironmental point of view.

A sandy, organic-rich level indicating a marsh environment (and so originally related to the lake level) has been used as "marker horizon" for the Late Glacial–Holocene transition. A wood sample found in the marker horizon from the S. Abbondio site was first dated at 11730 ± 180 yr 14C B.P. (Castelletti and Orombelli, 1986). A new wood sample collected during our 2003 drillings in the same deposits gave a 14C age of 13230 ± 120 yr B.P. (Centre for Isotopic Research, University of Gröningen). Therefore, during the period between about 13–11 kyr B.P. in the area of Como the lake surface level was stood at an elevation of 205–200 m a.s.l., very close to the present day one (198 m a.s.l.). The area was characterized by a transitional low lacustrine–swamp zone, at the air–water interface as corroborate by palynologic and mineralogic evidence.

In particular, while along the border of the basin (S. Abbondio and Ticosa sites) lacustrine shores developed, a marsh environment occupied the central part of the basin. A thick, sandy organic sequence is found in many boreholes at the centre of the basin (about 20–30 m of thickness in lake-front zone and 40 m in Cavour Square) while it becomes thinner towards the borders.

Our data show that the "marker horizon" is located at approximately 50 m depth in the Duomo area, while it outcrops in the S. Abbondio site. This difference is probably due to Holocene subsidence, that reaches an average maximum rate of 4 mm/yr during the last 12000 yr B.P. (see also the abstract by Comerci et al. in this volume).

New drillings planned for October 2005 would cross about 50 meters of Holocene sediments allowing us to reconstruct the recent history of physical environment with extreme detail and to calibrate realistic models of interaction between natural processes and human impact in this sector of Lake as well as in the whole Lario Basin.

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The Subsidence of Como: Human Impact or Natural Tendency?

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The town of Como (Lombardia, Northern Italy) is seated at the southern edge of the western branch of Lake Como at the foot of the Alpine Chain. It is an important cultural and industrial settlement since Roman times, because located along a key commercial route, easily connecting Italy with northern Europe across the Alps. Lake Como (or Lario) is the third largest and the deepest lake in Italy, and lies in a 60 km long, downstream-bifurcated river-glacial trough cutting across the Central Alps, intensely modelled by an ice tongue up to ca. 2 km thick during the Last Glacial Maximum.

The urbanized area is affected by subsidence phenomena. In particular, remarkable rates of ground sinking have been recorded immediately after World War II.

To effectively understand the origin of this phenomenon, we have taken into account the role of all the different natural (Climate, Geology, Tectonics) and human (e.g., hydrological works, water withdrawal from wells) components in the geologic and environmental evolution of the Como sedimentary basin, from Late-Pleistocene to present.

Our work is based on A) field survey, B) air photo interpretation, C) literature stratigraphic, archaeological, topographic, and subsurface data compilation, D) drilling of exploratory shallow boreholes, E) radiocarbon dating, F) pollen analysis, G) 3D geological model reconstruction, H) a new precision levelling survey; I) SAR interferometry (PSInSAR).

Literature data (Castelletti and Orombelli, 1986; Bini, 1993) and our new analyses show that during the early late glacial the Como area hosted a proglacial lake at 270 m a.s.l. with a S-ward drainage. With the progressive ice thawing, the lake level in the Como area dropped to an elevation of 205 to 200 m a.s.l., very close to the present-day level (198 m a.s.l.), as proven by the St. Abbondio lacustrine terrace. The formation of this terrace implies a dramatic change in the Lario landscape and the birth of the modern Lake Como. We examined this site in detail by analyzing 17 boreholes drilled for the St. Abbondio church restoration, calibrated through three new shallow boreholes. The stratigraphy of the St. Abbondio recent deposits (as the one under the Como center) shows pro-glacial lake sediments poor in organic matter in the lower part, and lake shore deposits rich of wood horizons in the upper part. A wood sample from this site was first dated at 11730 ± 180 yr 14C B.P. (Castelletti & Orombelli, 1986). A wood sample we collected in 2003 from the same deposits has yielded 14C age of 13230 ± 120 yr B.P. (Centre for Isotope Research, University of Gröningen). Therefore, at this time (ca. 13–11 ka B.P.), while along the border of the basin (St. Abbondio site) a lacustrine shore developed, a marsh environment occupied the middle part of the basin, as testified by the tens of meters of loam and sand rich in organic matter found in many of the boreholes analyzed (more than 70).

The maximum depth at which this stratigraphic layer was drilled has been utilized to estimate the rate of natural subsidence from ca. 13,000 yr B.P. to present. The velocity of subsidence is given by: $V = (S - \Delta z)/T$ where V is the velocity, S is the sediment thickness, Δz is the sums of depth variations due to level water oscillations, T the sediments age. Supposing $\Delta z = 0$, the maximum subsidence rate during the last ca. 13,000 yr is bracketed between 1 to 4 mm/yr, with the higher value distributed in the lakeshore area. Moreover three archaeological sites of Roman age, now buried under 2.5–3 meters of sediments, have provided the historical long-term average subsidence rate.

In order to assess the ground movements, from 1928 to 1997, several institutions (Italian Military Geographic Institute, Politecnico di Milano, regional and local authorities) carried out precision leveling surveys. Values of ground lowering higher than 20 mm/yr have been measured in the districts close to the lakeshore from 1955 to 1975, presumably induced by the indiscriminate ground water exploitation. With the drastic reduction of water pumping in the Como plain, the subsidence rate slowed down to mean values of 1–2 mm/yr in town, with some benchmarks still or even reversing their trend (data refer to 1981, 1983, 1990, 1997 leveling campaigns). However, along the lakeshore the ground continued to rapidly sink, for example 6 mm/yr in Piazza Cavour.

In May 2004 a new precision leveling survey was carried out by APAT to assess the present-day ground vertical movements. Except for a few benchmarks that since 1997 have continued to lower with a rate higher than 10 mm/yr, all the benchmarks in the Como plain showed rates comparable to that of the natural subsidence, with velocities of 2–3 mm/yr along the lakeshore and even smaller in the inner part (e.g. 1 mm/yr in the duomo area).

Furthermore, TRE (Tele Rilevamento Europa) has measured the ground deformation by means of the Permanent Scatterer (PSInSAR) technique during the years 1992–2003. The velocities obtained in the Como plain by the two different techniques are in very good agreement, proving the reliability of the data. On the reliefs that border the plain the InSar measures show positive movements (with rates higher than 2 mm/yr on Brunate Mount), confirming the uplift of the Como pre-Alpine chain known in literature (e.g. Arca and Beretta, 1985).

Thus, the Como subsidence seems to be a localized phenomenon, affecting only the geomorphologic depression on which seats the town, filled by unconsolidated Late-glacial and Holocene sediments.

The ban of water exploitation in the Como plain (since 1989 the lake feeds the local aqueduct) has slowed down the subsidence but it is not enough: the shoreline area is still sinking and the risk of lake floods progressively increases.

Further investigations and monitoring already scheduled will allow a more precise constraining of the present-day trend of the subsidence in order to predict its near-future evolution and to lay down the basis for a possible prevention and mitigation planning.

Holocene Rapid Climate Changes and Social Responses in Marginal Environments: Cross-disciplinary Evidence from the Acacus Mts. (Libyan Sahara)

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A recent interest of archaeological investigation lies in the analysis of cultural trajectories, particularly in relation to the interface between environmental variations and social responses. However, this kind of approach has to combine different and unequal proxies: climate, landscape, people, and time.

Archaeological research in the Acacus Mts., south-western Libya, in the core of the Saharan desert, allowed us to gather in the last decade a fair quantity of data from Holocene sites: settlements, rock art contexts, burials. A cross-disciplinary view of cultural adjustments matched against environmental patterns allows for a different perception of social responses to rapid climatic changes during the Holocene. Archaeology, genetics, rock art, archaeobotany, and geoarchaology set the agenda on land use, mobility and social identity as major issues for the explanation of prehistoric pastoral society.

The evidence from the Libyan Sahara shows how archaeology can build its explanations on an extraordinary data set, and can use as a supporting documentation a long-term scale archive to analyze the relations between natural dramatic events (such as aridity and desertification) and social dynamics.

Prolonged Severe Drought in Western North America: Prognosis and Lessons from the Past

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Population growth in western North America, particularly the Southwest of the United States and adjacent Mexico has accelerated at a staggering pace. The population of the city of Los Angeles has grown six-fold, from about 577,000 people to over 3.7 million since 1920. Even more striking, in the same period the population of Las Vegas grew by 200 times and the population of Phoenix grew by 47 times. This has generated a massive increase in water needs, including a 410% increase in domestic water use in the Southwest since 1950. In relatively arid areas such as the Southwest, or the western prairies of Canada, local precipitation and groundwater are insufficient to meet water demands and domestic, industrial and agricultural water needs are met through the addition of water obtained from large river systems such as the Colorado River in the United States and Mexico, and the Saskatchewan River system in Canada. Flow in these systems depends upon snowpack in the mountains of the North American cordillera.

Long-term records of variability in precipitation and river flow provide reasons for concern about water resources in western North America. It is appearing increasingly likely that water planning has been based upon overly optimistic assessments of water availability and insufficient consideration of potential drought magnitude or duration, As one example, the total allocation of water rights from the Colorado River to the states of the Colorado basin and Mexico is 16.5 million acre-feet per-year (approx. 20 megalitres per-year). Unfortunately, long-term monitoring of flow over the past century and tree-ring based estimates extending back over 500 years suggest that the actual average flow of the river is only between 13 and 15 million acre-feet (16 to 18 megalitres). In addition, tree-ring records and evidence from other sources, such as lake sediments, sand-dune activation and stream channel studies, indicate that regions such as the Colorado basin or the Saskatchewan basin have experienced severe and prolonged droughts in the past 1000 years during which time average flows were decreased by 40 to 20% for periods of decades to centuries. In some cases, such as between 900 and 1300 AD aridity extended from the western plains of Canada as far south as southern California. Current reservoir capacity on the Colorado was strained by the most recent drought (1999–2004 AD) and demonstrated that the reservoir system cannot mitigate a severe drought of more than about 5 years duration.

Paleoclimatic records not only provide evidence of past severe and sustained droughts, but also insights into their causes. Recent work has highlighted the relationships between variations in Pacific and Atlantic sea surface temperatures and prolonged droughts in western North America. In many cases, however, these records also show that the frequencies with which significant aridity episodes and droughts occur is variable—making future drought prediction difficult.

The current situation in western North America—exponential population growth of an advanced stratified society in a region threatened by chronic water shortages and potential devastating droughts is not unprecedented in the Southwest. Insights into the relationship between severe sustained droughts and societal response can be gleaned from the paleoclimatic and archaeological records of past events. The Anasazi people developed a materially advanced prehistoric culture centered in the southwestern United States between 1200 BC and 900 AD, during which time they progressed from the incipient cultivation of corn and squash to a complex society building large buildings and population centers of stone and adobe. After obtaining maximum population densities around 1000 years ago, the archaeological record shows the Anasazi suffered a series of population declines and abandonment of lands. There is also evidence of great social unrest and conflict. By the time of Spanish arrival in the 17th Century the descendents of the Anasazi were but a remnant of their former extent demographically and geographically. The remaining people were settled close to rivers that provided somewhat reliable water. Tree-ring records have long shown that the period of decline corresponds to a period of droughts between about 1100 and 1300 AD. There is evidence of efforts by the Anasazi to mitigate drought impact through small reservoir and irrigation construction. More recent work suggests that drought alone did not cause the decline of the Anasazi, but was likely coupled with unsustainable population size, depletion of other resources such as wood and severe societal unrest and warfare.

For many reasons, including current technological sophistication, the extensive network of global trade that supports modern societies and the national and international laws and governance that regulate reactions to resource supply problems, a catastrophic event such as the Anasazi decline is unlikely in the future. However, it is likely that a severe and sustained drought such as those that have occurred in the past would lead to acrimonious civil and inter-governmental litigation, significant economic reconfiguration (including substantial changes in agricultural practices), and potential declines in immigration driven population growth rates as municipalities limit construction and growth due to water concerns. Indeed, all of these features have appeared in various forms in California in response to relatively mild droughts of the past few decades.

Natural, Rapid and Cyclical Climatic-Environmental Change in the Mediterranean Area and Human Responses During the Last 3000 Years

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The Mediterranean Area acts as a boundary zone between humid and desert zones and is highly sensitive to variations in climate and environment. Indeed, shifts in the climate bands towards north or south by only a few degrees of latitude may result in dramatic changes in soil surface conditions. This may cause, for example, desertification in areas that previously had a humid climate or vice versa.

Multidisciplinary geoenvironmental research was carried out to shed light on the climatic significance of different sediment types that have accumulated over the last 2500 years, located at various latitudes and in geographical areas with different morphoclimatic conditions (Ortolani et al., 1991; Ortolani and Pagliuca, 1993, 1994, 2001). The sediments, which cover many archaeological sites, were not affected by human impact between the Archaic Period and the Middle Ages.

In the Mediterranean area, the presence of wind-borne sand in coastal dunes is the most significant geoenvironmental indicator linked to warm-arid climatic conditions. Under conditions of heightened aridity (rainfall lower than 200 mm/yr, typical of desert areas), windborne coastal sand may even invade areas a considerable distance from the sea, forming windborne accumulations that cause the vegetation cover to disappear. This has been widely shown in the literature and verified by direct research (Ortolani and Pagliuca, 2001).

The most typical sediment characterising wetlands consists of soil that allows the development of vegetation and which differs ac-cording to latitude, local climatic and morphological conditions, and substrate lithology (Ortolani and Pagliuca, 2001). The vegetation occurs both on the surface of coastal sand dunes, which are thus stabilised, and on the alluvial sediments of the plains and altered substrate of the rocks of hill and mountain slopes.

The most significant sediments found in Mediterranean coastal dune zones in which severe climatic and environmental changes have occurred in the past consist of buried soils within layers of wind-borne sand. The presence of buried soils indicates that precipitation increased appreciably for a sufficiently long period of time to allow soil formation. Hence, there was a change in climatic conditions from desert to humid. Sediments indicating considerable climatic changes in currently humid areas include windborne sand and alluvial deposits of considerable thickness that cover areas where human impact has occurred. The presence of wind-borne sand indicates that rainfall decreased sharply until desertification (rainfall below 200 mm/yr) resulted (Ortolani and Pagliuca, 2001).

During the peak of warm-arid climatic changes, "increased greenhouse effect" environmental conditions similar to those expected in the near future were established. During the transition periods from humid to warm-arid and at the beginning of cold-humid climatic variations, other significant geoenvironmental variations (hydrologic and geomorphological instability) occurred concurrently with the marked increase in rainfall that took place after warm periods. During periods in which the temperature increased by 1–2 °C, coastal zones were affected by desertification up to about latitude 42° N. During temperature decreases, the areas of alluvial plains subject to human impact and settlements were affected by an accumulation of huge volumes of sediments. This resulted in aggradation and progradation of the coastlines in the northern part of the Mediterranean, while soil formation occurred on the surface of the coastal dunes in the southern and northern parts.

The climatic zones shifting in the circummediterranean area strongly influenced human migration, at local and continental scale, during the Holocene and the historical period. We recognised a general migration at the beginning of the Holocene warm period (about 8000 years BP) from Central to Northern Europe and from Southern Mediterranean Area to Southern Iraq. Another general human migration is evident at the end of the Holocene warm period, about 4200–3800 years

BP, from Northern Europe and from Southern Iraq towards the Mediterranean Area. During the historical period there are evidences of repeated migrations from Eastern and Northern Europe towards Italy and from the Apenninic mountain belt towards the coastal areas during the Little Ices Periods. During the warm periods there was a migration from the coastal areas towards the apenninic mountain belt.

The main result achieved through geoarchaeological research is the identification of cyclicity (period of about 1000 years) of the major climate and environmental changes that have resulted in 100 to 200 year environmental crises. Paleoenvironmental, paleoclimatic and geoarchaeological data show that the Mediterranean area was chiefly affected by environmental conditions similar to those of the present day (Ortolani and Pagliuca, 2001).

There is clearly a close correlation between climatic and environmental changes and solar activity. Prolonged solar activity maxima coincide with warm "increased greenhouse effect" periods and repeated solar activity minima coincide with cold periods ("reduced greenhouse effect"), such as the Little Ice Ages. The history of mankind and the environment in the last few millennia highlights progressive, cyclical climatic and environmental changes that consistently occur in multicentennial periods.

Using instrumental data and those obtained from natural archives, we propose a climatic reconstruction of the past 2500 years.

A valid frame of reference for assessing and quantifying the changes that will occur at different latitudes during the Increased Greenhouse Effect of the Third Millennium is provided by: (1) climatic and environmental data relating to the Warm Medieval Period in the Mediterranean area; (2) results achieved from research into geoenvironmental changes linked to historical climatic variations, especially those of the last few centuries, and; (3) various multidisciplinary data obtained from research conducted in various parts of the world.

Instrumental data chiefly concerning the last 150 years in the Mediterranean show a consistently close correlation between environmental variations (increase in solar activity and temperature and changes in the quality and quantity of rainfall) and the period of transition from the cold-humid climatic conditions of the Little Ice Age to those that may probably characterise the Warm Period of the Third Millennium (Increased Greenhouse Effect of the Third Millennium).

If cyclical climatic variation as occurred in the past will continue, it might result in new environmental conditions along the belts bordering the current climatic zones. In particular, a large part of the areas that are currently subtropical deserts might be transformed into humid areas. These conditions may be at times better and at times worse than those of the Little Ice Age.

This speculated shift in Mediterranean climatic conditions a few degrees to the north would cause an appreciable change (decrease) in rainfall in The Mediterranean Area and consequent climatic desertification of the coastal zones, as it happened just 1000 years ago during the Medieval Warm Period.

Central-northern Europe, also, will be severely affected by near future climatic environmental change. Since the 18th century, this area has been characterised by an almost homogeneous distribution of rainfall over the year and consequently, a constant river water regime. Mediterranean-type rainfall could probably increasingly affect this area in the near future. This seasonalisation of rainfall would result in an increased frequency of bankful flow conditions. Ongoing millennial climatic cyclicity forecasts that river valleys will be affected by repeated catastrophic flooding. Given that these valleys were urbanised on the basis of a constant river water regime, serious damage to the consolidated socio-economic organisation of central-northern Europe would therefore result.

The near future climatic change will affect severely the southern part of the present day humid belt of Asia causing the northwards shifting of the desert zone. Many million people will be forced to migrate northwards and westwards. The wars for water control ("liquid gold") will increase.

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Recurring Flooding Events During the Holocene in the South American Extratropics: Laguna Mar Chiquita, Argentina

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Recent weather patterns combined with results of high resolution paleostudies indicate that the role of tropical and subtropical areas may have been underestimated as forcing factors of changes within the global climate system. Thus, the study of well-constrained paleoenvironmental records in these regions became critical. The sedimentary and isotopic record of Laguna Mar Chiquita (30°54′S-62°51′W) provides a unique archive of the alternating low and highstands during the 20th century that have been instrumentally and historically documented reflecting regional rainfall variability. This sequence of variations in the hydrological balance of Laguna Mar Chiquita is synchronous and in phase with other hydrological changes observed in southeastern South American rivers pointing towards the regional scale of the reconstructed paleohydrology. The associated flooding events have had a catastrophic impact on the lake catchment and are seriously compromising the sustainable development of this mostly agricultural region. Additionally, substantial changes in biodiversity and population dynamics have accompanied these lake level changes.

A first well-calibrated sedimentary record covered only the last 300 years and thus is insufficient to formulate predictive models of future catastrophic events. A series of long cores were recovered allowing the reconstruction of lake-level variations prior to 20th century, covering the hydrological changes that occurred in this area since the Last Glacial Maximum (LGM). This quantitative estimation of paleolake levels shows a recurrent pattern of highstands since the late Pleistocene holding often a magnitude equivalent to present-day conditions. A wet phase followed the negative water balance during the LGM that ended at ca. 13,700 BP. A subsequent abrupt negative hydrological balance was followed by highstands conditions and thus positive P-E ratios since the Early Holocene until ca. 4,200 BP when started a new hydrological reversal. Dry conditions were mostly dominant from the Middle Holocene until the last quarter of the 20th century when an outstanding humid phase started. The integration of these paleodata with a refined chronology may provide a critical tool to further elaborate realistic models of sustainable development in a region of ascertain environmental vulnerability.

Impact of Holocene Explosive Activity of Etna Volcano (Italy) Estimated by Pollen Analysis of Marine Sediments

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For its geographical position at the centre of the Mediterranean Sea, Sicily represents a key-site for estimating the environmental evolution of this region during the Holocene. In the Etna area environmental changes are related not only to climate variations and human impact, but also to the volcanic activity of Mount Etna. The historical explosive activity of Etna is characterized by several basaltic eruptions. In order to evidence the relationship between the explosive activity and the environment evolution, we have undertaken stratigraphical, mineralogical, paleomagnetic, pedological and palynological analyses on marine and continental deposits. Marine cores were collected along the Catania coast, SE to Mt. Etna, a favourable zone for recording the pyroclastic deposits ejected by the volcano.

Pollen analysis was carried out on the ET99-18 deep-sea core, located at 1,083 m b.s.l., in the Jonian Sea, east of the Etna edifice (37°32′39″N, 15°15′51″E), over 200 cm of muddy marine sediments representing the last 4000 years. These sediments include the FG tephra (90 cm from core-top, representing the 122 BC plinian basaltic eruption products) and FL tephra (163–172 cm from core-top, representing the Sicani eruption products, 3150±60 BP).

In the lower part of the sequence covered by the pollen diagram, vegetation is dominated by grasslands and wooded steppe, typical of arid-temperate stands. Quercus forests were developed in the moister zones, while Fagus, Abies and Pinus woodlands were present at higher altitudes of the Etna edifice.

A clear variation in the pollen assemblage and a decreasing of pollen concentration verifies in correspondence of the tephra layers FG. Here a decrease in cultivated plants (Corylus, Olea, Vitis) and natural forests is associated with an expansion of steppic grasslands.

In the last 2000 years, after a new forest expansion, mainly by mesophilous elements (evergreen and deciduous Quercus), the progressive reduction of forested areas and the development of steppic communities, would suggest an increase of human exploitation in the region.

Climate and Land-use Phases around the Alps: A Case Study from Lago Lucone (Northern Italy)

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In rural societies population and social stability mainly depend on harvest success and thus on favourable climatic conditions. As extensively documented for the past 500 years, the consequence of a series of cold and humid years increased death rates (Maise, 1998; Pfister, 1988; Pfister et al., 1999). Based on these historical observation and on climatic proxies (i.e. residual 14C and glacier oscillations), decreases in archaeological findings in France, Germany and Switzerland at around 800 and 400 BC have been interpreted as climatically driven (Maise, 1998).

In order to address the response of prehistoric societies to climatic change, palaeobotanical anthropogenic indicators of four radiocarbon-dated sediments from Switzerland (Soppensee, Lobsigensee, Lago di Origlio e Lago di Muzzano) were compared to independent climatic proxies (Tinner et al., 2003). Taking into account the dating uncertainties, contemporaneous phase of forest clearances and of intensified land-use at 2100–1900 BC, 1750–1650 BC, 1450–1250 BC, 650–450 BC, 50 BC–100 AD and around 700 AD were detected at all sites (Tinner et al., 2003). These land-use expansions coincided with periods of warm climate as recorded by the Alpine dendroclimatic and Greenland oxygen isotope records. These results suggest that harvest yields have increased synchronously over central and southern Europe during periods of warm and dry climate. In conclusion, these results suggest a high climatic dependence of European prehistorical societies during many millennia (Tinner et al., 2003).

A sediment record retrieved from Lago Lucone (45°33′ N, 10°29′ E, 249 m a.s.l., northern Italy) was used to test this hypothesis. Presence of human populations was attested by pile-dwelling settlements from the Early-Middle Bronze Age (∼2000–1300 BC), with one settlement at only 100 meters distant from the coring site (Bocchio, 1985-1988; Guerreschi, 1980–81; Martinelli, 1996). Pollen and plant-macrofossil analyses were applied to a sediment core of 250 cm, and four dates provide the time control (Valsecchi et al., submitted). Mixed oak forest was cleared during the Early to Middle Holocene and replaced by open vegetation during the Bronze Age (∼2000–1100 BC). Several anthropogenic indicator plants increased during that time, suggesting a strong influence of human activity on the landscape. At the beginning of a phase of high human impact (∼2000 BC), independent climatic proxies, such as Alpine climatic phases (Tinner et al., 2003) and short-term atmospheric 14C variations, indicate a warm and dry climate. Thus, the Early-Bronze Age occupation phase occurred during a favourable climatic period that continued until ∼1250 BC. Later, archaeological and palaeobotanical evidence indicate a sharp decrease in human pressure in the Lago Lucone area at the transition between the Recent and the Final Bronze Age (∼1100 BC). This decrease was delayed if compared with the extinction of pile-dwelling settlements in the Lago di Garda area (around 1300 BC).

However, this general decline at around 1300–1100 BC is probably synchronous with the end of the pronounced cultural phase at 1450–1250 as documented by other palaeocultural records south and north of the Alps (Soppensee, Lobsigensee, Lago di Muzzano, Lago di Origlio) and the independently inferred end of the correspondent warm-dry phase. However, due to discrepancies between important proxies of past environmental conditions, it is not possible to better assess the role of climate for these societal changes in northeastern Italy. Cultural crises (e.g. wars) or changes in spatial organisation as a forcing factor for declining human impact in the area cannot be ruled out under the present state of knowledge.

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The Drying of the Garat Ouda lake (SW Fezzan, Central Sahara): A Dramatic Effect of the Middle Holocene Climatic Change on Landscape and Human Occupation

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During the Wet Holocene (11–5 Kyr BP) a lateral branch of the wadi Tanezzuft (SW Fezzan, Central Sahara) fed a wide (more than 80 Km2) delta-lake system in the area of Garat Ouda. The delta was composed by several meandering palaeo-channels (evident in high resolution Ikonos satellite imagery) and was densely settled by human communities. The archaeological record in the area is very rich and it consists of fireplaces, lithics, pottery, grinding equipments and animal bones (wild animals, cattle and fishes); the archaeological evidences are systematically distributed along the Northern lake shoreline (Mesolithic sites) and along the palaeo-channels (Pastoral sites). The abundance of findings testifies that throughout the Holocene the delta-lake system was constantly attended by the Mesolithic and Early to Middle Pastoral communities.

At 5 Kyr BP, after several millennia of activity and human frequentation, the Garat Ouda basin suffered a heavy crisis and rapidly dried out. The abrupt decrease in water reservoirs was due to the drop in Monsoonal rainfall supply to the Central Sahara: the result was the dramatic contraction of the course of the wadi Tanezzuft and the extinction of its lateral branch. As confirmed by a detailed field survey and by several radiocarbon and TL dating, after that dry event no human occupation is recorded in the area of Garat Ouda: Late Pastoral sites consist of scarce scattered fireplaces, very poor in archaeological material, and they are not related to the palaeo-channels system.

Rapid Climatic Change, Palaeoenvironmental Studies and Cultural Response B

Evolution of the Sedimentary Infilling of the Hersek Lagoon (Turkey, Izmit Gulf): Possible Relationships with Tsunamis in the Marmara Sea

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The eastern part of the Marmara Sea is frequently affected by the seismic activity of the North Anatolian Fault (NAF). This activity is responsible for tsunamis and submarine landslides in the Marmara Sea (Öztürk et al., 2000; Altinok et al., 2001). During historical times (0–2000 AD) at least 9 major tsunamis have affected the Marmara Sea (Kuran & Yalçiner, 1993). They were mainly located in the vicinity of the Izmit Gulf (Altinok et al., 2001). The last high magnitude earthquake having affected the area (17th August 1999, Mw = 7.4) has induced a tsunami in the Marmara Sea with waves reaching 2.5 m (Altinok et al., 2001).

In the framework of the EU-funded RELIEF project (RELiable Information on Earthquake Faulting, www.ingv.it/paleo/RELIEF), ten sediment cores with a length varying between 1 and 4 meters have been collected in the Hersek lagoon (Izmit Gulf, eastern Marmara Sea, Turkey). The aim of this coring campaign was to reconstruct the evolution of the sedimentary infilling of the Hersek lagoon in relation with the tsunamis triggered in the Marmara Sea.

After having been scanned by x-rays, the cores have been opened, described and photographed. The physical properties of the sediment (magnetic susceptibility, γ-density, p-wave velocity) have then been measured with high resolution (5 mm) on a GEOTEK multisensor core logger (GFZ, Potsdam). In order to interpret the variations of these high resolution signals, two long cores have been selected for complementary analyses: TOC, forams, grain-size by laser diffraction, and bulk- and clay-mineralogy by x-ray diffraction.

Results demonstrate that the sediment is mainly made of fine silt-sized particles containing dispersed Turitella and Cardium shells. The bulk mineralogy of the sediment is made of quartz, clays, plagioclase, calcite and halite. Some samples contain aragonite. The clay mineral assemblages are dominated by smectite and illite. Some reworked shell deposits (mainly Cardium) as well as sandy layers are intercalated in these fine sediments. These instantaneous deposits have probably been deposited in high energy environments, that may be in relation with tsunamis or storms in the Marmara Sea.

In order to reconstruct the sedimentation rates, radiocarbon dates have been obtained on non-reworked particles. These data allow us to estimate the age of the instantaneous deposits.

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Charcoal Studies as Means to Record Wood Fire Catastrophes and Abrupt Changes in Vegetation: A Balance Between Nature and Human Activity

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Charcoal analysis (Anthracology) and other related studies such as pollen, micro-charcoal, phytoliths etc., are a valid way to study the dynamics of the vegetal cover both under man pressure and climatic changes. Forest fires, excessive grazing and systematic and intensive woodland are some of the causes of the rapid and dramatic palaeoecological transformations that took place during the last 10.000 years.

Repeated burning events change the vegetation and the soil in a irreversible shape. The residual charcoals contribute to a better knowledge of the evolution of the woody flora with considerable accuracy, particularly at high altitude. In the plain soils, e.g. in the Po plain, crop activities often destroy the charcoals derived from wood fires and we have only information from archaeological charcoal, especially if derived from funeral fires. In Italy, soil anthracology, or pedoanhtracology is at the early stages so the only evidence available to reconstruct the Late Glacial and Early Holocene vegetation comes from charcoal from Mesolithic hearts.

It is only from the 3rd millennium BC that charcoal from other contexts different from hearts are available in the Central Alps, as in Cavargna Valley, between Como and Lugano See.

Over-exploitation of Resources and a Possible Climatic Co-factor in the Collapse of the Terramare Culture (Middle and Late Bronze Age, Northern Italy)

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The Terramare, archaeological sites generated by a civilisation which settled the centre of the Po plain during the Middle and Recent Bronze ages, were abruptly abandoned at the end of this period. The reason for this collapse is still a matter of debate. In the context of a multi-causal explanation, this paper discusses a possible climatic factor, inferred from recent discoveries at the site of Poviglio Santa Rosa (northern Italy).

The culture of the terramare produced a systematic and intensive agricultural and pastoral exploitation of the environment, and caused heavy deforestation. Water was a critical resource and was carefully managed. The moat which typically surrounded most of the sites was meant to concentrate and redistribute water to the fields through a network of irrigation ditches. The study of the water wells discovered at the fringe of the terramara of Santa Rosa reveals a drop in the water table during the late Recent Bronze age, caused by a dry event of regional relevance.

Chronological contiguity, supported by the archaeological context between this occurrence and the abandonment of the Terramare system, strongly suggests a causative link between the two events.

The climatic event, a minor episode in the history of the Holocene climate, nevertheless acted as a catalyst in a stressed environment whose resources were over-exploited by rising and uncontrolled demographic pressure.

Lake Como (Lario): Innatural Trophic Level Trend Due to Pollution

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The Lake Como's hydrographic basin covers an area of 4,552 km2; it is mainly located in the north-western sector of Lombardy, and to a lesser extent in the Ticino and Grigioni districts (487 km2) of Switzerland. The lake stretches 90 km in the N–S direction, and 125 km in the W–E direction.

The pollutants are carried into the lake's waters through the hydrographic system, by means of run-off processes or meteoric precipitations.

37 streams carry their waters into the lake, as well as 2 main tributaries which flow into the lake's northernmost tip. These are the Adda River (carrying 50% of the total water volume that flows into the lake from tributaries) which is also the only emissary of the lake, near Lecco, and the Mera River, carrying 20% of the waters flowing into the lake from tributaries.

Located into a transversal cryptodepression of the Southalpine chain, Lake Como is the deepest of the Italian lakes, reaching -412 m in the offshore waters in front of the Argeno village.

Due to its characteristic "upside-down-Y" shape, the lake may be subdvided into three different basins: the upper lake (or nothern basin), the Como branch (southwestern basin) and the Lecco branch (southeastern basin). The southwestern basin is the deepest one, with a water exchange rate that is longer than the other two basins. The northern and southeastern basins are characterised by a more intense hydrologic activity. The theoretic water exchange time for the whole lake is around 4.5 years, one of the longest among the deep southalpine lakes.

Lake Como may be classified in terms of its glacial origin or on the basis of its thermal regime, a classification criterion that better defines the "ecologic vocation" of the water body.

In the case of the Lario, during mild and dry winters the vertical mixing of waters is only partial in its deepest portions; therefore, the lake is defined as oligomitic.

Phosphor, that represents the key factor in limiting the growth of the producers in the lake, comes from cultivated and uncultivated crops, as well as from domestic wastewaters produced by residents and tourists and from cattle-breeding and industrial wastewaters.

The natural condition of the lake's waters would be an oligotrophic one, with an average phosphor concentration of 7,5 mg/m3; however, in the last decades, as a consequence of the increasing enrichment in nutrients, the lake has progressively become eutrophic.

It is well known that the excessive amount of nutrients, altering the balance of the lake's ecosystem, is a major cause of pollution.

Lake Como has been the focus of scientific interest since the dawning of the limnological researches in Italy; historically, two phases might be recognised: The first one, which began back at the times of Alessandro Volta (1745–1827), was characterised by interesting studies, although limited to the investigations of a few scientific issues; the second one, which began in 1986, was marked by more articulated studies and researches.

In 2003, researchers from the Faculty of Science of the University of Insubria (A. Pizzala, A. Cantaluppi), examined and selected a great deal of scientific data regarding phosphor and nitrogen in the lake's waters, collected during studies conducted on different occasions. These data have been compared and divided in 11 groups correspondent to 11 areas of the lake, in which the data might be grouped on the basis of detectable analogies. These zones were defined and named according to the sampling locations and the names of the nearby main geographic sites (Como, Cernobbio, Moltrasio/Torno, Argegno, Menaggio/Bellagio, S.Vito/Corenno Plinio, Colico, Bellano, Lierna/Grumo-Civenna, Abbadia Lariana, Lecco).

Therefore, it has been possible to elaborate a picture of the trophic evolution of the lake as a whole and as an assemblage of different zones. The historic series of phosphor and nitrogen have been presented by means of tables (with reference to their bibliographic sources) and graphs, useful for illustrating the trophic evolution of the lake. The Authors have chosen to work with average values of phosphor and nitrogen, focussing respectively on the hypolimnium, epilimnium and the whole water column.

For explanatory purposes, it is possible to take a look at the graphs relative to phosphor and nitrogen referred to the whole water column, respectively for the Como area (mostly subject to incoming wastewaters from textile factories) and the entire lake.

With regard to the whole lake, it is possible to highlight that the trophic evolution of its waters has shown an anomalous trend in the past few decades, markedly different from the normal increase of trophic levels to which any lake is inevitably subject.

It is possible to point out that, starting in the 80s, there has been an improvement of the trophic conditions of the lake's waters, caused by the decrease of the limiting factor represented by phosphor. The average amount of this element was 80 mg/m3 in 1977-78, a clearly eutrophic condition, but it sank to 35 mg/m3 in the 2nd half of the 90s, an almost mesotrophic condition.

It is not difficult to explain this difference from the natural trend in terms of the antrophic presence (industry and tourism) in the lake's basin; in the same way, it is possible to explain the observed decrease in phosphor in terms of the reduction of this element in the tensioactive products used by the textile industry. Such an improvement has been also possible thanks to the realization of water depuration systems, both at the domestic and the municipal level (i.e. the Comodepur depuration plant, where a large volume of wastewaters from dying factories are subject to treatment). A recent study, sponsored and supported by the Ministry for the Environment and the Como Provincial Administration, whose title is "Project aimed at the mitigation of eutrophic processes in the Lake como's waters" (Politecnico di Milano: Chiesa-coordinatore; Università degli Studi di Milano: Chiaudani-coordinatore, Negri, Borsani; Centro Volta: Bartesaghi, Pizzala, Taiana, CCR/CEE di Ispra: Premazzi, Rodari, Rossi; ATE s.r.l.; Lombardia Risorse s.p.a.) and whose final results were published in 1993, kept in consideration the incoming amounts of phosphor and elaborated water reclamation projects.

With an external phosphor input to the lake of around 379 tP/year, in 12 years its average concentration in the lake's waters would decrease from 40 mg/m3 to 25 mg/m3, an amount that would then tend to stabilize. However, reducing these external inputs by 50% (by means of adequate and sustainable methods), it would be possible to reach concentrations as low as 13 mg/m3 in 12 years, an amount that is larger than the natural one (around 7,5 mg/m3), but that is compatible with a good quality of the lake's waters.

Sea Level Rise, Coastal Processes and Human Response

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Models of sea-level change in northwestern Europe show that at the beginning of the Holocene, Britain was connected to mainland Europe by an extensive land bridge. This area of land has been termed Doggerland after the relatively shallow water region of the North Sea known as the Dogger Bank. For southern Britain and southern Jutland, the presence of settled groups of people has been dated to about 12, 400 BP and it can be inferred that the land area between these regions would also have been settled. Direct archaeological evidence of such settlement is rare, but bones of horse, mammoth and red deer, similar to those of the faunas of adjacent lands, and flint artefacts have been found in dredges from the North Sea, suggesting that an abundance of wildlife attracted human predators. Holocene sea-level rise between approximately 10,000 and 6000 BP must have had a pronounced effect on the population of Doggerland, forcing retreat onto mainland Europe and the British Isles. Complete separation of Britain and mainland Europe probably took place between 7000 and 6000 BP.

Sea-level rise during the first half of the Holocene was relatively rapid and coastal processes, such as tidal scour of deep valleys, have left their mark on the topography and sediments of the floor of the North Sea. There is nearshore archaeological evidence of drowned settlements and coastal processes continue to have a profound effect on human habitation and activities. Human interference in natural processes can also be significant and the effects may be difficult to predict and often unwanted.

Erosion is a constant problem in many coastal areas and is likely to become more intense with predicted sea-level rise. Society is faced with the choice of trying to defend the coastline against erosion or allowing events to follow a natural course. The former can be a very expensive and long-term commitment, but has to be considered where investment in the coastal zone is very high. However, protecting the coast in one area may have a detrimental effect elsewhere and may even have unexpected consequences in the immediate vicinity. The latter also has financial implications if there is a need to compensate land and property owners for their losses and requires long-term forecasting of coastal evolution and appropriate coastal zone management plans.

Sedimentation along the coastal zone can lead to the silting up of harbours and access routes. Dredging keeps many modern harbours open, but this in itself can lead to problems, because international agreements on the disposal of dredge material are becoming increasingly strict. In the past, sedimentation has led to the almost complete closure of many small ports, with consequent changes in the life styles and work of coastal communities. As with erosion, human interference in the natural processes of sedimentation may lead to conflicts of interest.

Examples from around the world demonstrate the difficulties associated with inappropriate development and use of the coastal zone. In the face of sea-level rise, island communities face the greatest challenges: they have less room to retreat, more limited resources, and economies that are largely dependent on the coastal zone.

Pollen and Charcoal Evidence for Human Responses to Climate Change in Mediterranean Environments

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Disentangling human from climatic impact is an everlasting minefield, in a matter where there is no easy solution. Abrupt climate changes is generally suspected to be the overriding factor.

The best potential to detect the cause of the landscape change comes from combining continuous records of proxy vegetation and climate change such as from lake cores obtained as close as possible to archaeological sites, which are the direct link to cultural history. Pollen and charcoal analyses from Holocene lacustrine sediment records of two extant Italian lakes (Lago di Pergusa, central Sicily, and Lago di Mezzano, northern Latium) of Mediterranean environments are used.

There is generally no doubt that major events were happening across a wide geographical range and relatively synchronously for which humans cannot have been responsible alone. Dramatic and rapid tree pollen concentration drops, not necessarily matching tree percentage decreases, have been pointed out during forest phases in many pollen diagrams of Latium during the last hundreds of thousands of years and interpreted as vegetation responses to climate changes. As similar drops are also found during the Holocene at Lago di Pergusa and at Lago di Mezzano the requirement of finding a reason to such changes induced to consider the possibility that human communities were the cause. But how could prehistoric populations have induced sudden, enduring, dramatic arboreal phytomass reductions on a large scale only by cutting trees? The necessity to investigate on past fires has become clear and checked using micro-charcoals as indicators of forest burnings.

During the Neolithic and Eneolithic periods, since ca. 8000 years ago, the plant macrofossil record shows that the agriculture was a common practice all over Italy and both Latium and Sicily were just in the same cultural development of the rest of the country. We should therefore expect that human impact on the landscape had markedly increased as populations expanded rapidly under conditions favourable to farming and life. The fact that even human presence alone is hardly detectable in Mediterranean environments until the Bronze age, and that in many sites a clear human impact is found only since the Roman periods, is incredible. Prehistoric populations did not produce strong changes on the landscapes, at least on a broad scale, and their influence has therefore to be found in lake archives very close to archaeological sites. Two arguments can be used to explain this lack of evidence and delay in proofs coming from Mediterranean pollen records: 1) the distance between lake and archaeological settlements; 2) the indigenous origin of many edible plants and the difficulty in identification of many anthropic indicators.

Natural Calamites in the Latin Authors of Roman Age and the CLEMENS Project

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Ancient Romans have always given great importance to the occurrence of extraordinary natural phenomena, taken as signs sent by deities, which had to be interpreted and properly answered. As represented in Livy in his Ab Urbe Condita, the novendiales (banquets and sacrifices lasting for nine days) were the most typical reaction to one, or more commonly, a set of god's "messages", in the form of natural calamities, or even mere oddities, with respect to our understanding. Livy is the first known author, defined as a historian, who tells to posterity how the ancient Romans combined natural calamities with rites, intentionally created for the purpose to appease the gods.

So, Livy lists a number of novendiales following the fall of stones—even blazing stones—from the sky in Rome or nearby, very likely late activity of the volcanic center of the Alban Hills (Ab Urbe Condita, book VII, 28; he reports that in 347 BC: "A portent followed close on the dedication similar to the old portent on the Alban Mount; a shower of stones fell and night seemed to stretch its curtain over the day. The citizens were filled with dread at this supernatural occurrence, and after the Sibylline Books had been consulted the senate decided upon the appointment of a Dictator to arrange the ceremonial observances for the appointed days." and in book XXII, 36, when in 215 BC "It was reported that showers of stones had fallen simultaneously on the Aventine in Rome and at Aricia").

Elsewhere, he cites earthquakes (Ab Urbe Condita, III, 10, V century BC; IV, 21, V century BC; VII, 6, 362 BC, referring to a terrae motus in the Forum Romanum at the Lacus Curtius, providing in that way also for important archaeological information regarding the structure of the archaic site. In book XXII, 5, during the second Punic war, Livy tells us that in 217 BC: "Chance massed them together, each man took his place in front or rear as his courage prompted him, and such was the ardour of the combatants, so intent were they on the battle, that not a single man on the field was aware of the earthquake which levelled large portions of many towns in Italy, altered the course of swift streams, brought the sea up into the rivers, and occasioned enormous landslips amongst the mountains."). He also talks about floods (Ab Urbe Condita, VII, 3, in 363 BC when: "However, the first introduction of plays, though intended as a means of religious expiation, did not relieve the mind from religious terrors nor the body from the inroads of disease. Owing to an inundation of the Tiber, the Circus was flooded in the middle of the Games, and this produced an unspeakable dread; it seemed as though the gods had turned their faces from men and despised all that was done to propitiate their wrath"; or in book V, 15, that tells about the extraordinary rise of the Alban lake in 398 BC during the war against Veii, that required, to placate the gods and save the city, following the recommendation of both an Etruscan soothsayer and even the Oracle of Delphi, the complex excavation of a drainage tunnel, which stills awaits to be fully understood.

Unfortunately, Livy's masterpiece is largely incomplete: we have only 35 of the original 142 books (1–10; 21–45, some sparse fragments, and a compendium dated at the III–IV century AD, called Perìochae). His report, spanning 7 centuries, is not first hand: his main source were the archaic authors, like Valerius Anziatis, Licinius Macrus, Claudius Quadrigarius and Fabius Pictor, whose plain but precise work is now almost completely lost, as most of the historical and literary Latin production up to the first century BC. For the narration of Rome's expansion in the oriental territories and the unitarian vision of the happenings in the Mediterranean basin, Livy's main source was the famous Greek historian Polibius.

Other authors have provided sometimes dramatic descriptions of calamities, e.g. Pliny the Younger in his account of the 79 AD eruption of Vesuvius, and many others, like Lucretius Carus, Anneus Lucanus, dispersed in the huge amount of literary production of the late republican and imperial times.

In many modern technical reports it is possible to encounter citations of ancient texts related to natural calamities (e.g., seismic and flood catalogues). Nevertheless, up to now a compendium of excerpta comprehending the whole range of natural disruptions reported in Italy and in the Mediterranean basin in ancient times is not available. Hence, APAT has decided to collect these excerpta in a database named CLEMENS, acrostic for Corpus Latinorum Et Medievalium Naturae Scriptorum. The purpose is to make available through the web an analytical and easily searchable list of accounts by ancient writers of environmental phenomena. This may help to find new, or better evidence of natural phenomena, since dealing with ancient documents, surprises can always be expected. Having at hand a complete body of citations of environmental events by an author, and those by different authors of the same period, should serve to better understand the cultural background of the author and of his period and to better interpret the sense of the quoted environmental effects.

So, CLEMENS should become a tool aimed not only at fulfilling a scientific curiosity, but at completing and making more readily available the knowledge on out-of-the-ordinary ancient environmental events and the reactions of our ancestors.

Environmental Hazards and Societal Vulnerability

Surface Rupturing at Mt. Etna Volcano: Consequences on Environment and Human Activities

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Surprisingly enough, the most active volcano of the Mediterranean sea also hosts a wealth of evidence of early human settlements, which, from the Bronze age to now, not only have endured the volcanic violence, but have grown to populated cities (the largest being Catania, that was cut in two by a large lava flow in 1669 and destroyed by the 1693 earthquake). So, Etna is a privileged area to analyze the relation between natural violence and human reaction to it. In addition to volcanic eruptions, Etna is affected by active ground ruptures in its eastern, most inhabited, side facing the sea.

Ground displacement may result from volcano-related movements due to dyke-induced rifting and flank instability sliding. Likewise, purely tectonic faulting certainly plays a significant role. Surface faulting shows very different features and is associated to a variety of processes. The occurrence at Etna of both coseismic and aseismic surface rupture events is well known, also along the same fault. Commonly, coseismic surface faulting is here associated with very shallow ($H <$ 5 Km), moderate earthquakes, which occur with short recurrence timing (tens of years). Such earthquakes produce macroseismic intensities reaching even the IX–X grade MSK along elongated, narrow zones including significant surface faulting, with end-to-end rupture length up to 5–7 Km and vertical offsets up to 90 cm. It is very clear the striking difference in the relations between magnitude and surface rupture length or the coseismic offsets for these earthquakes. Fault creeping affects extensively most of the faults of the volcano, with modern (last 200 years) creep rates ranging from 0.5 to 2.3 cm/year. Surface rupturing, either coseismic or due to creep, produces in the area disastrous damage, especially when crucial lifelines cross it.

In this note, we describe paleoseismological investigations recently undertaken along the Moscarello, Pernicana and S. Leonardello faults, among the most active faults affecting the Etna volcano, and their primary and secondary effects on the environment and human activities.

The Moscarello fault is one of the most active faults of the Timpe system, in term of slip rates and seismicity. During the past two centuries, this fault has generated four seismic events (in 1855, 1865, 1911, and 1971) with intensities of VII–VIII to X MSK. All these events were accompanied by surface ruptures up to 6 km long and with maximum dip-slip displacements between 25 and 90 cm. During the earthquakes the surface ruptures produced collapse of rural houses. Exploratory trenches evidenced a vertical component of the Holocene slip rate on the order of 2 to 3 mm/year, in good agreement with the short-term value inferred from the historical ruptures.

In the northeast side of the volcano, the Timpe System interrupts to the north against the arch-shaped Provenzana-Pernicana-Fiumefreddo fault system, trending east-west to west-northwest-east-southeast for ca. 18 km. This fault system crosses the volcanic edifice from the central crater to the sea. This very active system plays an important role in the geodynamic and morphologic evolution of the area, and it is interpreted by some authors as the northern boundary of the unstable eastern flank of the volcano, sliding toward the sea. Its kinematics is essentially left-lateral, with local extensional components lowering the southern and eastern sides. Slip occurs as a result of both coseismic rupture and continuous or episodic creep. The slip rate, > 2 cm/year, is the highest known in the Etna volcanic area, deforming roads, houses, the Messina-Catania tollway and a gas pipeline. Paleoseismological studies in the central segment of the system, corresponding to the Pernicana fault, revealed a vertical slip rate higher than 2.45 cm/year for the last 1.0 ka and aseismic movements along the fault planes.

One more morphologically outstanding fault of the Timpe System is the mostly normal San Leonardello Fault, with its up to 30 meters high scarps cutting the middle-lower slopes of Etna.

Based on the Late-Pleistocene-Holocene offsets, the authors estimate a slip rate of 1.25–2.5 mm/year. In historical times the fault's behaviour has been not uniform along strike. Coseismic ruptures have characterized the northern and central parts (e.g. earthquakes of 1881, 1920, 1950 and 1989) never exceeding intensity VIII MCS. The southern sector has moved mostly by creep. The fault activity, similarly to the other active faults in the area, has caused, and still causes, significant distortions to the communication routes and to buildings. Close to the main fault trace, exploratory trenches were excavated across a secondary graben, above which there is now a rapidly developing industrial settlement. The trenches have allowed to recognize and describe recent secondary ground deformation, very likely linked to the main fault, posing a significant hazard to the buildings resting on it.

Rich is the evidence testifying of the lost of fundamental understanding of the Nature by man in this delicate environment. As pointed out in many other situations, it is plain that the too fast economic growth of the last century is the main responsible for this new ignorance, for which not even disasters appear to be a sufficient cure.

The Tsunami Risk in Lake Como (Italy)

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Lake Como is the deepest lake of the Alps (-425 m below lake level) and with its surface area of 142 km2 the third largest along the southern alpine margin lakes. Its drainage basin is in a central position within the Alpine chain and corresponds to one of the major morphological pathways between northern and southern Europe.

Pursuant to new limno-geological investigations, that combine a bathymetric survey (Multibeam Simrad 3000) with a high-resolution seismic reflection study (single-channel 3.5 kHz) and a coring campaign (gravity short-corer), the sedimentary subsurface of the L ake Como western branch is characterized to the average sediment depth of 50 m. The recorded data show that the western branch of the lake can be subdivided in several sub-basins, that have different characteristics from the morphological, physical and sedimentological point of view. In particular, two areas of great interest are a) the Tremezzo-Bellagio plateau area at the northern end of the Como branch and b) the Argegno deep basin.

The plateau area, located at the northern tip of the Como branch, has a water depth of about 140 m and separates the Como branch from the rest of Lake Como. The high-resolution seismic analyses of this area illustrate that the base of the sedimentary cover is composed of glacial deposits. The morphology of these glacial deposits influenced the subsequent lacustrine sedimentation. The depressions between the glacial deposits were first infilled by onlapping pelagic and laminated sediments locally intercalated with confined mass-flow deposits. In the following phase, pelagic well-layered sediments composed of acoustically finely laminated mud with rare sandy layers draped the glacial deposits. They are also interbedded with sub-acqueous mass-flow deposits.

The interpretation of the bathymetric data highlights the presence of two major scarps along the south-western slope of the plateau. That scarps are clearly mappable also on the seismic data, where reflection truncation testifies the scarps recent activity. Besides, at the base-of-slope, remoulded sediments occur, which show that the south-western slope of the plateau is quite unstable.

The Argegno sub-basin is characterized by an over 10 km long area with water depths of over 400 m, comprising the lake's deepest point with a water depth of 425 m. This sub-basin shows different depocenters, which are filled with onlapping, acoustically well-layered pelagic-type sediments and intercalated turbidite deposits. In particular, two mega-turbidite deposits were detected on the high-resolution seismic lines, each with a considerable volume in the order of 10*106 m3. The estimated ages of these events are extrapolated from isotopic analyses (137Cs, 14C) and sedimentation rates obtained from the short cores. According to the distributions and the thicknesses of these two mega-turbidite deposits, a source area located at the northern tip of the Como branch can be proposed. Based on the morphological and sedimentological characteristics of the area, we suggest that these mega-turbidites resulted from the development of sub-lacustrine landslides along the south-western slope of the plateau area. Possible trigger mechanisms leading to these catastrophic events include overloading of slope deposits, major flood events, significant lake-level change and earthquake shaking.

These megaturbidite events registered in the Lake Como have an extraordinary volume and thickness for the lacustrine environment and represent a major natural hazard. Underwater mass movements in fact, can provoke tsunami and seiches, water oscillations that can cause elevated damage along the lake shore. In the case of Lake Como, the mass movements registered in the sedimentary sequence had their source at the northern limit of the western branch (plateau area). The movement of the flows were longitudinal along the branch and the involved sediments filled the topographic pre-existing depression in the southern part. The mass movements probably had also a consequence on the water column (generation of surface waves). In the central part of the branch, where the water column is of about 400 m, the water movements may have been of less relevance compared to what happened towards the end of the branch near the city of Como, where the water depth is significantly lower (few dozen of meters as average water depth) and where tsunami or seiche waves are likely to form higher amplitudes. In addition,the gently inclinded subaquatic slopes of the Como area, that favour higher wave runup, plus the gentle coastal morphology of the valley plain towards the south both increase the potential hazard since a wave may inundate a large area of relatively low elevation.

Capable Faults of the Eastern Etna Region and Reduction of their Environmental Hazard: An Application of the ITHACA database

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We present the new map of capable faults of the Etna volcano region (Eastern Sicily), compiled within the frame of the ITHACA (Italy Hazard from Capable Faults) project. This project, carried out by APAT-Geological Survey of Italy, aims at building up an updated database and GIS of capable faults (i.e., active faults able to produce significant deformation at or near the ground surface) affecting the Italian territory, analyzed in terms of their seismic and environmental hazard potential.

The eastern flank of the Etna volcano is characterised by frequent, low magnitude and very shallow seismic events. Common hypocentral depths are shallower than 1-2 km, hence within the volcanic blanket, which rests on a relatively shallow clay basement. Therefore, notwithstanding the small magnitude, this seismic activity is able to induce noteworthy ground surface effects. At the same time, frequent creep phenomena take place along well-defined structures, either or not associated to seismic events and/or volcanic eruptions.

Consequently, these surface deformations are commonly interpreted as the result of the interaction between regional tectonics (along the Ibleo-Maltese and Messina-Fiumefreddo fault systems) and local volcano-tectonic and gravitational processes.

The area affected by surface ruptures is bounded to the north by an east-west trending fault system (Pernicana and Fiumefreddo faults) and to the south, in a more subdued way, by the Tre Castagni and Tre Mestieri–Nicolosi fault systems. Such region is slowly sliding toward the Ionian basin (lateral spreading), probably in response both to fault movements along the Ibleo-Maltese fault system and to the periodic pulses of the Etna magmatic chamber.

This sector of the volcano apparatus is sharply characterized by NNW-SSE trending tectonic terraces, tens to hundreds of meters high, generated by normal to normal-dextral faults belonging to the so-called Timpe system. Being these faults well-aligned with the northern projection of the Ibleo-Maltese fault system, many authors, ourselves included, consider them as part of it. This has relevant implications in terms of the local seismic hazard, considering that the Ibleo-Maltese fault system is the suspected source of the 1693 M 7.4 earthquake, giving the possibility for much deeper and energetic seismic events in the Etna region, as indicated also by the 1818 M 6 earthquake.

Coseismic surface faulting events and creep phenomena (not always clearly understood by local administrations) are responsible for heavy effects on human structures, such as buildings, roads, railways and lifelines. For example, the survey of the ground effects caused by the 2002 volcano-tectonic events, jointly performed by APAT and the Sicilian environmental agency (ARPA) has pointed out many damages to the water supply network.

To provide a useful tool for the reduction of the environmental effects of faulting, APAT is now compiling a georeferenced database, where capable faults and water supply as well as other environmentally-sensible networks can be overlapped and intersections (zones of expected peak damage and failure) easily evidenced.

Preliminary Volcanic Hazard Evaluation on Mount Etna (Italy) Based on Geological Map and GIS Analyses

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This paper proposes a methodology beginning from the geological map—and using GIS analyses—in order to assess the hazards associated with lava flow activity. The examples here presented derive from a new detailed geological map of Mount Etna's eastern flank. In the recent history of Etna volcano over the last 15,000 years it is possible to distinguish, through the application of high-resolution stratigraphy, more than 130 lava flows along the eastern flank. These field data have been organised into a geographical database in order to enable GIS analyses for hazard evaluation to take place. We have combined geological and digital topographic data, with the locations of human settlements, to create maps showing the interactions between human activity and recent eruptions of Etna. We use this as an analytical tool to assess Etna's future effusive volcanic activity.

Results of this study suggest that the whole area studied is part of the lava flow expansion basin of Etna and that no settlements may be considered really safe in the middle-long term. A preliminary and qualitative hazard map showing effusive activity and lava flows invasion on Mount Etna volcano can be assessed by geological data modelled using GIS software. This GIS methodology can be applied to other volcanoes with similar eruptive styles.

The Dark Side of the Nile: Catastrophic Nile Floods and Human Respones in Ancient and Historical Times in Egypt

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A series of severe droughts ca. 4200 BP led to famines, strife, and the dissolution of centralized government in ancient Egypt. Following an initial episode of shock and upheaval, localized efforts to revive political coordination and management of Nile resources led to the re-emergence of centralized government on the basis of new ethical, social, adminstrative and technical platforms. Eyewitness accounts of droughts during the 10th and 12th centuries AD provide an insight into the social respones to catastrophic Nile floods in ancient times.

Rapid Caspian Sea Level Change, and How to Prepare for Natures Trend Breaks

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Three times in the last century Caspian shore dwellers were caught by surprise. In 1929 Caspian Sea level, until then rather stable at -26 m below oceanic level, unexpectedly started to drop strongly, over two metres in less than fifteen years. Harbours silted up, rivers extended their courses downstream, wetlands desiccated, and sturgeons hardly could reach their spawning grounds anymore, recalling disasters like that of the Aral Sea in the more recent past. Plans were made to divert northwards flowing rivers in northern Russia and Siberia towards the Caspian, and a dam was built to isolate Kara Bogaz Bay from the Caspian. Scientists predicted sea level fall would continue. But in 1977, when sea-level had dropped already three metres, the Caspian suddenly started to rise, at a rate of 13 cm per year, a hundred times the present eustatic sea-level rise in the oceans. Relief soon turned into concern. Villages were inundated, people had to evacuate, infrastructure built on recently emerged terrain was destroyed, soils suffered salinization, wildlife habitats drowned, and Kara Bogaz Bay was hastily reopened. Plans were made to divert sea water to the drying Aral lake. Scientists predicted that sea level would continue to rise. But in 1995 sea level, now back at -26 m as in the twenties, suddenly started to drop again, stabilizing around -27 m in the last ten years.

The causes of Caspian Sea level change are as yet ill understood. Influx from the Volga river, accounting for 80% of the input side of the water balance, and evaporation at sea level on the output side, are controlled by different climatic zones. Short-term cycles such as the 1929–1995 cycle may be forced by internal atmospheric processes such as the North Atlantic Oscillation. But in historic times oscillations of much higher amplitudes have occurred, from -22 m during the Little Ice Age to -34 m, or possibly even -48 m in the Warm Mediaeval Period, an amplitude of 12–26 metres in less than millennium, possibly synchronous to cycles in solar activity. There was an Early Holocene lowstand at -80 m, and a Last Glacial highstand at +50 m, an amplitude of 130 metres in probably not more than 20,000 years. Unlike elsewhere in the world, present Caspian shores are somewhere halfway the most recent highstand and lowstand. In spite of the great advances in understanding of our climate system, in spite of the predictive power of our Global Ciculation Models, in spite of the accurate monitoring by detailed monitoring by satellite systems such as Topex-Poseidon/Jason, opinions about future Caspian sea-level trends diverge.

Nature has three ways of time keeping: time's arrow, time's cycle and time's spike. Time's arrow refers to one-directional processes such as radioactive decay and the deceleration of earth rotation by tidal friction through geological time. Time's cycle refers to often astronomically forced cycles such as tide, day and night, the seasons, and the climatic cycles of different amplitudes and duration; time's spikes are the unexpected catastrophes such as earthquakes, volcanic eruptions, sudden floods, often derived by non-linear processes from cyclic ones such as plate tectonics and astronomically regulated changes in energy input at different latitudes at the earth's surface.

Caspian shore dwellers have experienced what we tend to forget: that climate and sea-level changes are cyclic processes, some of them at human time scales like the Caspian, but often at greater-than-human scales: on Nature's time scales. If we are prepared to see the present period of global warming as part of time's cycle, or even as a short spike in Nature's time, if we try to look beyond the future global sea-level highstand, Nature might look less dark to us.

Debris Avalanches and Cryptodomes Offshore Vesuvius (Italy): Consequences on the Natural Environment

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One of the most important natural catastrophic events is the episodical huge sector collapse of volcanoes. Such slope failures produce high velocity debris avalanches that can move for distances exceeding 10 km. Oversteepening of the flank causes by cryptodome intrusion is one of the more common invoked triggering factor for flank collapses. Sometimes, as in 1980 on Mount St. Helens, such flank collapses can trigger the explosive eruption of rising magma column, suddenly depressurized by decapitation of the volcano. Several historic breached crater eruptions have resulted in fatalities, many from tsunamis produced by debris avalanches entering the sea from coastal volcanoes. Vesuvius, located in southern Italy close to the continental shelf of Naples Bay, is an active volcano that grew within the breached crater of Monte Somma. The interpretation of core data and high-resolution seismic profiles offshore of Somma-Vesuvius documents interlayered volcanic and marine units in the Late Quaternary succession. Two thick debris avalanche deposits were identified and mapped on the continental shelf. The identification of cryptodomes and two debris avalanches originating from Somma-Vesuvius are fundamental evidences of two flank collapses in the volcano history. Probably shallow intrusions (cryptodomes) steepened the south side of the Monte Somma causing it to be unstable and catastrophic landslides gave rise to the breached crater of Monte Somma and a chaotic landscape that extended into Naples Bay. In particular, the younger debris avalanche has a volume of approximately 1 km3 and is linked to the 3.5 ka Avellino plinian eruption. The products of the Avellino eruption cover an areas of approximately 2000 km all around the volcano and destroyed the Ancient Bronze Age settlements belonging to the facies of Palma Campania.

The 1669 Mt. Etna Eruption: Scientific and Social Reactions

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In 1669 Mt. Etna erupted continuously for three months and affected a large territorial area, including Catania and several of the surrounding villages: moreover the lava flow also reached the sea. It was one of the greatest eruptions from Etna ever recorded until that time and was of great interest to both the scientists and the people living in the area, obviously for different reasons.

The scientists of the time studied the eruption, in particular the Neapolitan scholar Giovanni Alfonso Borelli who described the event in the "Historia et meteorologia incendi aetnaei", published in Reggio Calabria in 1670. This was a result of the effects of the so called "scientific revolution" taking place in the second half of the 17th century which included also the study of natural phenomena.

The local communities affected by the eruption were highly concerned due to the dimension and the seriousness of the phenomenon itself.

This paper will present and analyse some of the various reactions to such a catastrophic event.

The Impact of Mega-floods in Mozambique

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Floods are the most common type of natural disaster in Mozambique due to its climate irregularity and unique drainage. The climate is predominantly tropical with two seasons: the wet and dry. Cyclones occasionally hit the country during the rain season exarbating the rainfall amounts, causing often widespread flood hazards. The catchments areas of the main Mozambican river basins extend over into the neighbouring southern African countries and these find their way to Indian Ocean through Mozambique. In early 2000, as it was world-wide broadcasted, the coastal and lowland of southern Mozambique experienced a period of catastrophic floods of the last 50 years, due to the heavy rains, Eline cyclone and high water flow from the upper catchments. The floods claimed more than 700 lives mainly along the Limpopo River, more than 250000 people were displaced from their homes, and economic infrastructure, such as roads, railways and agriculture land were lost. The total coast, flood damage and relief works were equivalent of about 25% Mozambique's GPD. Floods are integral part of hydrologic cycle and they are recurrent events, therefore, they will strike over and over again. To estimate the frequency of these floods is very difficult due to limited time period covered by instrumental meteorological data, and uncertainties from sampling floods periods. One possibility to expand the record of past catastrophic floods is the analysis of the sediment record that has the potential to archive such event. Mozambique hosted the ICSU: Project Dark Nature workshop on the impact of mega-floods-how to identify mega-floods in palaeorecords in November 2004. The meeting focused in particular on the frequency and impact of recent and sub-recent mega-floods and flood action programmes, including field trip to 2000 flood plains of the Limpopo and Incomati flood plains, and the areas destroyed by fluvial erosion in Maputo, as well as the study of a sediment core from the Incomati flood plain. The coring site was selected due to the fact that Incomati River floodplain is inundated periodically by the overbank flow, and store sediments which are washed from the slopes of the red inland sand dunes. The retrieved core is predominantly grey to very dark grey in colour with organic matter (root leaves) at the surface, followed by sticky clay with brown mottling spots and buried reed fragments. The buried reeds were fresh, and were found pending to certain angle. The sediment pattern in the lowermost part of the core is predominantly sticky clay with a layer of organic matter at deep of 140–145 cm. The organic dark layers showed fire disturbance, and are interpreted as buried top soil. The pending reeds were forced by overtopping flow into the floodplain. The discussions in the field, as well as the study of the sediment core lead to an understanding of what kind of sediment to look for, and where to look for sediments.

Recent Left-oblique Slip Faulting in the Toluca City Area (Trans-Mexican Volcanic Belt). Seismic and Volcanic Hazard Implications

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The Trans-Mexican Volcanic Belt is an east-west active volcanic arc related to subduction along the NW-SE Middle American Trench and characterized by seismicity and Holocene synvolcanic arc-parallel faulting. Major intra-arc faults within the central part of the volcanic belt were described by previous authors. The Tenango Fault, trending east-west and bounding the intra-arc Lerma Basin, was considered one of the most important faults and characterised only by Holocene normal movements. The Tenango Fault shows a clear morphological trace more than 50–60 km long, cuts in the middle the Nevado de Toluca volcano edifice, and is composed of some segments and a narrow graben. Several morphostructural and field evidences indicate activity of this fault at least in the last 50,000 years, particularly in the Holocene. The strike and geometry of the fault segments from satellite and aerial photos suggest a predominant transtensive left-lateral kinematics. Field work focused on Holocene fault movements, including trenching the fault trace, reveals displacement of volcaniclastic deposits and lava bodies as long as man made infrastructures. The structural stations analyzed confirm a predominant left lateral strike-slip motion with an associated extensional component of the Tenango fault; the estimated horizontal slip rate is about 0.3–0.5 mm/year. Relationships between volcanism along the Tenango Fault and its kinematics demonstrate the influence of the regional tectonic on the evolution of a continental volcanic arc. Particularly, the Tenango Fault controls the emplacement of the fissural lava flows of the monogenetic Chichinautzin volcanic field and the growth, destabilization and collapse of the recent summit dacitic domes of the Nevado de Toluca volcano. Moreover, the movements of the Tenango Fault cause an important seismic hazard in the intra-arc Lerma Basin, where several towns, including Toluca city with more than 1 million of inhabitants, are located; the basin is filled by lacustrine and unconsolidated volcaniclastic deposits.

Tsunami and Rapid Catastrophic Environmental Change. The Hazard Along the Italian Coastal Area

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A research about the geoenvironmental impact of the 26 December 2004 tsunami, evaluating local morphology, run-up and waves provenance, has been carried out. In the northern part of Sumatra, in Thailand and in the oriental zone of the Sri Lanka, the long wave of the tsunami has been of over 1500 ms of amplitude, with a middle height from about 5 ms to over 10 ms.

Marine water's volume flowed on the earth has been enormous and the sandy water endowed with notable speed and discharge rapidly transformed into debris flow. On thousand meters the coast have been invaded, in few ten seconds, from about 2.500.000 to 5.000.000 of cubic meters of water, with a discharge of about 50.000–100.000 mc/sec, equal to 5–10 times the course of the Po River when it is in flood.

A normal big wave that invests the Mediterranean coast during a violent sea storm has a middle amplitude of about 20 m and a height of about 5 ms. The volume of water invading the coast is about 50 cubic meters in about 2 seconds with a discharge of about 25 mc/sec for every meter of beach. The wave of the tsunami, for every meter of beach, has poured on the emerged area about 5000–10000 meters cubes of water with a varying discharge from around 25 to 50 mc/sec for an inclusive period between 60 and 120 seconds. The most frequent geoenvironmental impacts has been: Destruction of the beaches predominantly constituted by bioclastic sand; Soil Erosion; Soil and water table salinisation; Accumulation of sand and brackish mud on the emerged earth; Partial destruction of the coral barriers.

The disastrous tsunami that has devastated the coasts of oriental south Asia has also lifted a general interest in Italy. Till now the available data underline that also the Italian coasts at greater risk (affected by many disastrous tsunamis during the last 900 years) are not protected by planning finalized to prevent and to limit the damages, especially during the bathing period. Within the research it has been simulated the impact possible today in the same places (Messina Strait) affected by the 1908 tsunami. Remembering the images of the effects of the 1908 tsunami and of the recent event of Indian Ocean, the seriousness of the connected risk to tsunami is evident.

A recent research allowed us to reconstruct the cause of the disastrous 1908 tsunami that followed the 1908 earthquake that devastated the provinces of Reggio Calabria and Messina provoking about ten thousand of victims. On the base of accurate historical researches has emerged that the tsunami affected the coasts of the epicentral area about 10 minutes after the earthquake. Considering the brief distance among the two banks of the Messina Strait (2 km) and that the seismogenic structure has been situated in the submerged area, it is impossible that the coseismic deformation directly caused the tsunami. In few second, in fact, the waves would have invaded the Sicilian and Calabrian coasts. We concluded that the cause of the tsunami must have been a big and rapid submarine landslide happened south of Reggio Calabria in the zone where the run-up has been maximum (more than 10 meters).

The 30 December 2002 Stromboli tsunami and the December 1908 Messina Strait tsunami permitted to reconstruct the speed of tsunami wave propagation along the Italian coasts; it results of about 100 km/h for the Stromboli tsunami and of about 120 km/h for that of Messina Strait. Such values are significantly lower than the speed of propagation of the oceanic tsunamis like that of December 26th 2004, characterized by a speed of about 600 km/h.

About 70 tsunami affected the Italian coast during the last 900 years. They affected the following areas: 14 between the Liguria and southeastern France; 23 between the Strait of Messina, oriental Sicily, southern Calabria Aeolian Islands; 10 along the Adriatic coasts; 9 in the Gulf of Naples; 3 in Tuscany; 2 in northern Sicily (Palermo–Cefalù); 2 in southern Sicily (Sciacca); 1 in ionic northern Calabria; 1 in the Lazio. This research has allowed to map the coast that till now have been interested by anomalous and sudden movements of the sea; it's possible to underline that the most greater number of events has been provoked by submarine landslides affecting the unstable edges of the continental shelf.

On the base of the data till now available it is possible to delineate the Italian coastal areas exposed to major tsunami hazard.

Assessment of Heavy Rainfall-induced Natural Hazards in Alpine environments: The Experience of the Interreg III-B Project CatchRisk

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In the last years the Alpine area may have experienced an intensification of flood and slope instability phenomena caused by an increase in frequency and intensity of heavy rainfall events, leading to territorial damage and losses of human lives.

Several Alpine regions have developed different methodologies to assess the hazard and risk of events which are linked to heavy rainfall, such as floods, superficial landsliding, debris flows and rockfalls. The demand of an exchange of know-how arose among the Alpine regions; it should enhance the creation of operational tools of common hazard assessment procedures and territorial management that can be applied on catchments with different characteristics and in different contexts in the Alpine space.

In 2002, the European Community launched the project Catchrisk, which was realized within, and partly financed by the European Interreg III-B Alpine Space initiative. The project's main goal was to enhance the communication between the regions of the Alpine space and to create common approaches for the definition of hydro-geological risk scenarios on the scale of hydrological catchments, their alluvial fans and main river courses. Particular attention was given to mass transport processes, such as rockfalls, shallow landslides, debris flows and river floods.

Within CatchRisk, where representatives of 11 regions of the Alpine space from 4 nations cooperated, the topics were addressed to assess—among others—flood hazards, the triggering of shallow landslides, debris flow expansion on alluvial fans and the reach of rockfalls. A particular effort was done to develop methodologies within GIS (geographical information systems) environments and to define risk scenarios. The efforts had the main final goal to mitigate the impact of these natural hazard phenomena on the territory and draw conclusions on the land use. The knowledge exchange and results of CatchRisk are documented in a scientific report and in guidelines for public administrations and professionals.

In this presentation the project CatchRisk is outlined, focusing on its main goals: interregional exchange and communication and presents some of the developed tools for hazard and risk assessment within hydrological catchments, alluvial fans and main river courses—the model environment of the Alpine space.

Particular attention is given to the activities developed in the working group which concentrated on the processes, which develop within a catchment basin: rockfalls, superficial landslides and debris flows. The reach of rockfalls was assessed using a statistical approach, the method was implemented in a GIS environment. The triggering of superficial landslides was studied using a regional model based on a statistical approach. Also, GIS-models were developed and implemented to study the triggering of superficial landslides, based on a geotechnical-hydrological raster model. A debris flow monitoring and alert system was installed on a catchment basin prone to this type of hazard.

Geotechnical Characterization and Modeling, Via Particle Method, of the Sciara del Fuoco Volcanic Debris, Stromboli Island, Italy

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The Stromboli island is one of the most active volcanoes in the world; it belongs to the Aeolian Archipelago in the Tyrrhenian sea off the Italian southern coast. It rises approximately 2.6 km above the sea floor with the summit at 924 m above the sea level. In the past 100,000 years, Stromboli has evolved as a complex stratovolcano. Its structural evolution has been complicated by destructive phases as vertical caldera collapses, gradual slope erosion and four large sector collapses affecting the NW flank (Pasquarè et al. 1993; Tibaldi, 2001), which alternate with growth phases. These collapses resulted in the creation of the Sciara del Fuoco horseshoe-shaped depression.

Our interest has been focused on local and general stability of the Sciara del Fuoco recent volcanic debris, that can be mobilized evolving in granular flow running along the Sciara del Fuoco into the sea, in relation to the present volcano activity. These debris consist of ejecta, ranging from meter-sized bombs to lapilli and ash, related to the recent volcanic activity. They appear unconsolidated to depths of some tens of meters with a slope at the limit equilibrium angle. These loose deposits represent a potential unstable mass that can be mobilized evolving in granular flow running along the Sciara del Fuoco into the sea. This phenomenon can lead to the formation of tsunami waves that can easily reach the Stromboli and Ginostra villages, as occurred in the latest landslide events of December 2002 and January 2003.

This paper presents the first steps toward the stability analysis of volcanic debris via numerical modeling: 1) geotechnical characterization of materials 2) calibration of the numerical model based on experimental geotechnical data.

1) The involved materials has been characterized by the following activities; a) sampling of materials collected at depth between 0–1 m at the base of the Sciara del Fuoco depression and in the summit area and, for comparison, in the Fossetta and Rina Grande-Schicciole depressions, where similar phenomena has been registered, b) measure of physical properties by standardised laboratory tests, c) consolidated-undrained triaxial compression tests. According to the Unified Soil Classification System (U.S.C.S), the studied deposits consist mainly of gravel and sands (SP or SW), with a coefficient of uniformity $CU < 7.3$; without silt or clay fractions. The natural water content is $W < 6.3\%$; the specific gravity of the solid soil particles is Gs=28.5–30.2 kN/m3; the maximum and minimum dry unit weight, determined from the grain size fraction less than 9.5 mm are, respectively, 12.9–14.8 kN/m3 and 16.6–17.4 kN/m3, from which porosity has been computed n=40–55%. Consolidated-undrained triaxial compression tests yield for the peak and residual values of cohesion and shear strength angle: peak values cp=0, phip=43°–51° and residual values cr=0, phir=39°–49°. The reported values do not account for the grain size fraction larger than gravel.

2) Calibration of numerical model. The volcanic debris has been analysed by the distinct element theory and in particular the two dimension-based code Pfc2d (Itasca), defined as a discrete element code on the classification of Cundall and Hart (1992), has been chosen. The code allows finite displacements and rotations of discrete bodies, including complete detachment, and recognizes new contacts automatically as the calculation progresses. In this study it has been assumed that the debris behaves as an assembly of rigid particles whose movement depends on the inter-particle forces acting at each contact.

In order to create a conceptual model which well represents the actual rheology of materials and its influence on slope dynamics, a set of biaxial tests upon the synthetic material has been simulated by numerical modeling and compared with the experimental triaxial compression tests (Dolezalova et al 2003). To define the numerical model, the 2d porosity has been calculated from the 3d experimental porosity (Hainbuchner et al 2003), considering the particle size distribution obtained by the laboratory grain size analysis. The sensitivity analysis has been focused on finding the particle mechanical parameters that better represent the rheology of the volcanic debris at the macroscopic scale. The deformation in granular synthetic material is controlled by the normal and shear contact stiffness (kn ad ks), and the shear strength is mainly controlled by the material 2d porosity, particle size distribution and particle friction coefficient (μ). The relationship between the particle friction coefficient and the overall material friction angle is not yet well defined in literature (Oger et al. 1997). The analysis confirms that a specific correlation must be determined for different materials as a function of the acting stress state and taking into account the scale effect. This relation represents the first goal in modeling debris slope instability by particle numerical methods.

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Flood-dominated Fan Delta System Induced by the A.D. 79 Somma-Vesuvius Eruption at Amalfi Coast, Southern Italy

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The Stream Canneto and the adjacent Stream Dragoni have deposited a coalescing fan delta system along the sidewall of Amalfi Coast, a rocky coastal area on the southern side of the Sorrento peninsula. The submerged delta system has an area of about 7 × 105 m2 with a delta-front gradient averaging 25–27° to water depths of 50 m, about 500 m from the shore. The intertidal and supratidal delta are narrow areas where the settlements of Amalfi and Atrani developed because of water resources and low topographies.

Both Streams drain high-relief basins and have high-gradient steep-sided profiles cutting into carbonate bedrock discontinuously covered by reworked fallout deposits of the A.D. 79 Somma-Vesuvius eruption. These latter occur as well lithified flood/landslide accumulations (locally called Durece) up to 40 m thick along the Stream valleys.

Large floods and sliding phenomena have frequently occurred in this area, suggesting rapid slope morphodynamics. Slides are triggered by intense rainfalls over a range of magnitudes, inducing displacement of the sedimentary covers rapidly flowing down slopes (earth/debris flow). These events induced severe flood-flow in the main Streams: the first delivery area for the displaced materials then ultimately transported to the delta area and adjacent inlets. Indeed, the floods also caused major damage to property and loss of livelihoods, as testified by historical analyses, a mandatory step for the evaluation of the hydrogeological hazard.

Side-scan sonar imagery, multibeam bathymetry, ultra-high resolution seismic profiling and diving inspections on the subaqueous delta area, allowed for reconstruction of morphology and patterns of sediment distribution indicative of high energy sediment transport processes. Seaward of the main subaerial channels, clinoforms composed of coarse sand, gravels and submetric boulders, prograde towards deeper water. At shallow depth they crop out at seafloor, otherwise they pass upward into "massive" deposits about 2 m thick, by means of an unconformity surface. At present, the upper slope of the subaqueous delta is characterized by hard grounds and mattes of living Posidonia Oceanica, testifying a reduced flood control. A volcaniclastic level found offshore in core samples and recognized elsewhere as the underwater expression of A.D. 79 fall out event, develops at the base of the prograding units thus providing a lower chronological constrain.

The discovery of a fan-delta system offshore Amalfi coastal area testifies the recurrence of extreme floods as a consequence of the famous A.D. 79 Somma-Vesuvius eruption. These events were mainly fed by unstable accumulation of volcaniclastic fall-out deposits on a steep rocky coast, and induced a maximum seaward shift of the shoreline of about 500 m. The emplacement of the Amalfi fan-delta implied very critical conditions for human activities, lasting many decades after the destructive A.D. 79 eruption and after, as testified by flooding events occurred over the last century in this area.

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Earthquake Ground Effects, Seismic Hazard, and the INQUA Scale Project

Seismic Hazard Assessment for Guayaquil City (Ecuador): Insights from Quaternary Geological Data

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Guayaquil City, the chief fluvial and maritime Port of Ecuador, is located in the estuarine zone of the lower Guayas River Drainage Basin (South of the Ecuadorian Seaboard). This city has the largest urban residents with 2.156.636 inhabitants (Source: INEC, 2001); and together with Quito, the Capital's Nation city represents the 80% of the Industrial Production. However, this industrialized city is threatened by free from earthquakes. In fact, its closeness with significant seismogenetic structures makes it highly susceptible to tectonic events. The few available seismic hazard studies for the area of Guayaquil have been based essentially on seismological data. These studies have analyzed: (1) damage estimation to residential buildings (i.e., houses, schools, hospitals, etc.) (Argudo et al., 1993); (2) life-loss estimation models to the chief urban areas; and (3) assessment of Guayaquil seismic hazard through an adopted seismogenetic structure capable of generating large earthquakes. For instance, the Radius Project (Radius Project, 1999; http://geohaz.org/radius/LACont.htm) selected as reference structure the Subduction Zone, capable of generating magnitude 8 earthquakes, and located about 200 Km NW of Guayaquil.

In this paper, we discuss the contribution that detailed geological data can provide to the seismic hazard surveys of the area of Guayaquil city. We reviewed in detail the main seismic events that struck the study area and described capable seismogenetic structures through historical seismic data (implement it to the GIS tool); which will be applied to understand the actual situation of Guayaquil and its possible ground environmental effects as a consequence of moderate to strong earthquakes. For this study, we made a GIS database composed of 939 instrumental and historical intensity data (in the range of MM Intensity VI–XI) measured in 122 Ecuadorian seismic events (from 1557 to 2000). Information on these events has been provided by CERESIS Seismic Intensity Catalogue (www.ceresis.org/new/es/index.html), and from Web pages of some governmental entities (www.igp.gob.pe; www.igepn.edu.ec).

The most destructive historical earthquake that struck Guayaquil (with MM IX) occurred on 14th May 1942 (Mw 7.8), causing moderate to high damage in the central urban area (Argudo et al., 1993). The earthquake occurred near the subducting Carnegie Ridge off the coast of Ecuador, where the Nazca Plate subducts beneath the South American Plate. The instrumental epicenter was located up to 240 Km NW from Guayaquil city.

Moreover, other seismogenetic structures have also generated significant earthquakes that struck the area causing moderate to high effects to the Guayaquil suburban and urban sectors. The most representative are:

(A) The 9th July 1653, Guayaquil earthquake: it was located in the surrounding of the current city with MM Intensity of VII. Previous seismic hazard studies have not mentioned this event, perhaps, because of the scarce information available in the historical record.

(B) The 18th August 1980, earthquake (Ms 6.1) whose instrumental epicenter was located up to 28 Km NW from Guayaquil, with MM Intensity measured of VII-VIII. Seismic shaking was felt very strongly in the center and southern part of the city. For their epicentral locations, both the 9th July 1653 and the 18th August 1980 earthquakes could be tectonically linked to the active Colonche fault and to a potential Quaternary uplifting of the Chongon Colonche Ridge.

(C) The 12th Dec 1953, Tumbes earthquake (Northwest Perú and South Ecuador, Ms 7.3), whose instrumental epicenter was located up to 155 Km SW from Guayaquil city, the MM Intensity measured for Guayaquil was of VI–VII (Silgado, 1957). The possible seismogenetic structure which generated this seismic event is still not well defined. Based on our surveys, this earthquake could be linked to the Jubones-Tumbes Fault or to the capable Amistad Fault (see also the other Abstract by Chunga et al. in this vol.).

(D) The 27th July 1971, earthquake (Ms 7.5), whose instrumental epicenter was located up to 290 Km SE from Guayaquil, is the most distant event that produced significant effects in Guayaquil, with MM Intensity of VII. This event could be linked to the Macuma reverse Fault (Prov. Morona Santiago).

(E) The 4th February 1797, Riobamba earthquake (epicentral MM: XI): is considered as the strongest historical earthquake recorded in Ecuador (www.igepn.edu.ec/sismologia/sismicidad/-historica/efectos.htm). The instrumental epicenter was located up to 150 Km NE from Guayaquil city. The MM Intensity in Guayaquil has not been measured neither studied in detail (e.g. Argudo et al., 1993). This event has been attributed to the capable Pallatanga strike slip Fault (this fault crosses the western Andean Cordillera and joins the Gulf of Guayaquil), which is characterized by slip rates ranging from 1 to 5 mm/yr (USGS, 2003; http://pubs.usgs.gov/of/2003/ofr-03-289/). This large seismic event should be taken in account for future detailed paleoseismological studies, inasmuch as, its closeness to the Continental Megashear (composed by a right-lateral fault system about 2200 Km long, extended from the Gulf of Guayaquil, on the Pacific coast until the surrounding of Caracas, on the Caribbean coast) makes it an excellent test site.

All these historical facts emphasize the importance of understanding the main ground natural effects caused by earthquakes, such as: natural subsidence or acceleration of anthropogenic subsidence (at present day, this last phenomenon is observed in the southwest sector of Guayaquil), ground cracking, liquefaction or settlement of soils, massive rockfalls and landslides and other effects common to earthquakes that have occurred in similar geologic settings. In fact, the lithologic characteristics of the soil on which Guayaquil lies is very uneven. For instance: (1) the commercial and urban center rest on unconsolidated Holocene alluvial clay deposits interbedded with silty and clayey sand sediments; (2) the southwestern and southern part of the city, where it is concentred the less developed urban area, directly lies on filling in marshland; (3) in the northern part of the city: a) the residential areas rest on consolidated stratified silt siliceous deposits, belonging to the Guayaquil Formation (Danian age, Cretaceous–Tertiary contact) and as well upon volcano–sedimentary successions appertain to the Cayo Formation (Late Cretaceous age); b) the marginal urban areas lie on unstable foothills; and c) in the Kennedy Norte residential zone, large buildings lie on soft-sediments. Indeed, these lithologic characteristics would create suitable conditions for amplification of ground motions.

Therefore, for assessing the impact of seismically-induced ground effects in natural environment, we recommend to apply the new INQUA Intensity Scale which could be a powerful tool for the engineering community, allowing to properly taking into account the geological setting and the geotechnical aspects in the seismic hazard surveys.

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The 12 Dic, 1953, Earthquake, Ms 7.3, Ecuador-Peru border region: A Case Study for Applying the New INQUA Intensity Scale

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The INQUA Scale is a newly proposed Macroseismic Intensity Scale, based solely on Earthquake Environmental Effects (EEE). This Scale has been discussed during the two Local Meetings carried out in Guayaquil, Ecuador. One of the points raised throughout the Meetings, was the importance of post-earthquake damage assessment. Moreover, we briefly reviewed the modern anti-seismic building codes, in order to reconsider data relative to damage on buildings and make them confrontable with those of historical earthquakes. It's obvious, in fact that ancient buildings were constructed with different engineering standard from present ones. Regarding the INQUA Scale, the participants, technical and scientific community, has considered this new Scale as an excellent tool for the environmental analysis of past and contemporaneous Ecuadors earthquakes.

Indeed, the closeness of the Ecuador to the Subduction Zone (where the Nazca Plate subducts beneath the South American Plate) and the significant active and capable seismogenetic structures that affect the continental block, make it highly susceptible to tectonic and tsunamigenic events. Historically, from 1557 to 2000, 122 seismic events have been reported in Ecuador (in the range of MM Intensity VIXI). The following earthquakes generated important tsunamis along the Ecuador's coastal range: (A) The 31st Dec 1906, earthquake, Ms 8.8, located about 138 Km W from Tortuga, Prov. Esmeraldas. This earthquake is classified as the sixth largest earthquake worldwide in the past 100 years. (B) The 2nd Oct 1933, earthquake, Ms 6.9, located offshore from Peninsula Sta. Elena. (C) The 12th Dec 1953, earthquake, Ms 7.3, located up to 23 Km NW from Tumbes, Peru–Ecuador border region. (D) The 19th January 1958, earthquake, Ms 7.8, Ecuador–Colombia boundary. (E) The 12th Dec 1979, earthquake, Ms 7.9, located offshore from San Lorenzo, Ecuador-Colombia boundary. (Espinoza, 1992; Chunga et al., 2002).

Information about several earthquakes was recompiled in order to apply the INQUA Scale. In particular, we have selected the 12th Dec 1953, earthquake (Ms 7.3) as a sample event, because of two reasons: (a), the necessity to improve the information available for this event in Ecuador, and (b) the bibliographic documentations retrieved, that provide us an excellent description of the ground environmental effects in several cities close to the epicentral area (i.e., Silgado, 1957; www.vivatumbes.com/tumbes_1925/Terremoto.htm). The 1953 earthquake, struck the South Ecuador–Northwest Peru border region at 12.31 am local time, with 7.3 Ms magnitude and VII-VIII Intensity (MM-1931 Scale) (Silgado, 1953). Its epicenter was located offshore 23 Km NW from Tumbes and 155 Km SW from Guayaquil. The maximum intensities was felt in Tumbes–Corrales–Celica, respectively.

In the Tumbes and Corrales populations (Perú), 6 dead and at least 20 injuries were reported. Many local witnesses perceived a time shaking of about 40 seconds. Numerous material damages to both, Peruvian (San Juan, Zorritos, Santa Cruz, El Alto y Talara) and Ecuadorian (Gonzamaná, Celica, Azogues, Malacatos) villages occurred. Minor damage was reported in the Guayaquil city. Still, the tectonic source of this event has not been well-defined. According to our preliminary surveys, it seem possible to suggest a linking with either active faults (Jubones–Tumbes or Amistad) close to the epicentral area, associated to the compressive geodynamic model of the Subduction Zone. The Isoseismals of this earthquake were elongated about NW–SE (see Intensity Map of Silgado, 1957), almost parallel to the trend of the Jubones–Tumbes fault. For its closeness to this seismogenetic structure, and for its similar structural trend, the 1953 earthquake, could have direct relationship with the fault previously mentioned.

The documentation retrieved (Silgado, 1957) gave us an well description on the ground environmental effects accompanying the 1953 earthquake. The most significant effects occurred at the following sites: (1) large and deep cracks affecting alluvial soil with NW–SE trending reached up to 40 cm wide at Tumbes, on the Panamericana road, and up to 1.5 m wide between Zorritos and Tumbes; (2) significant liquefactions in alluvial sediments were observed in the Puerto Pizarro estuaries and other localities; (3) dry springs were activated in the Quebrada Bocapan; (4) significant earthquake fountains, 60 cm high, and sandy ground cracks with E–W trending were generated in the Puerto Pizarro seashore; (5) small landslides affecting loose sediments were frequent in the epicentral area, among them: El Alto, the surrounding of Zorritos, and many other villages along the Tumbes River canyon and flat settings. Small tsunamis with run-up heights of 20 cm were reported in La Libertad, northern coastal of the Peninsula St. Elena (Ecuador), about 138 Km NW from epicenter (Espinoza, 1992). Based on these field reconnaissance, carried out by Silgado (1957), and on our preliminary assessment, INQUA Intensity of IX should be well assigned to Tumbes and one INQUA Intensity VIII to the Corrales (Perú) and Celica (Ecuador) settings.

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Applying the INQUA Scale to Some Historical and Recent Peruvian Earthquakes

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This is a first approximation using INQUA scale to evaluate Peruvian earthquakes. Different macroseismic intensity scales were used to evaluate historical and instrumental seismicity, these scales are based on the damage caused during a seismic event, human observations, and a few effects in the nature. MM (Modified Mercalli Intensity Scale) and MSK-64 (Medvedev-Sponheuer-Karnik Intensity Scales) are more used in Peru but these intensities scales can not be used in uninhabited places, then the INQUA scale can be a valid tool to use in all places, taking into account the geological features too.

Historical intensity data are available for the most significant events occurred in Peru but this information is only available from 1471 after Spaniards arrived to Peru, these intensity data were used to estimate the magnitudes and rupture lengths for historical earthquakes.

Recently, the historical earthquakes were re-evaluated using MSK-64 scale and from 1979 the Geophysical Institute of Peru uses MSK-64 scale with a form of survey addapted by Ocola (1979) to Peruvian reality.

Peru is located in an active tectonic zone, most of the seismicity being produced from the subduction process when the Nazca Plate is subducting below the South American Plate. Nevertheless, many earthquakes are caused by crustal deformation and geological fault reactived originating great intensities. In this work was we used the INQUA Scale to evaluate 15 earthquakes occurred from 1687 to the present time, these earthquakes have more information and their sources are subduction or geological fault. A first testing with two earthquakes was used in Huancayo (1969, 6.0 Mw, h = 40 km) and Moyobamba (1990, 6.6 Mw, h = 24 km, and 1991, 6.5 Mw, h = 20 km) events, both earthquakes were generated by geological fault reactivated.

From the point of view of seismic engineering, it is necessary to have a real seismic zonation considering geological and ground features in each region of Peru, we considered the INQUA scale jointly with the other intensity scales, it will be a valuable contribution to be considered in future building codes.

INQUA intensity Scale Evaluation for the 1980 Southern Italy "Historical" Earthquake

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Within the framework of INQUA (International Union for Quaternary Research) activities, an important topic regards the "INQUA EEE Scale" (Michetti et al., 2004) for assessing earthquake intensities based only on the seismically-induced ground effects in natural environment (EEE stands for Earthquake Environmental Effects).

To improve the INQUA EEE Scale reliability, moderate-to-strong earthquakes, worldwide, are being analyzed by various working groups, in order to compare the obtained intensity values with those assessed with conventional scales (such as MM, MCS, MSK, EMS, JMA).

To this aim, we present here the revision and reinterpretation of the geological effects produced by the November 23rd 1980, Irpinia-Basilicata (Southern Italy) earthquake (Ms=6.9 NEIC, nucleation depth 10–12 km, epicentral intensity I0=X MCS), collected in the field soon after the event by several multidisciplinary groups (e.g., Carmignani et al., 1981), including some of the authors (EE and SP). The earthquake was a complex event, involving at least three distinct rupture episodes on different fault segments in a time span of approximately 40 seconds (Westaway, 1993). Over 300 localities were damaged with the loss of about 3,000 lives.

The earthquake induced primary and secondary effects distributed in an area of nearly 30,000 km2 principally located in the Campania and Basilicata regions. Tectonic surface ruptures, soil cracks, landslides, liquefaction, deep seated gravitational deformations and hydrological anomalies were observed.

After 20 years, we have decided to analyze the original evidence collected in the field by a) reviewing about 100 scientific papers, and b) performing new air photo interpretation, field surveys and interviews of eye witnesses. As a result, we have identified the most likely source of the 40 seconds event (Blumetti et al., 2002) and revealed the occurrence of numerous undocumented secondary effects (Esposito et al 1998, Porfido et al., 2002).

Coseismic surface faulting occurred over a length of almost 40 km, with a normal maximum displacement to the NE nearing 1 m at Mt. Marzano. A second rupture about 8 km long occurred ca. 40 seconds later on a SW dipping fault system between Muro Lucano and Santomenna with a maximum observed offset of 30 cm.

More than 200 landslides (mostly rock falls and pre-existing rotational and slump earth flows) were triggered over an area of 22,000 km2, with single volumes sometimes exceeding 1 million cubic m.

Ground cracks were also widespread in the epicentral area, as well as liquefaction phenomena, although the latter were generally modest in size. Hydrologic anomalies were reported even very far from the epicentre, in zones of low macroseismic intensity (IV MCS).

The application of the INQUA EEE scale to the above listed coseismic effects has allowed to reconstruct an autonomous macroseismic field, to be compared with the MCS-MSK intensity field (Postpischl et al., 1985).

The analysis of the most recent strong "historical" earthquakes in Italy based on the INQUA EEE scale serves as a test of the approach to be adopted to improve the comparability of the many older earthquakes listed in the Italian seismic catalogue.

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Testing the New INQUA Intensity Scale in Greek Earthquakes

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The new INQUA seismic intensity scale is an important challenge in the fields of macroseismology and earthquake geology. Therefore, testing of the new scale is of critical importance with the aim to calibrate the scale, to compare it with conventional scales as well as to improve it. Such testing has been attempted in particular cases of Greek earthquakes selected on the basis of some certain criteria that maximize the prospects for successful testing. More presicely, the selected earthquakes have in common that they were strong and their macroseismic effects included not only damage in buildings and other structures but also ground failures of several types like local landslides, rock-falls, ground fissures and soil liquefaction. In addition, the macroseismic fields of the selected earthquakes were studied and intensities in conventional scales were assessed during post-event field surveys undertaken by the authors. As a consequence, the observational material is reliable and detailed enough and, therefore, provides a good basis to test the new INQUA seismic intensity scale. On the basis of the above criteria we selected to test intensities related with the next earthquakes: Kyllini, NW Peloponnese, 16 October 1988 (Ms = 5.8), Athens, Attika, 7 September 1999 (Ms = 5.9), Lefkada island, Ionian Sea, 14 August 2003 (Ms = 6.3). An inventory of macroseismic effects as well as of conventional intensities has been created for each one of the studied earthquakes. On the basis of the macroseismic effects inventory intensities in the new INQUA scale were determined. A comparison between the conventional and new intensities has been made and the results are evaluated as regards the efficiency and possible future improvement of the new INQUA scale.

Seismic Hazard Assessment for a High Populated and Industrialized Area: The Case of the Insubria Region (Lombardian Southern Alps, Italy)

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One of the purposes of the Dark Nature Project is the characterization of natural risks for densely populated areas; the importance of this issue has been reminded to us in the last years by numerous catastrophic events. Regarding Northern Italy, after the recent Salò earthquake (Nov 24, 2004; Mw 5.0), a new attention has been paid to the seismic hazard assessment in Lombardy. This research is focused on characterizing the maximum magnitude and recurrence intervals of future potential earthquakes in the Insubria region between Western Lombardy and Ticino, at the Italy-Switzerland border, a densely populated and high industrialized area. Based on available historical and instrumental data, the seismicity of this region is characterized by modest magnitude events with relatively long recurrence intervals. The present seismic code, which is derived from the earthquake catalogue, considers most of this area at one of the lowest level of seismic hazard of the whole Italian peninsula. However, geological and geomorphological evidence suggests that Quaternary structures within the thrust belt beneath the Lombardian Southern Alps foothills are active and should be better evaluated in terms of an ungraded seismic hazard. A review of literature, field mapping and geomorphic study, along the Lombardian foothills has allowed us to identify evidence for active Late Quaternary compressive tectonics along the Lombardian South Alpine piedmont belt. This includes: a) in the Insubria region the presence of a sequence of glacial and fluvioglacial Middle Pleistocene deposits which are uplifted ca. 200 m along the foothills between Como and Lecco across the forelimb of an active anticline, Albese con Cassano; b) in the piedmont area between Brescia and Lake Garda, uplifted fragments of now largely eroded and buried fault-related folds are preserved at Castenedolo and Ciliverghe, as firstly interpreted by Desio (1956). Notably, however, western and eastern Lombardy are characterized by very different levels of historical seismicity. To the east, near Lake Garda, the Castenedolo and Ciliverghe structures coincide with the epicentral zone of the Dec 25, 1222, Brescia earthquake, one of the stronger Alpine earthquakes that struck the Po Plain (Io = IX MCS, macroseismically derived magnitude = 6.2; Magri & Molin, 1986; Serva, 1990; Guidoboni, 2002). Therefore, near Brescia the evidence of recent folding is associated with a significant earthquake hazard (see Livio et al., this volume). In contrary, in the Insubria region, the evidence of Late Quaternary shortening has not yet been related to strong historical earthquakes. In order to better understand the differences in historical seismicity along the Lombardian piedmont belt, we investigated relationships between surface geomorphology and associated deep structures in both the Insubria region and the area near of Lake Garda. We modeled geological, morphological and hydrological features, using the Albese con Cassano ridge (East of Como) as a type example for the western part of the belt. Orombelli (1976) previously described the Albese con Cassano area as a tectonic structure which 1) uplifted a sequence of glacial to fluvioglacial Middle Pleistocene deposits, 2) produced a secondary compressive fault within this sequence, 3) tilted more recent pro-glacial lake deposits, and 4) diverted the local drainage network. Our investigations allowed to confirm these data, and to propose that the presence of uplifted Middle Pleistocene deposits provides evidence for the possibly active nature of a growing anticline which accumulated ca. 200 m of vertical displacement during the Middle Pleistocene to Present (?). Comparing structures in the Insubria region with the thrusts near Lake Garda, the geometries and the fault length or segmentation appears similar, although slip rates are likely to be lower towards the west. If this interpretation is correct, the seismic potential of the Insubria region could be considered comparable to that one near Lake Garda, although faults there (Insubria) likely have longer recurrence periods. Future research will be aimed at validating this hypothesis in a search for additional evidence of active Holocene shortening and paleoseismicity to better define the maximum magnitude and recurrence intervals of past earthquakes in this high populated area.

The Database of Coseismic Environmental Effects as a Tool for Earthquake Intensity Assessment within the INQUA EEE Scale Project

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Refining the record of relevant Holocene natural events, and therefore of past seismicity, is one of the goal of the Dark Nature Project. Hazard forecast and risk mitigation must be based on high-resolution paleo-records. In this paper, we discuss new methodological approaches for the study of earthquake ground effects, allowing a better comparison between seismological and paleoseismological evidence.

In the last years, scientists dealing with seismic hazard assessment have started to acknowledge the potential substantial role of earthquake environmental effects (EEE) for earthquake intensity assessment. In fact it has become evident that EEEs should be taken into account for the following reasons:

i) compared to traditional macroseismic scales, they ensure a higher comparability at the global scale, as EEEs are free from the influence of cultural and technological aspects;

ii) all the effects on humans commonly used to calibrate intensity of shaking, suffer from saturation beyond intensity IX–X of the modern 12-degrees macroseismic scales;

iii) they allow to extend the time span of earthquake catalogues to prehistoric times. In fact, surface faulting and other secondary effects (principally liquefaction) related to prehistoric events can be in some cases dated and sized through detailed paleoseismological investigations.

In 1999, based on these general statements, an international group of geologists, seismologists and engineers promoted the compilation of a new scale of intensities based only on environmental effects (EEE Scale). A draft version of this scale was presented at the 14th INQUA Congress in Reno (2003), after an appraisal of the environmental effects induced by about 150 earthquakes distributed worldwide. A first update came one year later (Michetti et al., 2004) at the 32nd IGC in Florence.

A 4-years long international project (2003–2007) approved by INQUA and carried out by the INQUA TERPRO SubCommission on Paleoseismicity, http://www.apat.gov.it/site/en-GB/Projects/-INQUA_Scale/default.html) is revising the present version of the scale, by analyzing the EEEs triggered by recent and historical earthquakes. In particular, several Regional Working Groups are testing the scale with well-documented seismic events occurred in their country. The ultimate goal of the project is to present the final version of the scale at the 15th INQUA Congress (in Cairns in 2007).

Either coseismic environmental effects and man-made structures are strongly influenced by the site stratigraphy and morphology. In general, as commonly occurred for the conventional macroseismic scales applied to historical events (MM, MCS and partly MSK), the local EEE intensity value is attributed through an "expert" evaluation based on the description reported in the scale for that specific effect, i.e., without the statistical approach followed by the most recent conventional scale (EMS).

Wherever possible, the local EEE intensity should be evaluated taking into account not the single effect, which typically occurs at a site, but all the effects observed within a limited area of "uniform" geology (locality), for example a river valley, mountain slope, large hill, a village or part of it, etc.. Therefore, the archiving process should be done at two levels of progressive detail (locality level and site level). In traditional macroseismic studies, the scale of locality level is typically a village, while a single macroseismic object (i.e. a single building), where damage degree can be defined but not intensity, is an analogue of site.

In order to ensure the objectivity of the testing procedure, participants to the project have agreed on the need to store information regarding EEEs into a database precisely defined in its structure and format, which follows the draft form initially adopted for the field survey. Actually, only a rigorous approach ensures the comparability of environmental effects triggered by earthquakes occurred in geologically and tectonically very different settings. This database, conceived as the tool to effectively store and retrieve information regarding past and new earthquakes by the participants to the project, is already accessible in the web page of the project and will be periodically updated with the contributes from the regional WGs.

The EEE database has a relational structure kept as simple as possible. Several masks facilitate the input of data, from the most general to the most detailed ones. There are four main tables in agreement with the logical approach of the EEE Scale. So, each record in the table "Earthquake" is associated with one-to-many records in the "Locality" sub-table and each record in "Locality" is associated to one-to-many records in its EEE Sites sub-table.

As the main table "Earthquake" presents general information on the seismic event, including surface faulting parameters, the table "Locality" reports all the information about the locality where one or more coseismic effects have occurred, i.e. location (coordinates, altitude) and local expression of the earthquake (e.g., local macroseismic intensity, site PGA).

The table "Site" summaries the characteristics of the site (location, geomorphological environment, etc.) and the type of effect (surface faulting, slope movements, ground cracks, ground settlements, hydrological anomalies, tsunami, not geological effects). Information about the effect size, as requested in the EEE scale, can be archived in detail according to the type of effect. Information about damages on man-made structures (buildings, bridges, roads, etc.) in the same site, can be archived in a proper table "Effects on man-made structures". In order to standardize the descriptions of the effect and the site, data input is helped through the selection of attributes from a predefined menu.

Finally, it is possible to assess the range of EEE intensities (minimum and maximum values) compatible with the size of the effect and its features. As the data input for a locality has been completed, it is possible to assess the EEE intensity for that locality on the basis of all EEE effects occurred within that locality.

Moreover, in order to map the field of EEE local intensities, the EEE database allows to generate a table of localities with coordinates and EEE local intensities, that can be exported and loaded on a GIS project.

In addition, a proper "EEE form" devoted to field annotations immediately after a seismic event has been prepared, due to the common difficulty to work directly with a database directly in the field during an emergency. This form contains the same fields and structure of the EEE database.

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Damaged Cave Deposits Record 200,000 Years of Paleoseismicity: Dead Sea Transform Region

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Geological research of past earthquakes, typically retrieving records from soft sediment deformations, can benefit from the study of rockfalls and damaged deposits in caves. Dating of damaged speleothems and deposits overgrowing rockfalls constrains the dates of the damaging earthquakes. We have compiled a long-term (200 kyr) paleoseismic record at the Soreq and Har-Tuv caves, near Jerusalem, Israel. The study caves, located 60 km west of the Dead Sea Transform (DST), record earthquake damage from DST ruptures (and possibly, smaller local intraplate events on faults that have not reached the surface or have yet to be observed). The study caves are outside of the rift zone and most likely record stronger and less frequent earthquakes.

Non-seismic sources of collapse, such as ice-movements, ground subsidence, and cave-bears, cited often as alternative origins of cave damage, were considered and refuted. Neither ice cover, nor perma-frost, have occurred in this region during the investigated period. Ground subsidence does not pose a problem since the cave floors are solid carbonate rock. The caves have only non-natural openings, and therefore cave-bears have not entered. The study caves offer an excellent opportunity for paleoseismic research as they contain a large amount of fallen cave deposits of all types and sizes, such as stalactites, stalagmites, soda-straw speleothems, and pillars, as well as other forms of damage. The two study caves present the opportunity to correlate between two nearby sites.

Comprehensive maps of the Soreq and Har-Tuv caves were prepared and demonstrate dominant EW and NW-SE orientation of fractures, and dominant EW and NS orientation of collapsed speleothems. The prevailing orientations of collapsed speleothems are parallel or perpendicular to the trend of the DST. These preferential orientations of collapse strongly support a seismic source of collapse. We identified "new generations" of speleothem growth on top of collapses. This post-collapse precipitation constrains ages of collapse. Unconformities between the collapses and the in-situ regrowth were recognized, and termed paleoseismic "contacts". Laminae above and below each unconformity were separated and dated by the 230Th/234U mass spectrometry and other methods. The pre- and post-seismic dates of a collapse bracket the period within which the earthquake occurred. The closer in age the pre- and post-seismic deposits are, the better constrained the earthquakes age is. When dating post-seismic regrowth on collapsed bedrock (as opposed to collapsed speleothem), only the post-seismic age is available. We also drilled cores into the flowstone floor and discovered laminae that embed fallen small stalactites (known in the literature as soda-straw formations). We dated the laminae that embed the fallen stalactites, which give the age of the seismic event. We also compared the oxygen stable isotopic record (d18O) of the laminae adjacent to the tectonic unconformities with the extensive well-dated stable isotope record of Soreq Cave speleothems, as was reconstructed for the last 185 kyr by Bar-Matthews et al. (2000) and Ayalon et al. (2002), for paleoclimate purposes. This stable isotope technique comparison improves and corroborates the U/Th ages.

Thirty-eight collapses were sampled and dated of which at least 13 (up to 18) separate events were dated. Dating of simultaneous collapses at different areas of the same cave and in the two different caves also strongly supports a seismic source of damage. The one Holocene event observed in the cave correlates with lacustrine seismites dated in cores from the Dead Sea and with an archeologically recorded earthquake. An event dated to $\sim$13 ka is recorded by two collapses, for which there is no known dated contemporaneous soft sediment record in the region to correlate with. Most Dead Sea sediments recovered so far show a prominent hiatus at the Pleistocene-Holocene transition. For the period between 75 to 20 ky, we identified 4 events, 2 events (at 51.0–52.0 and 35.5–40.5 ka) correlate with seismites in the Lisan record (at 52 and 39 ka). Another event (at 46.5–46.7 ka) coincides with a hiatus in the lacustrine sections from 49 to 44 ka. An event at 70.2–72.8 ka correlates with a cluster of seismites in the pre-Lisan section. Twelve cave events older than 75 ka are at present the only dated paleoseismic record for this period in the region. Future work on the middle to lower Pleistocene Amora formation can be potentially correlated with our cave record. Overall, the karst paleoseismic record supports the lacustrine seismite evidence.

The long dating range of calcite cave deposits and their potential for recording seismic events can vastly increase the length of the seismic record. The long Late Pleistocene cave record is useful for correlation with other records and for substantiation of the method, while the Holocene events are valuable for seismic hazard assessment. The unique opportunity to compare the stable isotope profiles of the speleothem seismites with the extensive paleoclimate record of the caves improves the accuracy of the seismite ages.

Geological Evidence of Quaternary Tectonic Activity as a Tool for the Evaluation of the Seismic Potential of a Region: Some Preliminary Results on Castenedolo, Ciliverghe and Capriano Folds (BS)-(Northern Po Plain, Italy)

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Prevention and mitigation of the effects of natural catastrophic events, which are able to cause serious social and economic consequences, like earthquakes, is one of the goals of the Dark Nature Project.

The recent catastrophic Sumatra seismic event (Dec. 26, 2004, Mw 9.2) has redrawn the media's and the international scientific community's attention on the importance of Seismic Hazard Assessment (SHA).

We present some preliminary results on the localization and characterization, through geological and geophysical analyses, of some important structures buried beneath the Po Plain and located along the Southern Alps foothills west of Lake Garda.

As well described in literature (Serva, 1990; Doglioni, 1993; Castellarin & Cantelli, 2000; Boccaletti & Martelli, 2004; Fantoni et al., 2004), the Northern Italy structural framework is characterized by the growth of two thrust belts, surrounding the Po Plain: the Apennines and the Southern Alps. Structurally the external margin of the Southern Alps is constituted by folds and thrusts, buried below the Po Plain and mostly parallel to the Southern margin of the chain, which are generally tilted to the south and sealed by a Messinian unconformity; this has commonly been interpreted as the deactivation of the Southern Alpine deformation in Lombardy since the Upper Miocene. However, as reminded by the recent Mw 5.0, Nov 24, 2004, Salò earthquake, geological and seismological evidence suggest that the thrust belt beneath the Lombardian Southern Alps foothills should be better evaluated in terms of seismic hazard.

Our study area is located south of the piedmont belt of the central eastern Southern Alps, ca. 10 Km south-west of Lake Garda. Here, literature data (Desio, 1965) underlie the occurrence of some isolated relieves (Castenedolo, Ciliverghe and Capriano hills) whose presence cannot be explained by glacial or fluvioglacial morphogenic processes.

Each of these hills, in fact, has been interpreted as the culmination of a young anticline structure. At Castenedolo and Capriano Ridge Early Pleistocene marine deposits were uplifted more than 200 m; to the east, the Middle Pleistocene continental sequence constituting the Ciliverghe Hill was faulted, uplifted and gently tilted (Baroni & Cremaschi, 1986; Castaldini e Panizza, 1991).

Our work, aimed to a better characterization of these structures, is based on a) literature data compilation; b) geological and geomorphological field survey; c) DTM interpretation of the morphology of this sector of the Po Plain; d) subsurface data compilation (seismic lines and exploration drillings, courtesy released by ENI E&P; and water wells stratigraphic data, collected and courtesy released by Regione Lombardia); e) 3D geological model reconstruction.

Our work allowed us to identify some evidence of Quaternary compressive tectonics in the study area. In particular the seismic profiles clearly show a series of fault propagation folds, ca. 10 Km wide, controlled by the Plio-Quaternary growth of several out-of-sequence north verging thrusts. A regional marker horizon, represented by a sequence boundary termed "R surface" by Muttoni et al. (2003), and dated at ca. 0.9 Ma, has been used to identify and map these structures in detail. Preliminary results show a strong correspondence between structural and geomorphological high, confirming the tectonic origin of these isolated relieves and suggesting a recent activity of these structures. In particular, the observed deformations clearly affect the basin's quaternary filling up to at least the upper part of Middle Pleistocene.

It is important to note that this region overlaps with the epicentral area of the Dec 25th, 1222, Brescia earthquake, (Io=IX MCS; Magri & Molin, 1986; Serva, 1990; Guidoboni, 1986; Guidoboni, 2002) one of the stronger Alpine historical earthquakes that struck the Po Plain.

A reconstruction of the recent movements of these folds, through geometric and kinematic models (Zehnder et al., 2000; Johnson et al., 2002) applied to reflection seismic profiles, coupled with paleoseismological analyses, will allow us to correctly evaluate the seismic potential of the underlying associated faults, in terms of maximum expected earthquake magnitude and recurrence rates.

Dark Nature and Paleoseismology: Understanding the Seismic Landscape of the Southern Alps, Italy

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The knowledge of the seismicity level of a region is one of the key elements for evaluating the impact of natural processes on the society. Instrumental and historical data might be inadequate to reach this goal. For instance, historical seismic events having magnitude in the range of 6.0 to 6.5 have generated "catastrophic" effects in Northern Italy (e.g., Jan. 3, 1117, Verona; Dec. 25, 1222, Brescia; and Jan. 25, 1348, Friuli, events). Due to the dramatically increased vulnerability of the area (i.e., high density of both population and critical industrial facilities in the Po Plain), nowadays their recurrence would probably be much more damaging, in terms of both victims and economic loss.

The return period of such strong earthquakes, however, could be longer than the time window of ca. 1000 yr for which the Italian seismic catalogue (arguably one of the best in the world) is regarded as complete. Therefore, earthquake hazard studies in this region must be based on paleoseismological evidence.

In this paper I summarize the preliminary findings of a joint research project conducted by University of Insubria, APAT, ENI E&P, and University of Colorado, aimed at A) the seismotectonic characterization of the Southern Alps and B) the paleoseismic analysis along selected local active tectonic structures. This research is particularly focused on the sector at the border between the Po Plain and the Lombardia alpine foothills, an area where the relations between active tectonics and seismicity are still poorly recognized.

The first results show that the fold and thrust belt along the Southern Alps–Po Plain margin is characterized by significant Quaternary activity not only in the eastern sector (Friuli, Veneto; Slejko et al., 1987; Benedetti et al., 2000; Galadini et al., 2001) but also in the area between Lake Garda and Lake Maggiore. The most relevant geologic and geomorphic signature of this activity is the occurrence within the piedmont belt of isolated hills, which corresponds to the culmination of young anticlines and locally to the epicentral area of strong historical earthquakes (i.e., near Castenedolo, just west of Lake Garda, epicentral area of the Dec. 25, 1222, I = IX MCS, earthquake; e.g., Guidoboni, 1986; Serva, 1990). This feature was already noted by Desio (1965), but still very little is known about the seismic potential associated to these recent folds.

The large amount of paleoseismological data collected in recent years shows that each earthquake source creates a signature on the geology and the geomorphology of an area that is unequivocally related with the order of magnitude of its earthquake potential. This signature is defined as the seismic landscape of the area (e.g., Serva et al., 1997; Michetti and Hancock, 1997; Michetti et al., 2005).

We argue that the structural and geomorphic characteristics of these young anticlines can be used for the definition of the seismic landscape in the Southern Alps, following the same methodological approach that has been adopted for the intermountain basins in the extensional setting of the Apennines (Serva et al., 2002).

The preliminary results and methodological approach of these active tectonics and paleoseismological studies in the Central and Western Southern Alps might be relevant for several other alpine areas, showing similar seismotectonic features and poor seismic hazard characterization from the geological point of view.

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Using the INQUA Scale for the Assessment of Intensity: Case Study of 14/08/2003 Lefkada Earthquake, Greece

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The Lefkada (Ionian Islands, Greece) earthquake of 2003 (Mw=6.2, Ms=6.4) occurred few kilometers offshore the northwestern part of the island. According to the National Observatory of Athens, Institute of Geodynamics (NOAGI), its focus was located at 38.790 N, 20.560 E at depth h = 12 km. The maximum intensity has been evaluated as VIII (EMS), Papadopoulos et al. (2003), at Lefkada municipality. Few hours after the event, field surveys have been conducted in order to report the ground failures triggered by the earthquake.

The aim of this research is to compare the intensity parameters of the 2003 earthquake based on the EMS scale, with those assessed using the INQUA intensity scale. The intensity values, provided by the INQUA scale, are based solely on the ground effects.

This event was selected because of: a) the shock caused ground failure at several sites while the structural damages were few, b) the historical seismicity of the area indicates that at least two events during the 20th century (1914 and 1948) induced similar phenomena on the island, and c) these two past events occurred before the application of the first Greek seismic code (1959) to the building's construction.

In particular, the 2003 earthquake caused considerable effects on the northern part of the island where the reported rockfalls–landslides were widespread while liquefaction occurrences were observed at the municipality of Lefkada. On the southern part, the environmental effects are classified as marginal to modest; the rockfalls were rare and occurred along slopes where equilibrium is unstable. Building damages were reported mainly at the town of Lefkada (northern part) while many port facilities have been damaged in the whole island. Intensity values in the range between V to VIII have been assessed by Papadopoulos et al. (2003) for the 14/08/2003 event based on the EMS scale.

The historical records of the island provide well-documented information about ground failure triggered by two past earthquakes (27/11/1914 and 30/06/1948). According to the available seismic catalogues (e.g., Papazachos et al. 2000) these events had approximately the same source characteristics as the shock of 2003. Moreover, the reported environmental effects were distributed at the same sites of those triggered by the last earthquake. Galanopoulos (1950) reported that rockfalls and sand crater, probably due to densification, triggered by the 1914 and 1948 earthquakes at the road of Tsoukalades–Ag. Nikitas and the Pefkoulia beach respectively (similar phenomena were observed during the field observations, few days after the event of August 14th, 2003). The induced structural damages were significant, since many houses collapsed while others were severely damaged. For the seismic events of 1914 and 1948 the intensity values were in the range between VIII to IX based on Rossi–Forel scale, Critikos (1916), and between VII and X based on Mercalli–Graden scale, Galanopoulos (1950), respectively. These values had been assessed for the northern part of the island. The maximum epicentral intensities of these past earthquakes were evaluated as IX (MM scale) in both cases according to Papazachos et al., 2000.

The first Greek seismic code was issued in 1959, after the devastating Kefalonia's earthquake of 1953, and it was revised in 1984. A new revision took place in 1992 and updated in 2000 and 2003. According to the 1992 Greek Seismic code, the PGA coefficient for the Lefkada's seismic zone was established to a=0.36g with a spectral magnification factor $\beta o = 2,5$. Obviously, the implementation of this code contributed to the amelioration of the building strength. Therefore, the low-rise buildings of Lefkada were not heavily damaged by the event of 2003.

The intensity values of the 2003 earthquake (INQUA scale), that were assessed at 18 sites on Lefkada's island based on field observations, were compared with those provided by Papadopoulos et al. 2003 and with the evaluated intensity parameters of the past events. This comparison's conclusions are:

a) the major differences between the evaluated intensity parameters for the 2003 event, based on INQUA and EMS scale, are concentrated mainly at 4 sites, i.e. at the villages of Nydri (VII-INQUA, V EMS scale), Lygia (VII INQUA, V+ EMS), Kalamitsi (VII INQUA, V EMS) and Ag. Nikitas (VII+ INQUA, VI+ EMS),

b) at the same sites are also observed significant differences among the intensity values of the past events with the values of the last one, based on EMS scale,

c) the intensity values based on INQUA scale are more closed to the assessed values of the past events than the evaluated intensities based on EMS scale.

Dark Nature: Examples from Italy

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The modern scientific progress has often generated the illusion that the contemporary man might be able to put natural phenomena under control. In fact, our society appears more vulnerable today than in the past to the "dark nature" events.

Italy has experienced several disasters such as extreme volcanic eruptions and strong earthquakes.

In the last 60000 yrs giant ignimbritic eruptions occurred in the still active Campanian vulcanic area (53.000 yr B.P. Ischia Green Tuff, 39.000 yr B.P. Campanian Ignimbrite, and 15.000 yr B.P. Phlegraean Fields Yellow Tuff). The Campanian Ignimbrite produced 300 Km3 of pyroclastic deposits over an area of 30.000 Km2. An inferred thickness of ca. ∼1 cm covered the whole Eurasian continent. Although not likely to occur, the impact of such eruptions today would be terrible both in regional and global scales, probably leading to climatic changes. Moreover, in the Campanian volcanic area also a subplinian eruption (such as the one occurred in 1631 and highly probable at mid-short term), because of an indiscriminate urbanization (3.000.000 people live in the 30 km radius of Vesuvius volcano with a population density up to 15.000 people per Km2), would be absolutely disastrous in terms of victims and impact on the nation economy.

Not only volcanic activity could be de-stabilizing for the national socio-economy. Indeed during the historical period the Italian territory was struck several times by catastrophic earthquakes, with ruinous consequences on the Society. An example, in Northern Italy, is the event of January 3, 1117. Verona was severely damaged and numerous Romanesque churches were destroyed and never reconstructed. The impact of that earthquake on the society and the culture of that time was so relevant that it became a chronological point of reference to date other social events.

If the earthquakes besides being strong, are also frequent, the consequences may be even more terrible. In the span of time between 1688 and 1706 (19 years), along the whole Italian territory, 14 events (Intensity VIII–XI MCS) occurred with a nearly annual rate: Romagna 1688, Sannio 1688, Carinzia 1690, Ancona 1690, Val di Noto 1693, Irpinia 1694, Asolo 1695, Bagnoregio 1695, Carnia 1700, Benevento 1702, Norcia 1703, Montereale 1703, L'Aquila 1703 and Maiella 1706. Closer to present time, another sequence of damaging earthquakes (Intensity VIII–XI MCS) started in 1915 and ended in 1920. 6 destructive events took place in the Central and Northern Apennines: Avezzano 1915, Monterchi 1917, Santa Sofia 1918, Mugello 1919, Piancastagnaio 1919 and Garfagnana 1920. It is easy to infer that if analogous sequences were to occur today in Italy, their impact would be devastating in terms of victims and economic loss.

We believe therefore we should waste no more time and start soon a serious prevention program to make safe the Italian territory.

Reverse Faulting Between the "Gonfolite Lombarda" and Pliocene Marine Clays at Monte Morello (Novazzano, Ticino): Remarks on the Chronology of Compressional Tectonics in the Southern Alps, and Implications for Seismic Hazard Assessment in the Insubria Region

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The Insubria Region lies in the Southern Alps amid Lake Como and Lake Maggiore, along the border between Lombardia (Italy) and Ticino (Switzerland). This is a very densely populated and developed area, ranking among the richest ones of the whole Europe. In this sector of the Southern Alps, relationships of Quaternary faults and folds with earthquake processes are still inadequately investigated (e.g., Giardina et al., 2004). In order to review the geological evidence for evaluating past seismicity, and provide fundamental input data for seismic hazard assessment, we are conducting field mapping, geomorphic survey and seismotectonic analyses along the most important tectonic structures in this region.

In particular, here we focus on the regional north-verging backthrust that borders the Como and Chiasso Plains ("Monte Olimpino backthrust"; Bernoulli et al., 1989; Gelati et al., 1992). The compressional activity along this structure reportedly ceased during the Late Miocene, when also the emplacement of the most external south-verging fronts of the Southern Alps beneath the central part of the Po Plain took place ("Milano belt" of Bernoulli et al., 1989).

We have made new observations near the junction between the Faloppia Valley and the Chiasso Plain, at the Lombardy–Ticino border, where the backthrust clearly controls the geomorphology of the Spina Verde mountain front. In a small valley along the northern slope of Monte Morello, we have carried out new field work on the outcrop already described by Felber (1993), where Pliocene clays are juxtaposed against the sandstones and conglomerates of the Gonfolite Group (Oligo-Miocene) with a nearly vertical contact, whose origin is likely tectonic, according to Felber (1993).

Our new data confirm such origin, being the contact definitely due to a high angle reverse fault. Few tens of meters away from the fault plane, bedding in the Pliocene clays is sub-horizontal; moving closer to the fault, Pliocene beds are firstly tilted ca 20° northward, then become nearly vertical, and finally are clearly dragged against the fault plane and overturned. New palaeontological analyses show that the marine clays include a faunal assemblage typical of the Upper Pliocene (Pichezzi, personal communication).

Reconnaissance field work, structural interpretation and geomorphic analyses in a wide area surrounding this outcrop strongly suggest that this feature is not local, but typical of the whole region. In fact, post-Miocene activity of regional out-of-sequence back-thrusts seems to characterize all the structural belt between Lake Garda and Lake Maggiore.

In our opinion, these results illustrate the need for more detailed investigation on Quaternary tectonics and Holocene paleoseismicity in the Insubria Region, in order to verify if the now available seismic hazard estimates, essentially based on the historical catalogue (where seismic events are practically absent for this region), are in agreement with the geological evidence.

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Study of the Verny, 1887, Earthquake in Central Asia: Using Environmental Effects to Scale the Intensity

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The goal is to get mutually consistent assessments of intensity of shaking based on environmental and macroseismic effects caused by earthquake. Simultaneously, database structure for storing information on ground effects is discussed. Although all macroseismic scales prior to EMS98 include environmental effects for intensity assessment as their integral part, we make difference between environmental and macroseismic effects. Environmental effects are all kind of consequences of an earthquake (faults, ground cracks, landslides, rockfalls, etc.) observed in nature. Macroseismic effects refer only to human and man-made structure reactions to an earthquake. To measure the first type of effects, the Earthquake Environmental Effect (EEE) based INQUA scale [Michetti et al., 2004] is used. To measure macroseismic effects we'll use EMS98 [European Macroseismic Scale, 1998]. The Verniy, May 28 (June 9), 1887, earthquake is a large seismic event in Central Asia. It practically completely destroyed the regional center Verniy (later on Alma-Ata) and caused death tolls. An expedition was sent in epicentral area of the earthquake soon after its occurrence. The expedition collected and published [Mushketov, 1890] materials on the earthquake effects both in localities and in natural environment. As the case study represent historical earthquake it enables to verify if also in this situation the EEE information could be fit to rigid database structure and format. The presentation proves perspectives of environmental effects as a tool to calibrate earthquakes, if INQUA scale is used properly.

Sustainability, Land Use, and Rapid Environmental Change

Rapid Natural Change, Human Response, and the Role of Culture

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As papers presented at recent meetings of the Dark Nature project have amply demonstrated, natural science is coming to an increasingly clear understanding of natural environmental changes, their causes and their effects on the landscape. Thanks to the work of certain social scientists (in particular historians and anthropologists), we are also becoming aware of the historical (and prehistorical) human responses to those natural events. It is not yet clear, however, which are the crucial factors in any one society that lead to adaptive responses. In this paper I propose that, while diverse physical and socio-economic factors are relevant, the crucial element for appropriate responses to rapid environmental changes may be the cultural matrix prevalent in a society. In the following I briefly describe how we may understand the relation between culture and nature. Next, I draw attention to a particular example of cultural adaptation to rapid natural change, stemming from societies in the North American Northwest. I close by noting some practical consequences of this analysis.

Rapid Environmental Changes and Civilisation Collapse: Can We Learn from Them?

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In trying to measure the changes of our present environment, we use a series of monitoring schemes. However these instrumental records are often based on data ranging over the last 100–200 years only. If we want to set up preparedness measures, we need to know the full range of possible changes. Hence it becomes crucial to look back in time and see how rapidly, even catastrophically, the environment can change and affect societies.

J. Diamond uses five criteria to analyse the causes of societal collapse: environmental damage, climatic change, society's relations with hostile neighbours, relations with friendly societies and people's cultural response. A convergence of several of these causes will enhance the disaster extent. It seems that three factors need to be considered when analysing human recovery: the temporal scale (longer than the food storage capacity), the spatial scale (large area leaving nowhere to escape) and the cultural response (freedom to innovate). We shall examine collapses such as the Norse settlements in Greenland, Easter Island, the Mayas and the Early Byzantine period. We will draw examples from our own research, especially on the effect of earthquakes on the environment.

Geo-scientists and Historians also contribute by examining together how people have responded to those changes. Some societies have collapsed, others have revived. Some societies have then gone on doing exactly the same things without learning from the experience; others have modified their behaviours and successfully adapted to changes. According to J. Diamond, a group of people may make the wrong decisions by failure 1) to anticipate the problem before the problem actually arrives; 2) to perceive a problem when it actually arrives; 3) to try to solve it; and 4) to succeed to solve it.

If we turn now to more recent examples of environmental catastrophes, we do not seem to learn from them in most cases. In Istanbul after the Izmit 1999 earthquake and with the very high probability of an earthquake before long, the 12 million inhabitant city is still expanding and too often without the respect of anti-seismic building regulation. After the earthquake and the tsunami of the Indian Ocean in 2005, international help aims at rebuilding villages and replanting fields exactly where they were.

What are the mechanisms through which a society learns from the disasters of past catastrophes? Ancient societies could declare a land impure and create a myth that would keep people away. In the XXIst century, we must try to find modern solutions with politicians closely working with scientists. Maybe solutions such as the creation of nature parks and the voluntary movement of people could be examined and would be beneficial in the long run.

Sustainability Policy and Rapid Natural Change

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The most recent evolution of EU level urban policy has explicitly recognized the need to separate natural causes from man induced ones, as the basis for understanding the causality of events, and so providing the foundations for the most appropriate and effective policy responses to attain sustainability.

The perspective of the policy maker and the urban manager is also shaped by the drive to advance the sustainability (social, economic and environmental) of urban areas, aware that they are the places where the vast majority of the population of Europe (80%+) live, where social issues are resolved, and in which the prime motors of economic development are generated. Urban areas are also the principal sources of emissions and pollutants that lie at the heart of the problems of environmental sustainability and global warming at both local and global levels.

In this context the prime focus is on the interrelations of human activity and urban development on the one hand, and on the other, the apparent increase of extreme climatological events that have been linked to global warming effects. In particular, the interrelationships between urban growth and green house gas emissions, soil sealing, and the incidence of flood risk across a wide range of localities in Europe is notable, and a major concern for policy makers.

At the same time, it is necessary to integrate all individual causal influences in order to attain a more sustainable approach to urban management based on coherent policy responses. In particular, both horizontal and vertical integration is viewed as essential if efforts to secure horizontal integration of the sectoral interests at the local level are to be effectively communicated via the vertical coordination of all levels of government from local to national and EU levels.

The above considerations form the key ingredients of the intellectual drive of emerging policy for urban sustainability at the European level promoted by the EU, and based on a substantial body of EU funded research undertaken over the past ten years. The new policy frameworks for urban sustainability are currently evolving via the implementation of the EU 6th Environmental Action Programme over the period to 2010. Specific impetus is provided by the EU Urban Thematic Strategy with it's new requirements for the preparation of environmental plans and associated management systems for the 1000 cities of Europe with a population of 100,000 or more.

The significance of the above may be summarised as follows:

- increasing importance of the integrated approach to policy making and implementation at the urban level as an essential basis for the delivery of urban sustainability;
- enhanced need for multidisciplinary working and tools to support policy integration, plan implementation, and the assessment of policy effectiveness;
- clear shift in policy perspectives to incorporate natural risk elements in the portfolio of policy priorities at the urban level, providing new challenges for policy integration, interdisciplinary working and the development of the necessary skills and tools to deliver effective policy.

Monitoring Media Coverage of Natural Hazards in Italy

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Between September 2002 and December 2003, several natural catastrophic events struck Italy, confirming the high degree of seismic, volcanic and geologic-hydraulic hazard in our Country.

Etna Volcano (Sicily) resumed its activity after a period of quiescence, and, in November 2002, entered a sustained eruptive phase with the emission of lava flows and the occurrence of explosive episodes with the production of high eruptive columns whose volcanic ashes blanketed the city of Catania, producing damages and leading to the closing of the local airport.

In the same days, an increase of the well-known submarine degassing off Panarea Island (Aeolian Island), attracted the attention of the volcanologists and the media.

In December 2002, Stromboli Island (Aeolian Island) was hit by two tsunamis generated by landslides from the Sciara del Fuoco; there was no casualties, since the island was in those days almost inhabited.

Four earthquakes struck Italy in close succession, between September and November 2002: the Palermo earthquake (M 5.6), the S.Venerina earthquake (Sicily, M 4.4) and the S.Giuliano di Puglia earthquake (Molise). This event (M 5.4, claiming the lives of 29 persons, mostly children), in particular, drew the attention of the scientific community and the media on the need to better predict seismic events in areas previously considered only slightly affected by seismic hazard, as well as to elaborate strategies for mitigating the consequences of such events.

In November 2002, a M 4.2 earthquake hit the little town of Iseo, causing only little damage but raising worries about seismic hazard in Lombardy. Moreover, a series of geologic-hydraulic events hit the North of Italy in Autumn 2002 and Autumn 2003: The most relevant are the landslides that hit the Lecco and Bergamo provinces, and the November 2002 flood of Lake Como, that caused damage in the city and received a great deal of local media coverage.

With the purpose of analysing the ways in which newspapers report issues related to extreme natural events, as well as identifying the role played by the media in influencing the general public's perception of natural hazards, we carried out a textual and semanthic analysis of 430 newspaper articles. These have been subdivided as follows: 130 web articles, 92 articles published by national newspapers, 208 articles published by the Como leading local newspaper (La Provincia).

The analysis has been carried out using a list of selected indicators, such as "Journalistic accuracy in using risk-related terms", "Selection of informative sources", "Use of anthropomorphic representations when describing natural processes such as volcanism", "Alarmist tendency when describing natural hazards", "Scientific, in-depth coverage of natural hazards", "Tendency to the political instrumentalisation of the consequences of natural events", "Attitude towards dealing with the damages caused by natural events, rather than their prevention".

The results of the analysis show that media tend to gather information on natural hazards mainly from politicians and local administrators, rather than from academics and researchers. Therefore, information on natural hazards, at the national level, in most cases lacks scientific accuracy and presents a biased picture due to a lack of independence from political considerations. As opposite, local information shows a higher degree of independence and does not indulge in alarmistic tones and dramatizations.

Prevention does not appear a key issue for both local and national newspapers, and in-depth coverage of natural hazards-related topics is the exception rather than the rule.

The results of the monitoring show how the gap between scientific knowledge and the information provided by the media is still large, and that a major effort from both the journalists and the scientific experts is required in order to produce an environmental risk communication that is unbiased, accurate and independent.

The role of Knowledge in the Territorial Governance

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The "governance" of a sailing boat needs an accurate knowledge of all the points of weakness in the hull and in the rigging, in order to avoid that a natural event as a storm, or a hit of Mistral, could evolve in a tragedy. In fact, even with the most accurate weather forecasts, if a boat (or a territory) is right on the way of a disaster, the only way to prevent panic and to mitigate its consequences is to be aware of the boat (and territorial) leaks, to prepare the boat (and plan the territory) in the safest way as possible and so to be ready to face the inescapable event that is coming in the most rational mood. This strategy comes from the acceptance that mankind has to live together with natural events: it is possible to foresee them, to mitigate their effects, but not to avoid them.

Within this context, knowledge is the first, necessary step.

The knowledge of a territory, its physical features and its dynamic evolution needs to be pointed out in a detailed and homogeneous framework. But knowledge for itself is not enough: it needs to be easily available and the information has to be consistent and updated.

In a highly complex territory such as the one of Lombardy, this result can be obtained only establishing an open and well-related infrastructure of the territorial information. This system, according to the EU Commission proposal "INSPIRE" (Infrastructure for Spatial Information in Europe, www.ec-gis.org/inspire), consists in integrated spatial information services, delivered to the users (both policy-makers and citizens) from sources at different levels. "Data should be collected once and maintained [updated] at the level where this can be done most effectively": this INSPIRE principle means that different organizations (both public and private) involved in territorial analysis and management, should co-operate to produce a well-ruled flux of spatial information, characterised by the so-called "interoperability" of data.

The I.I.T. (Infrastruttura per l'Informazione Territoriale) of Regione Lombardia is moving in this direction from 2003, establishing agreements with public and private subjects for spatial data exchange and promoting experimentations in different basic themes, from the topographic data bases up to the landslides inventory, funded with regional, local and national and e-government resources.

Spatial Data dissemination is favoured by a dedicated website (Portale dell'Informazione Territoriale, www.cartografia.regione.lombardia.it) that permits search, navigation and download of geodata, coming from different sources and regarding different aspects of the regional territory, and the development of web services, as web data editing or local administrations support about existing planning restrictions.

Knowledge is basic for local and regional territorial planning (for prevention and sustainable development), for disaster management (when it finally comes) and for territorial governance, as a whole. But as the steering of a sailboat is efficient and safe only when the skipper couple a detailed and experienced knowledge of its boat and of the surrounding environment with the capability of making the crew members co-operate one each other, so the territorial governance needs that each member of the system co-operates within the system, drops its own interests and gives its contributions to the system, in terms of experience and data. This is probably the hardest goal to reach, despite the wide expressions of interest, and it's obviously concerned with mankind, not with technical complexity.

Natural Catastrophic Events, Historical Records and the Development of Scientific Knowledge

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The interaction between historical and scientific research in the study of natural catastrophic events of the past is a necessary tool in order to understand and evaluate their social and economic impacts.

In recent years, historians with different backgrounds and expertise have collaborated in particular with geophysicists and vulcanologists for compiling catalogues of earthquakes and volcanic eruptions. Also the historical recurrences of floods or landslides have been investigated in some areas and these may offer useful data for the evaluation of possible future hazards.

On the other hand, during the historical research initially focused on the collection of data for confirming and often increasing the number and the extent of natural catastrophic events, several pieces of information regarding the reactions of the affected population, as well as on the social, economic and political changes caused by the consequences of the event itself may be found in the primary sources. These complex historical records should not be undervalued, but instead analysed and compared with the interpretation of the phenomenon given by the scientists who were living, for example, at the time of a certain earthquake or volcanic eruption.

The problem of the communication between the scientific community and the possible victims of the catastrophic event, in order to suggest and establish plans or strategies, can be evaluated with the help of historians of specific scientific disciplines, such as the Earth sciences. The aim of this paper is to show the importance of such 'interdisciplinary teamwork', by presenting some case studies which have involved scientists and historians.