Quaternary Stratigraphy and Evolution of the Alpine Region in the European and Global Framework

Milano, 11 – 15 September 2006

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“Quaternary Stratigraphy and Evolution of the Alpine Region in the European and Global Framework”

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Foreword

The Alps are at the origin of the basic ideas on the Quaternary: climate variability and glaciations. Since more than one century climatic-environmental changes and Quaternary stratigraphy are strictly connected. Under the pressure of the growing environmental problems, the exponential increase of the Quaternary studies progressively brought forward a highly complex time-space pattern of climate changes, driven both by external and internal forcing. Although no more the global reference area for the Quaternary, the Alps, at the boundary between the polar and the tropical systems and between the Atlantic oceanic and the Eurasian continental regions, still are a key area to unravel the entangled matter of facts and causes in the puzzle of climate variability.

The stratigraphic research has a basic role to this purpose, both to scan in detail the local sequence of geologic events and to establish reliable correlations, at a local, regional and global scale. The new numerical dating techniques and the improved correlation methods are essential to the progress in this field. A consolidated and time-constrained stratigraphic framework is essential to the geologic mapping, to paleoclimatic and paleoenvironmental reconstructions, to pre-historic archaeology and to the history of man-environment interactions.

This conference organized by the INQUA Subcommission on European Quaternary Stratigraphy aims properly to update and to promote the knowledge of the Quaternary stratigraphy and evolution of the Alpine region in the European and global framework. The conference will focus on five themes.

- **The glacial history of the Alps.** Here, where the glacial theory was born, still many points need to be clarified, from the extent reached by ice in the different time slices, to the different responses of the various part of the chain, to the glacioisostatic vs. tectonic effects on erosion/denudation and recent rising of the Alps.

- **The last glacial-interglacial transition and the Holocene.** Again the Alps, one of the first reference areas for the Late Glacial, still deserve intensified studies on this crucial turnabout of the Earth environment, exploiting all the different environmental records available.

- **Continental vs. marine Quaternary events, registration and correlation.** The limit between land and sea has been for long time the boundary between two different Quaternary stratigraphies. Acknowledging the specific peculiarities of each record, the need to reconcile the two stratigraphies is requested, not only for correlations but also to understand the roles of ocean and continents in the climate variability.

- **Climatic and biotic evolution of the Alpine region and surrounding areas: Pliocene and Quaternary.** Paleobiology keeps a traditional role in stratigraphy. The wealth of the Plio-Quaternary continental biotic records adds value to the bio-stratigraphic tools, allowing the understanding of the dynamics of the ecosystems under the pressure of climate changes.

- **The contribution of geochronology to the Pleistocene stratigraphy.** Precise dating, with high time resolution, is essential both to long-distance correlation and to detect the high-frequency climate changes, those that are of major concern for the immediate future. The use of new methods in areas or time intervals poor or devoid of the materials requested by traditional methods, may again bring the Alps to the advanced front of the Quaternary studies.
Two field trips will follow the conference. The first is dedicated to the long lacustrine sequences of the Lombard Prealps: well known since the late XIX century, new studies put in evidence their importance for the Early Pleistocene stratigraphy and climate and vegetation history, also with annually-resolved time intervals. With the second field trip, two of the major south-alpine morainic amphitheatres will be visited, concluding with the visit to the archaeological site of Fumane, where a highly detailed Late Pleistocene sequence has been excavated.

The Milano group of Quaternary scientists is particularly glad to welcome the colleagues from the European countries and to have the opportunity to discuss together the South-Alpine Quaternary stratigraphic records.

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INQUA – SEQS 2006 Milano
Detailed program

Monday September 11, 2006

8.30 onwards Registration and upload of ppt presentations

10.00 – 10.20 Conference opening - Giuseppe Orombelli

10.20 – 12.30 Geological and glacial history of the Alps during the Quaternary: introductive key-notes

10.20 – 10.40 Frank Preusser, H. Graf, C. Schlüchter – Quaternary stratigraphy of Switzerland
10.40 – 11.00 Markus Fiebig – Glacial history of the Northern Alpine Foreland – classical and modern approaches
11.00 – 11.20 Miloš Bavec - The Pleistocene sedimentary record in Slovenia - an overview
11.20 – 11.40 Alfredo Bini – Glacial history of the lombardian amphitheatres
11.40 – 12.00 Gérard Nicoud, A. Triganon, F. Guiter, V. Andrieu-Ponel, D. Dupuy - Cartography and chronology of the glacial advances in the Lemanic area since MIS 5
12.00 – 12.30 discussion

lunch break

12.30 – 14.00

14.00 – 16.30 Geological and glacial history of the Alps during the Quaternary

14.00 – 14.15 Roberto De Franco, G. Biella, G. Caielli, F. Berra, A. Bini, M. Guglielmin, A. Piccin, C. Ravazzi, D. Sciunnach - Overview of high-resolution seismic prospecting in pre-alpine and alpine basins (Lombardy Alps)
14.15 – 14.30 Milovan Milivojevic, L. Menkovic, J. Calic - Pleistocene glacial relief of the central part of Mt. Prokletije (Albanian Alps)
14.30 – 14.45 Marco Giardino, G. Fioraso, W. Alberto - Quaternary geology and geomorphology of the upper Susa valley (W-Alps): new data for the reconstruction of the alpine relief evolution
14.45 – 15.00 Wim Westerhoff, H. Weerts - A new lithostratigraphic classification of Quaternary and Upper Tertiary deposits in The Netherlands
15.00 – 15.15 Cesare Ravazzi – Late Neogene and Quaternary stratigraphical evolution of the Southern Alps and their forelands in eastern Lombardy (N-Italy)
15.15 – 15.30 Daniele Luigi Pinti, X. Quidelleur, S. Chiesa, C. Ravazzi, L. Raisberg, P.-Y. Gillot - Sources and age of the Piànico tephra: a stratigraphic record of stage 19 in Southern Alps?
15.30 – 15.45 A. Brauer, S. Wulf, Clara Mangili, A. Moscariello - A new tephra layer from the Piànico-Sèllere varved interglacial lake deposits (Southern Alps, Italy)
15.45 – 16.00 Paolo Mozzi, A. Fontana, A. Bondesan - Stratigraphy and paleopedology of the post-LGM unconformity in the Venetian - Friulian Plain (Italy)
16.00 – 16.30 discussion
16.30 – 17.15 coffee break and poster session

17.15 – 19.15 Geological and glacial history of the Alps during the Quaternary

17.15 – 17.30 Angelo Cavallin, A. Pasuto, M. Soldati – The role of large landslides in the Quaternary evolution of alpine valleys and their paleoclimatic significance
17.30 – 17.45 E. Oddone, Alessandro Pasuto, F. Tagliavini - New geomorphological evidences of the Quaternary evolution of the Vajont valley
17.45 – 18.00 Lisa Borgatti, C. Ravazzi, M. Donegana, A. Corsini, M. Marchetti, M. Soldati – Early Holocene vegetation history and watershed events, Corvara in Badia, Dolomites (Italy)
18.15 – 18.30 Giancarlo Scardia, G. Muttoni, D. Sciunnach – Rock uplift of the northern Po Plain during the Pleistocene
18.30 – 18.45 Giovanni Monegato - The Plio-Pleistocene evolution of the Tagliamento river valley (Eastern Pre-Alps)
18.45 – 19.15 discussion

Tuesday September 12, 2006

8.45 - 10.30 The last glacial – interglacial transition and the Holocene: glacial advances, palaeolimnology, dendrochronology, and radiocarbon dating

8.45 – 9.00 Michael Friedrich, B. Kromer, S. Talamo - Late Glacial tree-ring chronologies of northern Italy
9.00 – 9.15 Bernd Kromer, M. Friedrich, S. Talamo, F. Kaiser, M. Schaub - Calibration of the radiocarbon time scale in the Late Glacial
9.15 – 9.30 Sven Lukas, D.I. Benn, T. Bradwell, F. Preusser, C. Schlüchter - Younger Dryas climate and glaciation in Europe – a transect from maritime Britain to the continental Alps
9.45 – 10.00 Elena Ortu, O. Peyron, R. Caramiello - Time-scale and intensity of lateglacial and Holocene climate oscillations in the South-western Alps
10.00 – 10.30 discussion
10.30 – 11.00 coffee break and poster session

11.00 – 12.45 The last glacial – interglacial transition and the Holocene: glacial advances, palaeolimnology, dendrochronology and radiocarbon dating
11.00 – 11.15 Maria Letizia Filippi, E. Arpenti, O. Heiri, S. Frisia, E. Vescovi, N. Angeli, K. van der Borg - Late-glacial to present palaeoenvironmental changes in Trentino, NE Italy: hints from lake sediments

11.15 – 11.30 Jürgen Reitner - The beginning of Termination I in the Eastern Alps: a change of paradigm

11.30 – 11.45 Silvia Frisia, A. Borsato, C. Spötl, I.M. Villa, F. Cucchi, D. Genty - Pleistocene and Holocene Alpine and Peri-Alpine speleothem $^{18}$O and $^{13}$C chronologies

11.45 – 12.00 Marco Peresani - Late-glacial alpine reforestation and human peopling: a general overview

12.00 – 12.15 Amelia Aceti – The early Holocene climate optimum: evidence from high-altitude peat deposits in the Italian Alps

12.15 – 12.45 discussion

lunch break 12.45 – 14.00

14.00 – 16.00 Continental vs. marine Quaternary events: registration and correlation

14.00 – 14.15 Valter Maggi – Pleistocene records from polar ice cores: the atmospheric perspective


14.30 – 14.45 Stefano Furlani, F. Antonioli, E. Fouache, M. Ghilardi, S. Faivre, R. Auriemma, V. Kovačić, F. Cucchi - Late Quaternary sea level changes along the Northern Adriatic coast: an interdisciplinary approach

14.45 – 15.00 Marina Iorio, J. Liddicoat, F. Budillon, R. Coe, L. Sagnotti, E. Marsella - Palaeomagnetic Secular Variation Chronology compared to $^{14}$C Geochronology. An example from late Pleistocene and Holocene marine sediment from the Western Mediterranean Sea

15.00 – 15.15 V. Di Donato, P. Esposito, Elda Russo Ermolli, A. Scarano, R. Cheddadi - Land-sea correlation of Holocene climatic events in the Sele Plain-Salerno Gulf area (southern Italy)

15.15 – 15.30 Luca Capraro - The Ionian Stage: a proposal for the Middle Pleistocene chronostratigraphy

15.30 – 16.00 discussion

16.00 – 16.30 coffee break and poster session

17.00 departure for the visit to “The Last Supper”

Wednesday September 13, 2006

8.45 – 10.30 Climatic and biotic evolution of the Alpine region and surrounding areas: Pliocene and Quaternary

9.00 – 9.15 Marta Donegana, R. Banino, R. Pini, C. Ravazzi, E. Vavassori – The Late Pleistocene pollen record of Azzano Decimo (southeastern alpine foreland)

9.15 – 9.30 Daniela Esu, D. Gianolla - A new finding of the genus Tanousia Servain (Hydrobiidae) from the Piànico-Sellere basin (Bergamo, N Italy): paleoclimatic and chronostratigraphic meaning

9.30 – 9.45 Federico Masini, B. Sala - Large and small mammal biochronology and chronostratigraphy from the Late Pliocene to the Middle Pleistocene of the Italian peninsula


10.00 – 10.30 discussion

10.30 – 11.00 coffee break and poster session

11.00 – 12.45 Climatic and biotic evolution of the Alpine region and surrounding areas: Pliocene and Quaternary

11.00 – 11.15 Anastasia Markova, van Kolfschoten T. - The evolution of European mammal assemblages during Late Pleistocene - Early Holocene transition

11.15 – 11.30 Ruth Drescher-Schneider, C. Jacquat, W. Schoch - Palaeobotanical investigations at the mammoth site of Niederweningen: a further step to the understanding of the Middle Würmian environment and stratigraphy on the Central Swiss plateau

11.30 – 11.45 Natalia Gerasimenko - Palaeoecological evolution of the Ukrainian Carpathians during the Late Pleistocene (lithopedological and pollen evidences)

11.45 – 12.00 Frédéric Guiter, V. Andrieu-Ponel, J.L. de Beaulieu, G. Nicoud, A. Triganon, E. Gandouin, P. Ponel, B. Blavoux - Palynostratigraphy of some Pleistocene deposits in the Western Alps: a review

12.00 – 12.15 Antonella Miola, A. Bondesan, S. Favaretto, A. Fontana, P. Mozzi, I. Sostizzo, G. Valentini - Palaeobotanical data for a biostratigraphy of the Last Glacial Maximum in the Venetian Plain

12.15 – 12.45 discussion

lunch break 12.45 – 14.00

14.00 – 15.00 Climatic and biotic evolution of the Alpine region and surrounding areas: Pliocene and Quaternary

14.00 – 14.15 Arnt Bronger - Pedostratigraphic correlation of loess-paleosol sequences in East and Central Asia with Central Europe - a second attempt

14.15 – 14.30 Philip Gibbard, Ehlers J. – Extent and chronology of late Cenozoic glaciations
14.30 – 14.45 Charles Turner – Correlation of the Holsteinian/Hoxnian interglacial of northern Europe with the Middle Pleistocene deep-ocean record

14.45 – 15.00 discussion

15.00 – 16.15 The contribution of geochronology to the Pleistocene stratigraphy

15.00 – 15.15 Christoph Spötl, Offenbecher K.-H., Meyer M., Mangini A., Kramers J. - Progress in late Pleistocene stratigraphy and paleoclimatology of the Alps based on speleothems


15.45 – 16.00 Sally E. Lowick, F. Preusser, G. Monegato - The principles of optically stimulated luminescence and its application to the dating of sediments from the Po Plain, northeastern Italy

16.00 – 16.15 discussion

16.15 – 16.45 coffee break and poster session

16.45 – 17.45 The contribution of geochronology to the Pleistocene stratigraphy

16.45 – 17.00 Michael C. Meyer, R.A. Cliff, M. Knipping, C. Spötl, B.R. Schöne - Climate variability at the Plio-Pleistocene transition recorded in laminated U-Pb dated alpine speleothems

17.00 – 17.15 P.R. Federici, D. Granger, M. Pappalardo, A. Ribolini, Matteo Spagnolo, A.J. Cyr - Egesen stage moraine dated in the Western Alps by means of cosmogenic beryllium-10

17.15 – 17.30 Joel Q.G. Spencer, C. Spötl - Characteristics of quartz-luminescence from Eastern Alpine glacigenic sediments

17.30 – 17.45 discussion

18.30 departure for the city center and visit to the head offices of CAI (Club Alpino Italiano)
Atanassova J., Stefanova I., Deltcheva M. - Late Glacial and Early Holocene vegetation changes in the Northern Pirin Mountains (Southwestern Bulgaria) – palynological data from Lake Popovo

Blyakharchuk T. - Late Glacial and Holocene vegetational and climatic changes recorded in lake-peat sediments located in the subalpine belt of Kuznetski Alatau mountains in the south of Western Siberia

Capelletti S., Comerci V., Motella S., Rossi S., Michetti A.M., Vezzoli L. and the Como Drilling Project Team - Recent environmental evolution in the metropolitan area of Como (Northern Italy): a new perspective from the Como Drilling Project


Favaretto S., Miola A., Roghi G. - Vegetation response to the Late Pleistocene-Holocene transition: a new high resolution Pre-Boreal pollen sequence from Southern Adriatic

Forno M.G., Ferrando S., Compagnoni R. - Plio-Quaternary stratigraphical reconstruction of the Castellamonte area, Torino Province, Italy

Galli A., Panzeri L., Martini M., Sibilia E., Vignola P., Andò S., Rossi P.M. - Application of OSL dating for stratigraphic study of Late Glacial - Holocene sand levels in the Po Plain near Imola

Gianotti F., Forno M.G., Ivy-Ochs S. - New chronological and stratigraphical data on the Morainic Amphiteatre of Ivrea (Piedmont, Italy)

Gibbard P., Ehlers J. - Extent and chronology of late Cenozoic glaciations

Kofler W., Krapf V., Oberhuber W., Bortenschlager S. - The abrupt 8200 cal. BP cold event and long-term climatic changes in the Eastern Alps: vegetation reactions and possible triggers

Laratte S., Rigollet C., Portier E., Buoncristiani J.-F. - Sedimentary dynamics in glacial and proglacial domains: Combe d’Ain, Jura (France), during the Last Glacial Maximum


Marjanac L., Brajković D., Mauch Lenardić J., Durn G., Brajković D., Radović S. - Correlation of Upper Pleistocene localities of southern Istria (Croatia): problems and progress
Marjanac L., Marjanac T. - Pleistocene sediments at Novigrad sea: evidence of glaciation of coastal Adriatic (Northern Dalmatia, Croatia)

Mastronuzzi G., Pignatelli C., Romaniello L., Sansò P., Calcagnile L., Quarta G. – The “out of place” layer of Il Pilone dune ridge (Brindisi, south Italy): genesis and age determination

Monegato G., Fontana A. - The Late Pleistocene of Illegio hollow (Friuli, NE Italy): trees buried by landslide 34 ka before the last maximum glacial advance in Tagliamento valley

Monegato G., Donegana M., Marchesini A., Pini R., Ravazzi C. - Climate and vegetation during the Last Glacial Maximum in the Friulian Prealps (NE Italy)

Rellini I., Trombino L., Rossi P.M., Firpo M., Piccazzo M. – Micromorphological characterization of a loess – paleosol sequence along the northern slope of the Ligurian Alps

Scardia G., Sciunnach D. - Multivariate analysis on the petrography of gravel from outcrops and cores: a case study from the Lombardian “Ceppo” facies (Northern Italy)

Simakova A. - The vegetation during the last Interglacial - Glacial cycle based on the palynological materials of the Southern Russian Plain

Tonkov S., Bozilova E., Possnert G., Velčev A. - Lateglacial and Holocene Palaeoenvironment and Vegetation History in the Northwestern Rila Mountains, Bulgaria

Vassio E., Martinetto E., Van der Burgh J., Cerutti A.K. - A Pliocene fossil forest between Alps and Po Plain Gulf (northwestern Italy)
Scientific sessions

Monday
September 11, 2006
Quaternary stratigraphy of Switzerland

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The Swiss Alps are an important region for reconstructing past changes in atmospheric circulation and environmental conditions due to its position downwind of the North Atlantic and due to the fact that the area was repeatedly glaciated during the Quaternary. The oldest deposits attributed to a glaciation of the Alps are found at Irchel Hill, in the northern part of the Swiss lowlands (‘Höhere Deckenschotter’ – upper cover gravel). The petrography and sedimentology of the deposits implies a glaciofluvial origin of the sediment (Graf, 1993). Age control is provided by mammal remains (MN 17) found in intercalated fine-grained overbank deposits, indicating an age between 2.3 and 1.8 Ma (Bolliger et al., 1996).

Relatively little is known precisely about the early part of the Quaternary, although some glaciofluvial sediments from northern Switzerland (‘Mittlere and Tiefere Deckenschotter’) were presumably deposited during this period (Graf, 1993). Knowledge about the late Middle Pleistocene environmental history comes from the sites of Thalgut and Meikirch. The basal part of the Thalgut site consists of glacial sediments followed by lacustrine deposits (Schlüchter, 1989), which bear pollen of Pterocarya (wingnut) and a substantial amount of Fagus (beech) (Welten, 1988). This implies a correlation of this interglacial with the Holsteinian, which may either be an equivalent of either Marine Isotope Stage (MIS) 11 (de Beaulieu et al., 2001) or MIS 9 (Geyh and Müller, 2005). At Thalgut, this interglacial is followed by a second sequence of glacigenic deposits, which is cut by an erosional surface that is interpreted to represent interglacial conditions. Above follows a gravel unit that presumably reflects deposition under cold climatic conditions but without any indication of an input of Alpine material. Hence, petrography of this latter unit does not provide any evidence for the presence of a glacier close to the site. The lake sediments above this gravel unit are the equivalent of the Eemian Interglacial as indicated by pollen analyses (Welten, 1988) and luminescence dating (Preusser and Schlüchter, 2004). In previous outcrop situations, two units of pro-glacial deposits above the Eemian sediments were exposed. These two units were separated by a weathering horizon implying that two independent Würmian ice advances reached the Thalgut area.

At the Meikirch drilling sites, a sequence of about 70 m of lacustrine deposits is found below c. 40 m of proglacial outwash sediment (Welten 1982, 1988). A re-interpretation of the sequence based on luminescence dating, detailed logging of the sediment cores and reviewing existing pollen data implies a correlation of the lacustrine sequence with the period from late MIS 8 to late MIS 7 (Preusser et al., 2005). If this interpretation is correct, MIS 7 would include three periods with a pronounced interglacial character, which are apparently reflected in the marine record by three distinct peaks towards warmer environmental conditions.

The Late Pleistocene climatic evolution of the northern Alpine Foreland has recently been reviewed by Preusser (2004). The most prominent issues in the present discussion of the Late Pleistocene in Switzerland are the well-developed and well-dated MIS 3 site of Gossau (Preusser et al., 2003) and evidence for at least three independent glacial advances into the Swiss lowlands during the last glacial cycle (MIS 5d-2) (Preusser et al., 2003; Preusser and Schlüchter, 2004; Preusser et al., 2006). These three Würmian glaciations are assigned to MIS 5d, MIS 4, and MIS 2, respectively.
Sedimentary evidence as well as environmental conditions reconstructed from pollen analysis indicate that glaciers retreated far back into the Alps after each of these glacial advances. The last glaciation of the Swiss lowlands (MIS 2) was apparently the most extensive ice advance during the Würmian. It reached the lowlands shortly after 30,000 yr ago (Preusser et al., 2006), and started to decay from its maximum position soon after c. 21,000 yr ago (Ivy-Ochs et al., 2004).

References


Preusser F., Schlüchter Ch. (2004) - Dates from an important early Late Pleistocene ice advance in the Aare Valley, Switzerland. Eclogae Geologicae Helvetiae, 97: 245-253.


Glacial history of the Northern Alpine Foreland – classical and modern approaches

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As early as 1723, John Jacob Scheuchzer recognized “two episodes of the deluge” because he had found a compressed peat between two layers of clastic deposits (Schlüchter, 1986). This was a lithostratigraphic interpretation of a sediment sequences at Hurifluh (Switzerland) according to the law of superposition after Steno (1669).

In 1882 Albrecht Penck published his first classification of the glaciations of the German Alps. Based on sediment profiles in the Inn valley and elsewhere he proposed three glacial periods. This division was in accordance with investigations in Northern Germany and surrounding areas (Penck, 1879). The conform classifications of the Scandinavian and Alpine glacial history were both based on the lithostratigraphic interpretation of sediment profiles only. According to morphological characteristics (“lower terrace”, “higher terrace”, “cover gravel”) fluvial terraces were mapped in the 19. Century but did not serve as key sites for glacial stratigraphy.

Later, in 1899 and in 1909, together with Brückner, Penck changed this point of view: Penck postulated the evident connection between melt water-, ice marginal- and subglacial features and argued consequently that by analyzing different levels of gravel terraces episodes of cold climate can be recognized much more easily. The newly developed morphostratigraphic approach to the glacial history of the Alps was expanded by Pencks successors (e.g. Schreiner and Ebel, 1981) based on the assumption that the lower edge of a gravel accumulation is like a “trace fossil”. The law of superposition was used, for example for loess sequences or lacustrine deposits but all results are tied to the backbone of morphostratigraphy. Some workers tried to combine Pencks morphostratigraphic classifications with independent lithostratigraphic evidence (e.g. Ellwanger et al., 1995) but the calibration of the different sites is still doubtful.

Nowadays morphostratigraphic and lithostratigraphic approaches are both in use in the Northern Alpine foreland (e.g. Fiebig et al., 2004) but the problems between the different classifications, e.g. in the correlation between Northern Germany and the South German Alpine foreland are still unsolved as well.

Schlüchter (1976, 1986, 1988-89, 1989) redefined the younger part of the Swiss Alpine Quaternary stratigraphy in lithostratigraphic terms. In the 1970 and 1980 his approach used especially palynostratigraphic marker to arrange various sediment profiles. Up to now the difficult structural design of the paleogeographic glacier advances in the Alpine foreland is not fully resolved and the discussion about palynostratigraphy is still going on (e.g. Preusser et al., 2005). On the base of IGCP 378 (Schlüchter, 1995)-terminology Fiebig (2003) tried a paleogeographic approach to the glacial history of the Alps but the age control is imperfect.

To learn more about the glacial history of the Alps absolute dating seems to be a very good tool. The Last Glacial Maximum (LGM-advance) is pinned in the Northern Alpine foreland by radiocarbon-, OSL- and Uranium-Thorium-dates between 28 and 20 ka. The Penultimate Glacial Maximum (PGM-moraine) is part of the Most Extensive Glaciations (MEG-moraine system). Datings provide several possibilities for the age range of the PGM, e.g. 60 to 90 ka (Fiebig and Preusser, 2003), 140 to 200 ka and even much older time spans (Schlüchter, 2004). The oldest part of the glacial story of the Alps is even more obscure. Despite some lithostratigraphic
successions with biostratigraphic marker horizons (e.g. Ellwanger et al., 1994; Graf, 1993), the age of the different Deckenschotter units is largely unknown.

References


Penck A. (1882) - Die Vergletscherung der Deutschen Alpen. Leipzig (Barth).


Schlüchter Ch. (1986) - The Quaternary glaciations of Switzerland, with special reference to the Northern Alpine Foreland. Quaternary Science Reviews, 5: 413-419.


Steno (1669) - De solido intra solidum naturaliter contento.
The Pleistocene sedimentary record in Slovenia - an overview

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The majority of Pleistocene sediments on the territory of Slovenia are of fluvial origin. At the southern rim of glaciated and uplifting Alps the terrestrial clastic sediments filled up the Ljubljana, Krško, Celje, Mura/Drava, and some other minor depressions while the glaciers left behind rather sparse sedimentary evidence of their existence. Regardless of the limited extend of glaciation, the fluvial sedimentation down to the outskirts of the former Pannonian Basin seems to be in close relation to glacial events in the Alps. Some of the better investigated regions are presented.

THE ALPS: The glacial cover of the Slovene Alps was generally limited to elevated plateaus and to alpine valleys. Bulk of the ice drained through valleys of modern rivers Soča, Sava and Savinja leaving behind rather limited sedimentary evidence (Bavec and Verbič, 2004). Along the Soča river, redeposited glacigenic sediments were dated to termination of the penultimate glaciation and to the Late glacial (Bavec et al., 2004). Older sediments are all either covered, or eroded. There is no firm age control on the sediments of the Sava glacier(s), however the geomorphology indicates several ice advances reaching at its maxima to the town of Radovljica or possibly beyond (Kuščer, 1955). Sedimentary evidence of the Savinja glacier is sparse due to erosion (Meze, 1966).

LJUBLJANA BASIN: Žlebnik (1971) provided the first comprehensive description of the Ljubljana basin fluvial infill, dividing it into four Pleistocene stratigraphic units: the older, the middle, and the younger conglomerate, and the gravel fill. Each unit supposedly corresponds to a single morphological surface (a terrace), with an exception of the gravel fill, which is divided into 8 terraces. While summarizing previous works Kuščer (1990) supported the idea that all the material is glaciofluvial and that units correspond to following “ages”: Günz, Mindel and Riss for conglomerates and WI, WI/II, WII, Late Glacial and post glacial for gravel fill respectively. He claimed that, with an exception of the two interstadial terraces, each terrace corresponds to a certain moraine ridge. Further works (in progress) show that tectonic influence over the sedimentation has been most probably underestimated and that the terrace system may not be so perfectly correlated with climate change (e.g. Geološki zavod Slovenije, 2004; Verbič, 2004b). Few dating attempts were made on the fluvial infill. pollen analyses were performed at several localities all indicating “post-rissian” age (Šercelj, 1962, 1970). A combination of $^{10}$Be and paleomagnetic measurement suggests ages < 62ka, 450-980 ka and app. 1.8 on different terrace surfaces respectively, yet with high level of uncertainty (Vidic, 1998). The Ljubljana Moor area differs from the northern part of the Ljubljana basin by its structural origin and its infill. The most complete Pleistocene pollen record in Slovenia was documented here (Šercelj, 1965). Beside showing vegetational variations from the “Early Würmian” until the Holocene, the borehole BV-1 revealed rapid subsidence of the basin floor in this period of time.

KRŠKO BASIN: Kuščer (1993) made the first modern subdivision of the Quaternary infill. The following investigators (e.g. Verbič et al., 2000; Verbič, 2004a), divided the infill into the following climate-controlled alloformations deposited by the Sava River fluvial system:
- Pliocene-Pleistocene deposits (name derives from Heritch and Seidl, 1919). The non-carbonate fluvial infill deposited upon Pontian (and older) sediments and covered by mid-Pleistocene fluvial infill was named Globoko alloformation;
- Brežice alloformation - the fluvial infill of carbonate rich gravel builds terraces that elevate approximately 25 meters above the Holocene infill of the basin. Luminescence dating of the sediment yielded a broad range of results that still lack a concise interpretation. Verbič (2004a) however estimates 145 ka as most plausible age, which would place the deposition of the alloformation into the final phase of the penultimate glaciation;
- Drnovo alloformation is the only preserved fluvial infill of the late Pleistocene. It is lithologically similar to the Brežice alloformation. With a high level of uncertainty, Verbič (2004a) estimates the formation age between 16 and 18 ka based on luminescence dates.
A set of four topographically lowest terraces is named the Vrbina allomember of the Drnovo alloformation. Its Holocene age was determined based on relative pedologic chronosequence, geomorphic expression and historical data.

References


Late Neogene and Quaternary stratigraphical evolution of the southern Alps and their forelands in eastern Lombardy (N-Italy)

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The eastern border of the Southern Alps in Lombardy, close to the Po plain foreland, is bounded by the great southalpine lakes Como (to the west) and Garda (to the east). The main stratigraphical and chronological insight for the evolution of this area during the Pliocene and Early Pleistocene derives from the sedimentary succession filling the Po plain foredeep, and from a series of intermontane lacustrine basins, representing exceptionally well-preserved sedimentary archives of the biotic evolution and proxies of climate change.

According to the structural data and to the subsurface stratigraphy of the Po plain, the last phase of orogenic deformation is dated from the Middle Miocene to the late Messinian. A deep dissection of the relief occurred during the Messinian as the result of the drying up of the Mediterranean Sea. At the beginning of the Pliocene, the sea transgressed over the foothill of the Southern Alps, forming a rias coast through the Miocene valleys. The occurrence of marine deposits of Early Pliocene age within the outermost valleys demonstrates their Miocene age, although there is no stratigraphic proof of a further development of this deep drainage system further upstream.

Sea level fall and uplift caused sea regression from the southern Alpine foothill during the late Pliocene. Nevertheless, still at the end of the Jaramillo subchron, the Padanian sea had withdrawn only a few km from the border of the foothill. River aggradation, tectonic activity, uplift, climate change and glacial advances are involved in the Early Pleistocene evolution of the prealpine drainage systems, and also affected the origin and history of the lacustrine basins of Leffe, Pianico-Sellere and others.

Three main glacial amphitheatres were formed since the end of the Early Pleistocene in the southern alpine foreland in front of the depressions nowadays occupied by the southalpine lakes (Como, Iseo, and Garda lakes). During the last century, several projects of geological mapping led to different conclusions about the number, subdivision and age of glaciations represented in these glacial systems. In order to break this deadlock, a multidisciplinary approach is wished, including field cartography, the integrated stratigraphy and geochronology of reference sections and drillings.
Cartography and chronology of the glacial advances
in the Lemanic area since MIS 5

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Compilation of ancient and recent profiles cored in the Evian area allowed us to propose a detailed stratigraphical review of hectometric detritical deposits which compose the southern bank of the Lake Geneva. Three types of sediments have been identified: glaciolacustrine, subglacial and lateral glacial deposits interbedded with peat and lignite layers.

Three Stratigraphical Units Complexes have been defined:
- the “Complexe Inférieur” dominated by glaciolacustrine sediments deposited before 30 000 BP but after the maximal expansion of the Wurmian glacier;
- the “Complexe du Plateau Gavot”, built in a context of active glacial margin between 30 000 BP and 27 000 BP. In this stratigraphical unit, a minimum of fifteen oscillations of the Rhône glacier have been identified whose lateral extensions might have reached the altitude of 850 m on the Plateau Gavot, and ca 1 kilometer southward;
- the “Complexe Emboîté”, characterized by glaciolacustrine sediments. Ice fluctuations occurred between 25.000 and 21.000 BP reaching the altitude of 650 m.

Mapping of the landforms and morainic ridges have also allowed to characterize (1) the external limits of smaller ice extensions (posterior to the maximum) and (2) the following final deglaciation stages between Geneva and Thonon areas. Two recurrences have been defined:
- the “Récurrence de Genève” (correlated with the “Complexe du Plateau Gavot”). The glacier was located at that time in the surroundings of Geneva and bordered by the channel of Machilly. Glaciolacustrine sediments were deposited upstream from that area while lateral valleys were blocked by the Rhône glacier. Two deglaciation phases were recorded at Thonon (fluvial channels and kame terraces);
- the “Récurrence du Petit Lac” (corresponding to the “Complexe Emboîté”). Two episodes of the final deglaciation were recorded by tills in the low kame terraces of Thonon, and downstream by morainic ridges. This recurrence reached the surroundings of Yvoire.

Finally, this chronological pattern is supported by 2D/3D geophysical prospections carried out by multi-sismic reflexion on the Grand Lac (Léman).
Overview of high resolution seismic prospecting in Prealpine and Alpine basins (Lombardy Alps)

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In the last few years Regione Lombardia (Direzione Generale Territorio e Urbanistica) and the National Research Council (C.N.R. - IDPA Milano) acquired high resolution seismic reflection profiles to characterize the Plio-Quaternary of Alpine and pre-Alpine valleys of the Lombardy Alps and to study their evolution. Other geophysical experiments were carried out in the study area, some examples are reported in Felber et al. (1994), Piccin and Coren (2004).

The aims of this presentation are: a) to show different seismic tests, performed during the experiments, which were oriented to optimise the acquisition techniques for shallow prospecting (50-1000 m depth) and to minimize their environmental impact and costs; b) to discuss the data acquired in the Alpine and pre-Alpine basins for different domains: glacial valley (Valtellina: Teglio, Sondalo and Bormio profiles), terminal moraine (Castello Brianza and Annone profiles), deeply eroded valley (fluvial and glacial) (Val Seriana - Val Borlezza: Clusone, Rovetta and Sovero profiles), and alluvial plain (Bosco in Città – Milan profile) (Fig. 1). Among these tests only the most representatives, for the aim of the presentation, are discussed.

Fig. 1: location map of the explored lines in the valleys of the Lombardia region

In the frame of Valtellina experiment, in order to compare the efficiency of different seismic source, the Bormio profile was acquired using both dynamite and a hydraulic mass-drop system (minipulse) as an energy source. The final stack sections for the two sources are shown in figure 2. As can be seen the minipulse source (Fig. 2b) shows more clear and more detailed reflected events (de Franco et al., submitted).
In the seismic reflection data acquisition the roll-along procedure was used. For the Teglio seismic line (Valtellina) an extended cable was used in order to acquire wide offset reflection phases, to better constrain the deeper reflected events (in the velocity analysis step) and to acquire simultaneously seismic refraction phases in order to control the velocity distribution within the sediments with first arrival refraction tomography. The Teglio reflection line was simultaneously acquired with a roll-along cable procedure and a fixed long cable which was located in the middle of the profile (de Franco et al., submitted) (Fig 3).

Based on the good results of the Valtellina experiment, in all the other experiments the extended cable procedure was performed. In these acquisitions a fixed cable with 96 or 120 channels was used, allowing the simultaneous acquisition of seismic reflection and refraction data with a reduction of times and costs.

**Fig. 2:** final stack of the Bormio profile. (a) explosive sources, (b) minipulse source.
The goals of the seismic experiment in the ‘Bosco in Città’ (a metropolitan park in Milan), carried out in March 2004, were: to check the logistic feasibility, to reduce the environmental impact of the prospecting and to define the optimal experimental parameter for short seismic line acquisition (de Franco et al., 2005). Therefore, the experiment was conceived in order to study the influence of different source and geophone spacing. The first part of the line (48 channels) was deployed with a geophone spacing of 5 m, the second (48 channels) of 10 m. The source spacing were of 2.5 and 5 m respectively for the first and the second part. In Fig. 4 the results of the data processing are shown and we observe that both part of the line are well resolved. The processing of the acquired data included the reflection and refraction data processing. Reflection data were processed with standard procedure using Promax and Sunt7 codes. The obtained reflection sections were integrated with the corresponding seismic velocity.
tomographic sections obtained with the inversion of the seismic refraction data. Two different 2D inversion of first arrival times were utilized: the CRT (Tondi and de Franco, 2004) and SEISOPT (Pullammanappallil and Louie, 1994). An example of final velocity model obtained with CRT inversion codes of the first arrival (Fig. 5) along the Clusone line is shown in Fig. 6 (de Franco et al., 2004). In general the integration of the two data sets improves the seismic migration of the reflection sections and the seismic interpretation, obtaining well constrained seismo-stratigraphic sections, coupled with an accurate seismic velocity section.

![Fig. 6: refraction velocity model obtained along the Clusone seismic profile. The dotted line indicates the basement top.](image)

The integration of reflection and refraction allowed to reconstruct both the main reflectors in the recent deposits and the geometry of the bedrock (Fig. 7).

![Fig. 7: final stack section of the Clusone seismic profile. The bold line indicates the basement top.](image)

We observe that the quality of the events reflected by the bedrock is generally higher in the glacial domain, probably due to a stronger impedance contrast whereas it is worse in the valley of the
fluvial-glacial eroded domain. The deeper seismic response also depends on the geometrical complexity and the geological features of the sedimentary cover. A clear demonstration of this fact is the good seismic response, up to about 1000 m of depth, of the Bosco in Città line where the sedimentary cover is characterized by a parallel stratification.

The integration with geological data (mainly well data) is important in order to identify the bedrock geometries and to constrain the reconstruction of the geomorphologic evolution (de Franco et al., 2004; de Franco et al., submitted).

References


Pleistocene Glacial Relief of the Central Part of Mt. Prokletije (Albanian Alps)

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The central and uppermost area of Mt. Prokletije (also known as Albanian Alps) is situated in northern Albania and eastern Montenegro. This area is known in geomorphological literature as the centre of Pleistocene glaciation on the Balkan Peninsula. This paper presents the forms of glacial erosion developed during the Pleistocene. Based on the traces of glacial forms, the reconstruction of the altitude of Pleistocene snowline and glaciers lengths is carried out. Special attention is paid to the genesis of glacial lakes Buni i Jezerces in Albania, and the lake Travno Jezero in the Ropojana valley in Montenegro.
Quaternary geology and geomorphology of the High Susa valley (W-Alps): new data for the reconstruction of the alpine relief evolution

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In the last few years, in the framework of academic projects, Ph’d thesis and other National and International Research Programmes, new geological and geomorphological data have been collected in the High Susa Valley, central part of the Italian Western Alps. Field-based activities and remote-sensing methodologies provided multiscale datasets and thematic maps allowing different outputs for the interpretation of the Plio-Quaternary stratigraphical evolution of the area, the upper Pleistocene glacial history, the neotectonic setting and their influences on present-day geomorphological setting and slope dynamics.

Case studies are here presented regarding:
- the eldest deposits are matrix supported carbonate micro-breccias (poorly cemented, with polygenetic clasts in a sandy-silt matrix), interpreted as detrital pseudocarniole by stream water transport in a karsts environment (Alberto et al., 2006); they contain pollen of Upper Pliocene-Early Pleistocene arboreal taxa from coastal environments;
- relict landforms due to ancient drainage systems are distributed aside aligned high relieves, according to succeeding “migrating” major watersheds;
- presence of neotectonic shear zones, whose recent activity controlled the major drainage segments, aligned along N60E and N140E directions (Polino et al., 2002);
- relict glacial landforms are preserved at “discrete” altitudinal belts, whose elevations range from 500 m asl up to 3000 m asl;
- several units of glacial deposits are associated to the above mentioned altitudinal belts: they have been differentiated by sedimentological characteristics, lithological composition and weathering profiles;
- a complex setting of slope instability phenomena has been mapped, characterized by various movements typologies, dimensions (up to billion cubic m in size) and evolutionary stages. All the surveyed landslides accumulations are post-LGM (mainly by morphostratigraphical relationships with glacigenic deposits), some deep-seated gravitational deformations also show a pre-Holocene, sin-glacial activity;

Fig. 1: LGM (in grey color) on High and Middle Susa Valley
- some slope instability phenomena deeply modified the recent geomorphological setting of the Susa valley, as shown by landslide dams and fluvial, lacustrine and glacial deposits buried by landslide accumulations;
- slope instabilities are unequally distributed in the area, being concentrated along neotectonic shear zones and particular litho-structural settings (Giardino and Polino, 1997).

![Fig. 2: geological and structural setting of the Susa Valley; spatial distribution of DSGSD is along the major shear zones.](image)

The analysis and comparison of the above mentioned Quaternary geological and geomorphological features allowed some significant advances in the reconstruction of the recent evolution of the alpine relief in the Susa valley sector. In a relatively complex setting, the role of some conditioning factors of the evolution has been outlined and some “critical” point recognized.

The strong Pleistocene alpine uplift conditioned differential erosional patterns, with major rates concentrated in the axial part of the chain and along major valley bottoms. The alpine relief is a low-conservative geomorphological context: well distinct landforms and related deposits are younger than late Pleistocene; older landforms, although clearly recognizable in some valley sector, are difficult to be chronologically interpreted because related deposits are completely eroded.

On the contrary the karsts environments showed to be more conservative, “saving” some relatively old records of environmental conditions (vegetation/climate; water composition/temperature); in any case collected data are of difficult interpretation and chronological attribution.

The analysis of the complete dataset evidenced an uneven temporal and spatial distribution of uplift: this conditioned the unequal distribution of elevations through the chain, the different degree of landform preservation, the occurrence of large slope instabilities. As a consequence, the Middle and High Susa valleys show sectors with strong differences in the geomorphological evolution and distinctive “leading” geomorphic processes. Some of them, such as those related to the Pleistocene glacial phases, acted at a regional scale, over all the Susa valley system; some others, such as the instability processes induced by deep-dissolution, had strong influences at a local scale.
References


A new lithostratigraphic classification of Quaternary and Upper Tertiary deposits in The Netherlands

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Ever since earth scientists have started to study the earth they all have attempted to describe and classify what they saw and to communicate about their observations. Since observations in earth science deal with the properties of strata on top of each other (in outcrops or in boreholes), these communications dealt with stratigraphy, i.e. the description of the layers that were observed. Layers of rock can be described and classified in many ways, and so it happened, and still happens. Lithostratigraphy is the classification of bodies of rock based on the observable lithologic properties of the strata and their relative stratigraphic positions. This implies that observable lithologic properties and stratigraphic position are the only criteria to be used when defining lithostratigraphic units. There is common agreement on mappability as the key criterion for the validity of a lithostratigraphic unit. In fact any new formation needs to be tested on its capability. A formation that can not be mapped makes no sense. Finally we should always remember that, just like any other stratigraphic classification, lithostratigraphy is only a tool! It is not a goal in itself. Its purpose is communication, interpretation and correlation.

With these considerations in mind, the Geological Survey of The Netherlands has revised the existing ‘litho’stratigraphic classification of Quaternary and Upper Tertiary deposits in The Netherlands that dated from the 1970’s. Revision was necessary because (1) the old scheme heavily relied on presumed bio- and chronostratigraphic correlations, and more importantly (2) the accent in mapping had shifted from pure geologic 2D paper maps to applied geoscientific 2.5 to 3D subsurface models. The revised scheme integrates onshore and offshore stratigraphy and it contains 25 formations. It has a hierarchic structure. Many members and beds are present in the formations. Finally, all formations are grouped in one Group to ensure embedding in the Stratigraphic nomenclature of The Netherlands that classifies the entire stratigraphic column in The Netherlands. From the year 2000 onward, the revised scheme has been used by the Geological Survey of The Netherlands. A complete 2.5D subsurface model of the entire country was built using the new classification on a 250 * 250 m grid scale using 17.000 drillings. The succesful construction of the model illustrates the practicability and validity of the new lithostratigraphic approach.
Sources and age of the Piànico tephra:  
a stratigraphic record of stage 19 in Southern Alps?

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Distal tephra derived from explosive volcanism provide invaluable stratigraphical markers in the geological record, particularly for the Quaternary in the Mediterranean basin (e.g. Paterne et al., 1986; Narcisi and Vezzoli, 1999). However, preservation of these tephra in both marine and continental settings can obliterate partially both chronological and provenance information, making difficult their use for stratigraphic correlations (Pouclet et al., 1999). Here we report on the sources, chemistry and K-Ar dating of a very well preserved tephra layer discovered few years ago in the Piànico-Sèllere Basin, Southern Alps, Italy (Pinti et al., 2001; 2003).

The Piànico-Sèllere is one of the best-preserved interglacial lacustrine sedimentary sequences in the Western Alps (Moscariello et al., 2000; Ravazzi and Rossi, 2000). Intercalated to a varved succession (BVC or Carbonate Varved Bed), a 0.8 cm continuous layer of tephra was discovered. The BVC is a 10.5 m thick succession of regularly laminated silty rythmites formed by submillimetrics light-dark couplets deposited within an annual cycle. These varves accumulated in a temperate deep lacustrine environment dominated by endogenic calcite sedimentation during the spring and summer seasons. In total, an estimation of ca. 17 700 yr duration has been provided for the BVC. The tephra has been discovered 60-70 cm below the top of the BVC unit and it is observed in most of the outcrops of the Pianico Formation, along the Borlezza River. The tephra is normally graded and shows a constant thickness of 7-9 mm all over the exposed lateral extent of the BVC unit. The tephra is set into the uppermost part of the light (spring/summer) layer, 0.1 mm to the subsequent dark (winter) layer. This indicates that the pyroclastic fall deposited undisturbed in the deep lacustrine environment of Piànico, during a phase of pure endogenic sedimentation, and that the eruption took place shortly before the end of the summer (Pinti et al., 2001).

The Piànico tephra, of trachytic composition, consists of 85% glass fragments and 15% primary magmatic minerals (orthoclase, oligoclase-andesine and biotite), which makes it a ‘vitric-crystal’ pyroclastic fall deposit. The glass is composed of microvesicular pumice and SEM images show blocky and Y-shaped shards with vesicles that are ovoid to elongated, indicative of high viscosity of the source felsic magma. The grain morphology suggests that the Piànico tephra was produced by an explosive subaerial Plinian-style eruption (Pinti et al., 2003). The trace element pattern for the whole rock and the glass fraction revealed an anomalous enrichment in the high field strength elements (HFSE) Nb and Ta. REE patterns, and new Sr and Nd isotopic data ($^{87}$Sr/$^{86}$Sr=0.704913±21 and $^{143}$Nd/$^{144}$Nd ratios of 0.512696±13) suggests an intraplate volcanism as the source of the Piànico tephra, which is uncommon in the Mediterranean region, dominated by orogenic and subduction-related volcanism (Lustrino, 2000). REE patterns are identical to those of the rhyolites of the Euganean Hills, a within-continental-plate volcanic region, 170 km east of
Piànico, while Nd and Sr isotopes have values intermediate between those of the Euganean Hills and those of the Mont-Dore stratovolcano in Massif Central, France (Milani et al., 1999). However, eight repeated K-Ar ages determined on the Piànico vitric shards by using the “Cassignol-Gillot” technique (Gillot and Cornette, 1986) give an age of 779±13 ka, much younger of the supposed source of the Euganean Hills, which is of Oligocene age (32 to 36 Ma). If the source of this tephra is still unknown, we are much confident on the obtained K-Ar ages, which are comforted by palaeomagnetic measurements that showed a reverse palaeomagnetic direction at the bottom of the Piànico succession, while a normal polarity has been observed on top of the BVC sequence (Pinti et al., 2001). This inversion was interpreted as the Matuyama-Brunhes, which makes the Piànico BVC interglacial formation the continental equivalent of isotopic stage 19 in the marine record. However, the Matuyama-Brunhes inversion is located in the second half of the MIS 19, while at Piànico it seems to precede it.

The K-Ar dating of this succession makes the Piànico Formation the best-preserved and complete interglacial formation in this sector of the Alps and it could make this sequence an important stratigraphical record for inter-regional correlations between early interglacial stages, which are mostly absent or highly speculative in the western Alps.

References


A new tephra layer from the Piànico-Sèllere varved interglacial lake deposits (Southern Alps, Italy)

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The sediment record from the Piànico palaeolake in the Southern Alps is continuously varved, spans more than 15,500 years, and represents a key archive for interglacial climate variability at seasonal resolution. The stratigraphic position of the Piànico interglacial sequence has been controversial in the past. The identification of a new volcanic ash layer by microscopic analysis provides a distinct marker layers for tephrochronological dating. Mineralogical and geochemical composition of this volcanic ash layer has been determined by means of microscopy and major-element electron probe micro analysis on glass shards. This allowed correlating the new Piànico tephra with the Brown Leucitic Tuff (BLT) from the Roccamonfina volcano in the Campanian volcanic complex (Italy). Available dating of near-vent deposits of the BLT provides a robust tephrochronological anchor point at around 393 ±12 ka for the Piànico interglacial sequence which thus is correlating with marine oxygen isotope stage 11. This new age makes the Pianico interglacial sequence younger than the previous Early Middle Pleistocene classification that was based on K/Ar dating of another distal ash layer.
Stratigraphy and paleopedology of the post-LGM unconformity in the Venetian-Friulian Plain (Italy)

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The Venetian-Friulian Plain, which corresponds to the eastern portion of the Southern Alps foreland basin, consists of several, coalescent alluvial megafans. The existence of these large-size sedimentary systems is allowed by the tectonic setting, while their evolution during the Upper Pleistocene and Holocene has been controlled mainly by climatic change and eustasy (Fontana et al., in press). The last event of major aggradation in the megafans of the Brenta, Piave and Tagliamento rivers was during the Last Glacial Maximum (LGM, 24-15 ka BP), when glaciers emanating from the Alpine valleys reached the plain and supplied the fluvial system with large amounts of sediments. During the late LGM the rate of aggradation lowered in the Brenta megafan and a wide incision of the fanhead developed in the Tagliamento megafan. During the Late Glacial and early Holocene an important phase of incision took place, and smaller telescopic lobes formed in the distal portion of Brenta and Tagliamento megafans. Sedimentation was absent or very low between 14-8 ka BP and only since the middle Holocene a new phase of deposition affected the coastal areas, probably related to the marine high stand. Widespread aggradation started once more around 4-3 ka BP, with formation of fluvial ridges along the terminal tract of Alpine rivers. This evolutionary trend has led to the deactivation of wide portions of the LGM megafans, where soil forming processes could act for time spans which, in most cases, comprise the Late Glacial and most part of the Holocene. The resulting soils have well defined characteristics, which depend on the time of exposure of the alluvial surface as well as on the variability of other soil forming factors, e.g. the mineralogy/geochemistry (especially carbonate content) and grain size of the parent material, the local topography and the groundwater table depth. In the apical, gravelly portions of the LGM Brenta megafan the soils have 30-40 cm thick argillic Bt horizons, with hue 7.5YR (Munsell Soil Colour Charts) (Ragazzi et al., 2004); they are classified as Cutanic Luvisols after the FAO World Reference Base for Soil Resources (WRB). In the distal parts, soils on the silty-clay floodplain are characterized by 20-30 cm thick leached Bw horizons, which rest on top of 30-40 cm calcic and gley Bkg horizons (WRB Gleyic Calcisols). The loamy-sandy soils of the adjacent fluvial ridges have leached epipedons but, depending on the local hydro-topographic conditions, do not always have Bk horizons and are classified as WRB Hypereutric(-Gleyic)-Cambisols. These soil sequences are very similar also in the LGM Tagliamento and Piave megafans. Only the apical Piave megafan differs, as Luvisols are absent and Eutri-Skeletic Cambisols are present instead (ARPAV-Regione del Veneto, 2005).

From the stratigraphic point of view, these soils have been developing on the post-LGM unconformity. The definition of these soil chrono-hydro-toposequences is very helpful in the recognition and analysis of the unconformity. In the coastal areas and in the northern Adriatic Sea, the Cambisols of the distal sectors of the megafan are normally preserved within the sedimentary record as buried soils, generally known as “Caranto”, which mark the boundary between the Pleistocene alluvial deposits and the overlying Holocene coastal-marine sediments (Gatto and Prevatiello, 1974; Tosi, 1994; Mozzi et al., 2003). Where the LGM alluvium is still outcropping, the soil characteristics are good age indicators and, thus, represent an important aid for geological mapping. Another important aspect of the problem is that similar soil-alluvium sequences formed
during past glacio-eustatic cycles. These latter have been described in several medium depths corings (100-200 m), drilled in the low Venetian-Friulian Plain, but the geometry, hierarchy and meaning of the observed unconformities and paleosols are still a matter of debate. The regional extension of the post-LGM unconformity and its good preservation makes it an interesting case study, which may serve as an analogue for a better understanding of older, large scale sedimentary events.

References

ARPAV-Regione del Veneto (2005) - Note illustrative della carta dei suoli del Veneto alla scala 1:250.000. ARPAV - Agenzia per la Prevenzione e Protezione Ambientale del Veneto, Padova.


The Plio-Pleistocene evolution of the Tagliamento River Valley

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The 2300 km$^2$ drainage basin of the Tagliamento River is located in the southeastern part of the Italian Alps, in the Friuli region. Along with most other catchments in the Southern Alps, the Tagliamento Valley was deeply affected by the Messinian Salinity Crisis, when the dramatic lowering of Mediterranean base level caused rivers in the region to deeply entrench their valleys (Bini et al., 1978) and then be infilled after sea-level rise during Plio-Quaternary time (de Franco et al., 2004). Stratigraphic analysis of valley deposits enables the reconstruction of the geologic history of the mountain catchment since the early Pliocene.

In valley deposits, three different unconformity-bounded stratigraphic units have been distinguished and ranked according to the bounding surface hierarchy of Miall (1996). The Messinian valley floor is a 8th order boundary because is the regional main disconformity. The three units are bounded by other two angular unconformities 6th-7th order boundaries, that represent the response to fault pulse between depositional units. These three successive units are exposed in valley outcrops for several kilometres.

The first preserved post-Messinian valley fill (basal unit) is represented by well sorted, intra-valley, fluvial conglomerates and sandstones. These can be correlated, on the basis of composition, with coarse-grained middle Pliocene Gilbert-type delta deposits cropping out near Osoppo, NNW of the town of Udine. Pressure-solution tracks on pebbles in both types of deposit display the same main stress direction, NW-SE (Caputo et al., 2002). This unit is deformed by two fold systems, which did not affect the younger deposits.

The second unit (middle unit) is preserved in the same geographic areas as the first. It is deformed by a general tilting to the NE; pressure-solution tracks on pebbles of the deposit display a main NNE-SSW stress direction. The deposits consist mainly of variably sorted and horizontally bedded fluvial conglomerates and sandstones, which locally interfinger with landslide-related breccia bodies and coarse alluvial fan conglomerates, along with minor silty lacustrine deposits. Unfortunately, chronological proxy data are not yet available for this unit; though its stratigraphic position and relationship to angular unconformities suggest a late Pliocene – early Pleistocene age. Petrographic analysis of the sandstones in this succession reveals an increase in carbonate clasts. The origin of this trend has not yet been determined.

The third unit (upper unit) may be subdivided into two members, both characterised by an upward increase in clast size, a decrease in carbonate clasts, and brittle deformation, with vertical faults with ESE strike. The river maintained its previous course during the deposition of the first member, which consists of moderately sorted and horizontally bedded fluvial conglomerates, as well as gravelly Gilbert-type delta deposits, landslide-related breccia bodies, and laminated lacustrine muds. Palynological analyses of the lacustrine muds suggest deposition during a warm period of the middle Pleistocene. The second member consists of coarse fluvial conglomerates, badly sorted and crudely bedded, with subordinate sandstones. It filled the trench inside the older valley units, which suggests an abrupt change in the drainage pattern.

In general, the relationships between these units provide useful information about the geomorphological evolution of the Tagliamento valley.
When the Tagliamento River began entrenching its valley, during the Messinian sea level drop, it flowed in an E-W direction, following the boundary between the Carnian Alps and Prealps, from its source to the San Simeone massif. There, it turned to the south, carving its valley across the Mesozoic carbonate succession until the Osoppo region. At that time, the confluence with the Fella River, the main tributary of Tagliamento River, was located there, i.e. south of the present position. The river maintained this drainage axis until the onset of major glaciations in the Alps, at the end of the early Pleistocene. Climatic change in the drainage basin is represented by the increase in maximum clast-size in the younger unit of the valley. Before the deposition of the second member, abrupt changes occurred in the basin. The valley experienced deep entrenchment and the axis shifted slightly northwards and eastwards, i.e. toward the present-day junction with the Fella River. The age of the first member of the upper unit suggests that this event coincided with piracy of the river during or after a glacial advance in the middle Pleistocene. This diversion caused the eventual abandonment of the south-western valley, which was joined by ice tongues of till during the Late Pleistocene glacial expansions.

Later, at the end of the middle Pleistocene or in the late Pleistocene, a segment of the upper valley was intersected by another stream capture event that forced the river to flow some kilometres south of its previous course.

References


The role of large landslide in the Quaternary evolution of Alpine Valleys and their paleoclimatic significance

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In several mountain valleys huge landslides, that have permanently modified the valley shape, can be found. These landslides are often associated with other surficial deposits that may contribute to the determination of the chronology of the main events that have influenced the geomorphological evolution of the valleys. The long persistence in time of landslide morphological features in the landscape, mainly due to the high volumes of material involved, has locally enabled the conservation of older deposits, sometimes of relevant paleoclimatic significance (e.g. glacial or periglacial deposits). Thus it is evident the chronostratigraphic importance of such sequences of surficial deposits for a correct and comprehensive understanding of the geomorphological evolution of mountain valleys after the retreat of the LGM glacier and of the main landslide triggering factors.
New geomorphological evidences of the Quaternary evolution of the Vajont valley

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In the last decade several studies on landslide risk and hazard in the Vajont valley (Italian Alps) have been carried out in order to assess the residual geological risk due to the Vajont slide. In this framework new geomorphological evidences allowing us to reconstruct the Quaternary paleoenvironmental evolution and of the valley have been discovered. These evidences mainly consist of very well preserved deltaic fluvioglacial deposits and extremely thin-layered proglacial lake deposits including several dropstones.

The preservation of these geomorphological features is mainly due to the proneness to landslide of the valley and to some huge postglacial landslides that sealed the previous deposits, protecting them from the erosion. This landslide and the underlying deposits have been investigated through ERT surveys that allowed to reconstruct the paleomorphology of the valley. Moreover geognostic boreholes have been drilled in order to evaluate the thickness of the landslide deposits and the deepness of the bedrock. The stratigraphical sequence is characterized by the presence of 40 m of moraine deposits in lodgment till facies underneath 90 m of landslide deposits.

The relative temporal correlation of all these new evidences permitted a comprehensive understanding of the geomorphological evolution of the valley after the retreat of the LGM glacier and of the main landslide triggering factors.
Early Holocene vegetation history and watershed events, Corvara in Badia, Dolomites (Italy)

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The early-middle Holocene lacustrine succession of Pescosta (Corvara in Badia, Italian Dolomites, 1520 m a.s.l.) records several watershed events before the onset of human pressure. The capability of this archive to relate climate change, watershed processes and vegetation dynamics in the catchment has been explored through a stratigraphic study, including the analysis of sedimentological features, magnetic properties, palaeobotanical records and radiocarbon datings. A landslide-dammed palaeolake existed between 10.1 to 7 kyr cal BP and was surrounded by a dense conifer forest. A long-term forest succession driven by ecological processes and by climatic conditions favourable to upward forest expansion is recorded throughout the pollen record. Within the normal fine clastic sedimentation deriving from detrital minerogenic supply, distinct graded layers enriched in allochthonous organic debris of terrestrial origin have been recognised. Thanks to the taphonomical properties of pollen and macroremains, these layers have been attributed to instant events produced by mass movements, eventually in connection to floods, yielding suspended fine organic debris on the lake surface. In many cases, the interpolated age of single lacustrine sedimentary events fits the chronology of large landslide events already known in the catchment from previous geomorphological survey and radiocarbon-dated by fossil tree remnants buried in landslide accumulations. Given the correlation between many of the lacustrine events with slope mass movements and associated floods occurred in the catchment, it is worth noting that the vegetation changes reconstructed from the pollen record do not reflect such watershed events, even those occurred at short distance from the lake. Therefore, the potential of detecting single watershed events by palynological evidence of vegetation changes in forest landscapes does not emerge from this study. On the other hand, the taphonomical properties of pollen and macroremains provide valuable insight on the mechanisms of watershed processes.

The lacustrine sequence of Pescosta spans a period of stable climate and vegetation and does not fall into the documented phases of enhanced landsliding in the Dolomites. At the same time, the record shows independent evidence of landslides and extreme meteo-climatic events, as rainstorms may be the triggering factors of the observed sedimentary events. This may be understood admitting that the recurrence of extreme meteo-climatic events, as triggers of the sedimentary events, is only partly dependent from the centennial and millennial scale Holocene climate variability, as shown in the last 300 years instrumental records. It can be concluded that Holocene mass wasting processes in this region were primarily controlled by geological and structural predisposing factors, together with the long-term effects of the deglaciation and permafrost melting, that may result in effects opposite to the ongoing climate tendencies. However, some periods of enhanced landsliding and of gap in the series of events can be pointed out, and appear to be modulated by the centennial-millennial climate phases known in the Alps for this time span.
Blind thrust hazards in the Po Basin, active slow shortening across the frontal Alpine wedge and implications for narrowing of the orogen in response to Quaternary erosion.

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Regional mapping of sequence stratigraphic boundaries in the western and central Po Basin suggests that active shortening has largely been and currently is being accommodated in the Alpine foreland in a line between the southern end of Lake Garda and the northern Apennines near Piacenza (Fig. 1).

Fig. 1: second derivative map of the 890 Kyr surface from TWT seismic reflection data (Courtesy on ENI E&P). Second derivative mapping can define axial surfaces of folds below the Po Plain. The color scale indicates the speed of variation of velocity of the surface. Parallel linear features define surface curvature and therefore axial surfaces and length of folds. Circled areas are well defined structural highs belonging either to the Alpine or the Apennine buried front. Note that features on edges of dataset are artifacts from surface interpolation.

We interpreted a dense coverage of seismic reflection and boreholes data in a 120 km wide region of the Po Plain between Milano to the West and Mantova to the East. Space-temporal patterns of strain across this area are defined by forward-breaking Alpine thrusts that uplift local structures at rates of 0.02 - 0.03 mm/yr (for a period beginning at the Messinian (7.2 Ma) through the end of the Pliocene (1.8 Ma). Fault-related folds defined by folding of a 1.6 Ma surface are discontinuous in the area we studied, typically 10-15 Km in length and mostly are contained in a NE-trending belt of compressive strain that extends from the northernmost Apennines to Lake Garda. A notable exception includes an east-west trending fold located less than 20 km due east of Milan. Strain as
defined by a younger sequence boundary dated at 890 Ka is marked by fewer but more rapidly uplifted and subtle fault-related folds formed above south-vergent blind thrusts. These mark the current leading edge of the active Alpine wedge.

Remarkably, at least one of these folds near Castenedolo near the southern end of Lake Garda has accommodated a fourfold increase in uplift rate since 890 Ka that has modern geomorphic expression, a portion of the eroded crest of the fold, located south of the terminal moraines produced by the Garda glacial system. The location of this fold, both in the subsurface and the surface also corresponds with the estimated macroseismic epicenter of the 1222 AD Brescia earthquake (Guidoboni et al., 2002) suggesting the folds imaged in our mapping are seismically active and pose a considerable threat of strong earthquakes to this densely populated and economically important region of northern Italy (e.g. Serva, 1990; Giardina et al., 2004). Estimates of fault area defined by the length of fault-related folds from our mapping, the depth of the current seismogenic crust and a range of values for earthquake recurrence suggests an Mmax of 6.0-6.5, consistent with felt effects from historical earthquakes. It should be also remarked that similar Quaternary tectonic structures (e.g. Campo dei Fiori, Varese, Bini et al., 1992; Albese con Cassano, Como, Orombelli, 1976; Sileo et al., submitted) have been described in the literature in the nearby area to the North, along the Southern Alps foothills, where high quality seismic reflection data are not available. Field investigations and geomorphic analyses are in progress at these sites in order to geologically characterize all the potential seismic sources in the region between Lake Como and Lake Maggiore. This is a relevant issue, since the present seismic code, essentially derived from the earthquake catalogue, considers most of this area at one of the lowest level of seismic hazard of the whole Italian peninsula.

Aspects of the geometry of fault-propagation folds formed above the south-vergent thrust at Castenedolo suggest strain is concentrated across a narrow forelimb early in its history (Messinian), consistent with a shallow fault tip located with a few kilometers of the then ground surface. Subsequent deep burial of the structure in the foreland of both the Alpine and Apenninic orogens then inhibited upward movement of the thrust tip, which has not propagated significantly upward since the Messinian, as compared to typical propagation to slip ratios for other similar fault-propagation folds. We also consider the implications of our work for the development of the Alpine wedge and Apennines in general and note that backstepping of the Alpine wedge occurs at roughly the same time as dramatic erosion from glaciation in the central Alps (e.g. Muttoni et al., 2003), suggesting a link between narrowing of the wedge, deposition of thick sediments in the Po and erosion of Alpine highlands. Additionally our work suggests a map-view linkage between the southernmost currently active Alpine thrusts against the leading edge of the thrust belt in the northern Appenines, for a period of at least the last 2 Ma. Forward propagation of both thrust wedges is therefore likely to have been affected by their contact point near Piacenza.

References


Rock uplift of the northern Po Plain during the Pleistocene

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Facies analysis, applied to five 150–200 m-deep cores taken by Regione Lombardia in the central-northern Po Plain, allowed us to recognize an overall regressive sequence consisting of cyclotemic shallow marine and fluvio-deltaic deposits overlain by fully continental sediments. Magnetostratigraphy, coupled with calcareous nannoplankton biostratigraphy, was used to date marine and fluvial-deltaic sediments to the Early Pleistocene and continental sediments to the Middle - Late Pleistocene. Sediment accumulation rates were of ~30–40 cm/k.y. during the Early Pleistocene, whereas an overall reduction in sediment accumulation rates to ~6-8 cm/k.y., associated to relevant unconformities, characterized the Middle - Late Pleistocene. Most marine deposits in the cores lie above sea level highstands of corresponding age, suggesting that they have been uplifted. In order to estimate the observed rock uplift, sediments were backstripped to elevations at times of deposition (expressed in meters above current sea level) by applying a simple Airy compensation model. Decompaction tests showed that sediment compaction was negligible, with an overall increase of sediment thickness of not more than 0.7%; this is explained with the limited burial depth attained by these sediments and the relatively low content of most compressible clay intervals. The correlation of the isostatically corrected sedimentary facies to a glacio-eustatic reference curve obtained from classic oxygen isotope studies highlights a positive elevation mismatch (rock uplift) in the range of 70–120 m, which occurred after the onset of the major Pleistocene glacial-interglacial cycles at rates of at least ~150–90 cm/k.y.. Although the driving forces of the observed rock uplift cannot be unambiguously identified, the overall trend of increasing uplift values from the buried front of the Alps to the chain axial zone and its timing of onset after the beginning of the major Pleistocene glacial-interglacial cycles seem to point to an isostatic readjustment of the chain probably due to the long-term erosional removal of sediments during major Pleistocene glacial advances.
Scientific sessions

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Late Glacial tree-ring chronologies of northern Italy

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Multi-millennia-long tree-ring chronologies are unique archives, which provide an annual, absolute time frame of adjacent regions. Most important for a precise and universal time frame of the Late Glacial and the Holocene, $^{14}$C analyses from tree-rings have been used to establish a high-precision radiocarbon data set which is the backbone for the absolute calibration of the radiocarbon time scale.

In Hohenheim tree-ring chronologies from subfossil oaks and pines found in Quaternary deposits of the rivers in Central Europe were combined to an uninterrupted tree-ring chronology, which reaches back to 12,410 BP covering the entire Holocene and extending into the Younger Dryas. In the Late Glacial several centennial-long floating pine chronologies from Central Europe covering large parts of the Bølling-Allerød-Interstadial (GI-1).

In this contribution we present existing Late Glacial tree-ring chronologies from northern Italy and discuss the opportunities to link those floating sections to the Central Europe chronologies. As the Mediterranean area was a major refuge of trees during the last Glacial we show that this area could be a key-area to bridge gaps in the existing Late Glacial tree-ring chronologies and to extend them into the Glacial.
Calibration of the radiocarbon time scale in the Late Glacial

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Many important archives of Holocene and Late Glacial environments are dated by radiocarbon, which requires calibration of $^{14}$C dates to calendar years, e.g. for comparison to ice core proxies. Beyond the range of the tree-ring based calibration (see companion paper by Michael Friedrich et al., previous page) the current $^{14}$C calibration data sets (IntCal04) are derived from marine $^{14}$C data. Here the conversion to the atmospheric $^{14}$C level requires assumptions about the marine reservoir age. From our ongoing efforts to extend the European tree-ring chronologies into the past (ESF-EuroClimate project Tree-14) we see evidence of a variable marine reservoir age in a key area, the Cariaco basin of the tropical Atlantic.

In our contribution we will present the evidence and discuss consequences for error margins of the calibration procedure in the Late Glacial, back to ca. 14,200 cal BP.
Younger Dryas climate and glaciation in Europe -
a transect from maritime Britain to the continental Alps

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The Younger Dryas was the last return to severe cold conditions prior to early Holocene warming and is recorded in several lateglacial proxy records in Europe and elsewhere on Earth. Although specific localised and regional studies have been conducted and initial numerical modelling results of Younger Dryas climate exist, no attempt has so far been made to compare these data on a larger scale to arrive at a unifying concept of European climate variability as manifested, for example, in the extent of glaciers across Europe's mountains. Here we present a first attempt to synthesise recent data gathered from the NW Highlands of Scotland and selected sites from the European Alps. In both areas, the style of glaciation and response to Younger Dryas climate change appears to be strongly controlled by basin topography, glacier size and local/regional temperature and precipitation patterns. In NW Scotland, large mountain glaciers were nourished by very high precipitation totals despite very low mean annual air temperatures resulting in glaciers that remained in equilibrium with climate throughout the second half of the Younger Dryas. This is evident from the analysis of palaeoclimate proxies such as beetles and chironomids and the presence of a large number of recessional moraines formed during oscillatory retreat, both of which indicate short glacier response times and high mass turnover.

In contrast, Younger Dryas glaciers in the European Alps retreating from their maxima appear to have been in equilibrium with climate for a much shorter phase in many places. This is evident from a smaller number of large moraines which indicate longer periods of stability during moraine formation followed by more rapid and largely uninterrupted retreat during which recessional moraines were largely not formed. Together, this evidence indicates that (a) response times of Alpine glaciers were much longer and (b) glaciers reached disequilibrium fairly quickly after having reached and maintained their maximum positions. Many Alpine glaciers are likely to have regained equilibrium in the early Holocene where readvance stages smaller than the Younger Dryas maximum extent have been documented.

Both glacier size and marginal response appear to decrease systematically from west to east across Scotland, indicating that precipitation was a strong control on glacier development and dynamics. The distribution and systematic variation in size also suggests that large-scale atmospheric circulation patterns across northern Europe with strong westerly winds were very similar to those of today. We will discuss in how far a similar pattern might have existed in the European Alps and what the implications for the larger-scale atmospheric circulation patterns were. Although the results presented here have to be regarded as a first attempt, they demonstrate that the pattern and size of glaciation during a certain period of time, in this case during the Younger Dryas, contain useful and important information that are crucial to test and refine numerical models used in the prediction of future climate change.
Late Neopleistocene – Holocene deposits, flora and fauna of the Lemeza river valley (southern Urals)

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On the banks of the Lemeza River, which belongs to the Belaya river basin (western slope of the Southern Urals), karst caves open in Carboniferous limestones (Fig. 1). Caves and grotto Verkhnya, Zapovednaya, Atysh I, Lemeza I-IV and Ust-Atyshskaya as well as terraces were biostratigraphically investigated by our group together with archaeologists (Institute of History, Language and Literature, USC RAS).

The following Quaternary stratigraphic complexes were recognized:
1) Fluvial deposits of the Middle - Upper Neopleistocene (Tabulda horizon?): site Kalinovka II, layers 6, 7;
2) Slope-eluvial deposits of the Upper Neopleistocene (Tabulda horizon): cave Zapovednaya, bore pit 1, layer 2: 28,700 ± 1,000 (LU-3715); bore pit 2, layers 1, 2: 37,250 (LU-3876);
3) Slope-eluvial deposits of the Upper Neopleistocene (Kudashevo horizon): site Kalinovka II, layers 2-5; cave Verkhnya, layer 2: 22,750 ± 1,210 (LU-3714); cave Zapovednaya: bore pit 1, layer 1: 12,380 ± 260 (LU-3861); cave Zapovednaya II: layers 1-2;
4) Slope-eluvial deposits of the Lower Holocene: cave Lemeza III, layers 2-6;

\textbf{Fig. 1:} scheme of the Atysh waterfall karst complex. Legend: 1 – cave Verkhnya; 2 - cave Zapovednaya; 3 - grotto Atysh; 4 - grotto Lemeza I; 5 - cave Lemeza II; 6 - cave Lemeza III; 7 - cave Lemeza IV; 8 - cave Ust-Atyshskaya.
5) Lacustrine and lacustrine - palustrine deposits of the Middle Holocene: site Kalinovka I, layers 7: 4,620 ± 40 (GIN-10859);
6) Slope-eluvial deposits of the Middle Holocene: cave Lemeza II, layer 2;
7) Soil of the Upper Holocene: sites Verkhnya Lemeza, layer 1; Zorenka, layer 1; Kalinovka II, layer 1; Kalinovka I, layer 1;
8) Lacustrine deposits of the Upper Holocene: sites Zorenka, layer 2-4: 1,770 ± 50 (GIN-10857b); Verkhnya Lemeza, layer 6: 250 ± 40 (GIN-10858);
9) Lacustrine - palustrine deposits of the Upper Holocene: site Kalinovka I, layer 2-6;
10) Fluvial deposits of the Upper Holocene: site Verkhnya Lemeza, layers 2-5, 7;
11) Slope-eluvial deposits of the Upper Holocene: caves Atysh I; Lemeza I; Lemeza II, layer 1; Lemeza III, layer 1; Lemeza IV, layers 1-3; Ust-Atyshskaya.

Palaeontological data are used for palaeoenvironmental reconstructions as follow:
1. Forest-steppe were widespread during the Late Pleistocene: warm forest-steppe was in the Tabulda time (cave Verkhnya, bore pit 1; cave Zapovednaya, bore pit 1, 2); cold forest-steppe was in Kudashevo time (Verkhnya, bore pit 1; cave Zapovednaya, bore pit 1). Data for the Early and Middle Holocene are insufficient. Coniferous-broad-leaved forests were dominant during the Late Holocene (sites Kalinovka I, Zorenka, Verkhnya Lemeza, and caves Lemeza II-IV).
2. The Holocene mollusc complex of the site Kalinovka I is represented by 7 freshwater and 10 land species. This complex is typical of faintly flowing water reservoir. Molluscs of the Tabulda time (cave Zapovednaya, bore pit 1, layer 3) are represented by few Holarctic land species, which live in moist places and leaf-bearing bedding in forests and meadows. The xerophile species Chondrula tridens (Müll.) lived in steppe areas on south-facing slopes.
3. During the Holocene amphibians and reptiles are represented by species, which areal extended to the Southern Urals region. Findings of Triturus cristatus (Laur.) and Bonbina bonbina (L.) testify to the presence of forest-steppe landscapes at the beginning of the Late Holocene. These species are nowadays absent from the studied area.
4. Late Holocene (Simskaya) fauna (caves Lemeza I, IV) consists of modern small mammal species, which lived in the mountain broad-leaved forests in the Southern Urals. Middle Holocene (Lemeza) fauna (cave Lemeza II) is characterized by steppe as well as forest species. Early Holocene (Atysh) fauna (cave Lemeza III) had intermediate characters between the Late Pleistocene to Holocene fauna (few typical tundra and forest species, predominance of steppe species).
5. Large mammals belong to three complexes, located closer to the east european regions: Shkurlatov (cave Verkhnya), mammoth (cave Verkhnya; Zapovednaya, bore pits 1-2) and Holocene complexes (caves Atysh I; Lemeza II-III, and Ust-Atyshskaya).
Past climate reconstruction in the Alpine area has a high interest for vegetation and archaeological studies. The strong altitudinal climatic gradient that characterises mountain areas results in a steep ecological gradient, so several ecotones occur in a small area. This results in an amplification of global climate signal so vegetation response to climatic changes is more pronounced at higher altitudes than in the lowland. Further, important climate differences characterise the different areas of the Alps. This phenomenon is relied to the high topographic complexity of the Alpine region, so that climate parameters and vegetal cover depend on local physiographic conditions (altitude, slopes, aspect, geomorphology). These differences might have had a strong influence on vegetal taxa migrations during the Lateglacial. Further, the effect of climate fluctuations of higher intensity in some areas of the Alpine region during the Lateglacial and the Holocene certainly affected human populations, causing their migration to more propitious areas in these periods. In the aim of exploring possibilities for the reconstruction of the climatic and environmental variability in the South-western Alps in the past, the standard "best modern analogue" method has been applied to several high altitude pollen sequences to provide quantitative climate estimates for the Lateglacial and Holocene periods. The studied sites (Laghi dell'Orgials, 2130 m and Lago delle Fate, 2240 m in the St. Anna di Vinadio Valley; Pian Marchisio, 1624 m, Rifugio Mondovì, 1760 m and Torbiera del Biecai, 1920 m, in the Ellero Valley) are presently located in the subalpine belt in the Italian Maritime Alps, but pollen sequences show that an arboreal cover was present on several sites during the Holocene. Based on an improved modern pollen data base containing 250 new pollen samples from the western Alps, the palaeoclimatic reconstruction yields different results for the different sequences. Variations of the durations and the intensity of climate fluctuations at different sites are discussed. Limitations in the pollen-based palaeoclimatic reconstruction are taken into account. These limitations are mainly linked to the phenomenon of uphill transport of pollen by wind to sub-alpine and alpine zones. Possible improvements to the reconstruction process are discussed.
Late-glacial to present palaeoenvironmental changes in Trentino, NE Italy: hints from lake sediments

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Paleoenvironmental and palaeoclimatic multi-disciplinary studies on continuous Late Glacial to Holocene continental sequences are still quite rare in Italy, especially in comparison with other European countries. The OLOAMBIENT project aims to reconstruct climate fluctuations for the Holocene in the Trentino region (NE Italy) combining lake sediment and speleothem archives. Two lacustrine sediment sequences were retrieved at the sites of Lavarone and Cornisello, to the SE and WNW of Trento respectively. The cores were object of a multi-proxy study, including sedimentological, mineralogical, geochemical, palynological and biological (diatoms, chironomids, dinoflagellates) analyses.

Lake Lavarone (0.05 km² large, 17 m deep) is a small tourist karstic lake which lies in a Liassic limestone plateau at ca 1100 m a.s.l. The lake bottom waters are almost permanently anoxic. The ca 10 m long sediment sequence collected in the deepest part of the basin and chronologically constrained by ²¹⁰Pb dating and 20 radiocarbon dates, is divided in 4 lithostratigraphic units. These vary from a bedded and in place finely laminated brown sapropelic diatomaceous carbonatic ooze at the top, with cm- to dm-scale intercalation of homogeneous reddish brown mud with abundant plant remains, to an organic-poor, light- to dark- grey bedded silty clay with intercalated mm- to cm-thick sandy layers, which ends in matrix-supported gravel. The sediments sequence records the transition from a just deglaciated environment (17000 yr BP?) characterized by a high detrital sedimentation rate, low organic content and steppe vegetation to the first afforestation in the “Bølling-Allerød” period, which led to an increase in total organic carbon content. This transition seems to be marked by a distinct increase in July temperature as highlighted by preliminary results from selected chironomids samples. Furthermore, the Younger Dryas period is well defined from the palynological point of view and seems to be marked by a distinct opening of the local vegetation in the region. A characteristic Holocene pollen sequence is found in the uppermost ca 5 m of sediment, with evident human presence on the site dating to the Roman age. Local events such as slide debris are superimposed on the regional trend and helps to understand changes in the ecosystem of Lake Lavarone.

Lake Nero di Cornisello is a low-alkalinity, small and deep high-altitude mountain lake (0.02 km², max. depth 38 m; mean depth 13 m) located on crystalline substratum at 2233 m a.s.l. in the S-Eastern Alps (Adamello mountain range Trentino, NE Italy) and is characterized by a very small catchment. The 1.8 m long sediment sequence is characterized by a sharp transition from a grey silty sand at the bottom (Unit I) to a brown sapropelic diatomaceous ooze (Unit III) with abundant moss fragments in the lower part (Unit II). Nine AMS radiocarbon dates and ²¹⁰Pb and ¹³⁷Cs dating from the top of the master core help to define the chronological framework.

¹ Project in the period 2003-2006 funded by the autonomous province of Trento
The sequence covers the last 14500 years with incredibly low (>0.02 cm/yr) but apparently continuous sedimentation rate. Pollen analyses confirm the presence of the Late-glacial/Holocene transition, making this record one of the oldest in Italy at this altitude. Chironomid and diatom assemblages show strong variation at this time, indicating great environmental changes.

The two described lacustrine series are extremely interesting as they form the first continuous Late-glacial to present palaeoenvironmental records from middle to high mountain region in Trentino (NE Italian Alps). They confirm theories about the problem of *Abies alba* and *Picea abies* provenance and highlight the fact that in some cases higher sites were deglaciated earlier than the valleys, and therefore offer a longer record compared to middle-low altitude adjacent sites. From this viewpoint, consideration is needed concerning the rate and mechanisms of migration of arboreal vegetation from the nearby ice-free valleys (Po plain, Astico valley for Lavarone) to the sampled sites. At the same time, the reconstructed vegetation changes during the Late glacial define a quite different landscape (more vegetated) from what was classically assumed by archaeologists working with early human settlement in the studied area. Parts of the Trentino may have been a more pleasant place than previously thought even during the last stadial of the Late glacial …
The beginning of Termination I in the Eastern Alps: a change of paradigm

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In the chronological sense the Würm Lateglacial, synonymous with Termination I, occurred after the Last Glacial Maximum (LGM; used here in equal term of the Alpine “Würm-Pleniglacial”) within the Upper Würm (Chaline and Jerz, 1984) and thus within Marine Isotope Stage (MIS) 2. The Alpine Würm Lateglacial is generally subdivided into glacial stadials, a concept first established by Penck & Brückner (1909). The term stadial is used to describe a stepwise deglaciation from the maximum position of the Würm in the foreland into the Alpine valleys and finally into the cirques with halts or re-advances, defined by end moraines. This paleogeographic development is regarded as a chronological succession beginning with the Bühl followed by Steinach, Gschnitz, Daun and Egesen as defined in the former Inn glacier area (Mayr and Heuberger, 1968; van Husen, 2004). Research activities in the Eastern Alps were mostly focussed on the younger glacial stadials, documented by morphologically well preserved terminal moraines. Recently SED ages between 16 and 15 kyr BP and a detailed paleo-glaciological model were presented for the prominent Gschnitz Stadial at its type locality in Tyrol (Ivy-Ochs et al., 2006).

Numerical ages and paleoclimatic data do not yet exist for the glacial oscillations between the LGM, lasting until 18 kyr \(^{14}C\) BP (~ 21.5 kyr cal BP; calibrated \(^{14}C\) years; Preusser, 2004), and the Gschnitz Stadial. Moreover, the concept of Lateglacial stadials indicating stabilised and thus equilibrated glacier tongues is based on the definitions of end moraines mostly due to geomorphological observations (Penck and Brückner, 1909; Mayr and Heuberger, 1968). There is no doubt that the interpretation of morphological features of glacial origin especially in high elevated cirques provides reliable results. However, the Bühl Stadial with its type region in the lower region of the Inn valley around Kufstein and Hopfgarten (Fig. 1) had been established in this way. As the supposed first halt of a still-intact network of valley glaciers after the LGM, the Bühl Stadial is the reference for all Alpine areas (van Husen, 2004) and beyond (e.g. Appenine; Giraudi, 2004).

According to the results of the re-investigation of the type locality of the Bühl Stadial the term Bühl Stadial should be abandoned (Reitner, submitted). Sedimentary and morphological evidence indicates that the Inn glacier as well as the other Eastern Alpine glacier (like the Traun and the Drau glacier) became stagnant in the big Alpine valleys followed by massive down-wasting. Hence this period after the LGM, at the beginning of Termination I is best defined as “phase of early Lateglacial ice decay”. Only the separated glaciers showed mostly climatically controlled but also mechanically induced glacier advance towards their Lateglacial maximum position (LMP). Furthermore, in the overwhelming cases no terminal moraines were produced during the LMP that could serve as a proof of glacier tongues in equilibrium with climate. This is also true for the oscillation of the glacier at Steinach am Brenner (Fig. 1), which was designated as the Steinach Stadial (Mayr and Heuberger, 1968). Considering the different glaciological settings a correlation of the various glacier advances during that time in the Alps seems to be rather problematic. However, as all the local glacier reactions occurred in contact to collapsing, down-melting big valley glaciers, an approach to look at the thickness loss with respect to LGM conditions is proposed in order to get an (albeit crude) hint for the chronology of the processes. It has to be stressed that this view is contrary to the former stratigraphical concept for “Bühl” and as well “Steinach”, where the
The recession of still active glacier tongues into the interior of the Alps was highlighted. Due to the variety of glacial, glaciolacustrine and glaciofluvial processes the term stadial is inappropriate for this period of ice decay. It is shown that this phase of ice decay can be defined and constrained by lithostratigraphic type sections.

Tentative correlation of the phase of early Lateglacial ice decay with the “Greenland Stadial 2c” (GS-2c; 21.2 – 19.5 kyr BP) is based on the sparse calibrated $^{14}$C dates from the Eastern Alps. In order to decipher this phase especially to get a link towards the high resolution climatic records in the Mediterranean it is necessary to further constrain the chronology. The first attempt of OSL-dating at Hopfgarten (Klasen et al., submitted) was quite prospective and showed the potential of this method. Surface exposure dating of erratic boulders in connection to paleogeographic situation of the ice decay is already in progress.

References:


Klasen N., Fiebig M., Preusser F., Reitner J.M., Radtke U. - Luminescence dating of sediments from the Tyrolean Alps, Austria, and implications for the reconstruction of ice dynamics during the last glaciation. Submitted to Quaternary International.


Pleistocene and Holocene Alpine and Peri-Alpine speleothem 

\(^{18}\text{O}\) and \(^{13}\text{C}\) chronologies

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Crystalline deposits formed in caves (named speleothems) are commonly formed of calcite chemically precipitated from seepage waters that percolated through overlying soil and carbonate rocks. The seepage water carries into the cave environment climate and environmental information which are then encoded in the stable isotope and trace element composition, as well as in the changes in annual lamina thickness of stalagmites. The great advantage of speleothems is that the chronology of climate variability can be precisely anchored to uranium series ages. Stalagmites commonly form when there is sufficient effective rainfall to sustain seepage through the vadose zone and enough biological activity in the soil to provide the necessary \(\text{CO}_2\) which, combined with water, forms the carbonic acid that dissolves the rock. Seepage water, thus, uptakes the \(\text{Ca}\) ion needed for speleothem calcite growth. Warm conditions and water surplus are, therefore, likely to be those that favour speleothem growth in temperate, continental regions.

To date, in the Alps of N-E Italy, we did not find stalagmites which formed prior to ca. 9000 years ago. This means that threshold conditions for speleothem growth (sufficient water surplus and soil) had not been reached during the Late Glacial. By contrast, in the Trieste classical karst, which was deglaciated even during the LGM, speleothems started growing in the Late Glacial, at ca. 17 kyr BP. Grotta Savi cave, which opens at 441 m a.s.l. near Trieste (45°37′05″N, 13°53′10″E), is cut in fissured limestone overlain by thin (< 50 cm) grassland soil cover, which situation optimizes the potential for a rapid response to climate changes. The present-day climate is characterized by mean winter and summer temperatures are +1.5°C, and +17.5°C, respectively. Below zero temperatures are recorded for ca. 70 days/year. The mean annual precipitation is about 1350 mm/year. The inner part of the cave has a constant air and water temperature of 12.3 ± 0.2°C.

A 27 cm high, candle-shaped, stalagmite (SV1) was sampled in Grotta Savi when still active. The time scale of SV1 is based on a total of 18 U/Th ages measured with multiple-collector inductively coupled plasma mass spectrometry (MC-ICPMS) at the Laboratory of Isotope Geochemistry, University of Bern (CH). The ages have been expressed in thousand of years (kyr) before the year 2000. The stable C and O isotope compositions were measured using a Delta\(^{\text{Plus}}\) XL mass spectrometer equipped with on-line automated carbonate preparation system (Gasbench II) and the 1\(\sigma\) precision of the \(\delta^{18}\text{O}\) and \(\delta^{13}\text{C}\) values was less than 0.1‰.

SV1 started to form ca. 17 kyr BP and grew continuously up to the present. The growth rate was very slow in the Late Glacial (≤10 \(\mu\)m/yr) up to 10.6 ± 0.22 kyr BP. In the Early Holocene, from ca. 10.6 to ca. 7.5 kyr BP the growth rate increased up to 32 to 43 \(\mu\)m/year. From ca. 5.7 to ca. 4.4 kyr BP there was another period of relatively fast growth (24 to 28 \(\mu\)m/year), and then growth rate stabilized at 11 \(\mu\)m/yr.
Calibration by using historical data revealed that there is a positive $\delta^{18}O_c/dT$ relationship. A 1°C rise in mean annual temperature should correspond to ca. 2.85‰ increase of SV1 $\delta^{18}O_c$. We reconstructed a slow and steady temperature rise of ca. 0.5°C since 10 ka BP. The calibration with the present, however, may not hold true for the Late Glacial, when climate was still in a “glacial mode” and the ocean had a different oxygen isotopic composition.

The system overcame the threshold conditions necessary to form speleothems ca.17 kyr BP. This means that prior to 17 kyr BP the soil and vegetation were not as yet well developed, and steppe-like environment was probably still dominant. At ca. 17 kyr BP there was enough vegetation and soil to initiate speleothem growth. The $\delta^{18}O_c$ values of the whole Late Glacial show a progressive trend to low values (Fig. 1).

The data we present, however, are not as yet adjusted for the ice-volume effect, which would make the older part of the record progressively more negative. By considering a maximum adjustment of ca. –1.2 ‰ at 17 kyr BP and of 0.5‰ at 10 kyr BP, the $\delta^{18}O_c$ values of the Late Glacial record would be similar to or slightly more negative than in the Holocene, with the exception of the period from ca. 12.5 to 11.5 kyr BP (Younger Dryas). Low $\delta^{18}O_c$ and low growth rate in the Late Glacial indicate that the mean annual temperature was still relatively low, but high enough to sustain biological activity in the soil zone. Low $\delta^{13}C_c$ values around ca. 14.6 to 15 kyr BP and between ca. 13 and 14 kyr BP indicate periods of higher soil activity, possibly related to more humid and warmer conditions. The structure of the last deglaciation reconstructed from SV1, thus, differs from that in Greenland, where it is characterized by a first, major abrupt warming at 14.6. In the Trieste karst, warming had already commenced prior to 17 kyr BP, allowing soil formation and vegetation recovery after the LGM. In this perspective, SV1 climate trend in the Late Glacial is more compatible with warming recorded by the EPICA ice cores in Antarctica.

The structure of the Younger Dryas (YD), or GS-1, in SV1 is characterized by a shift toward higher $\delta^{18}O_c$ values, coinciding with $\delta^{13}C_c$ enrichment of up to +1‰ (Fig. 1) from 12.0 and 11.4 kyr BP,
while the extension rate is extremely low (< 8 µm/yr). These characteristics indicate that the YD was most probably characterized by cool and relatively dry conditions (covariant C and O isotopes indicative of evapotranspiration). The $\delta^{13}C_c$, however, shows a minor peak toward more negative values within the YD, which indicates that there was an inter-YD period characterized by wetter and, possibly, warmer conditions that favoured soil activity. The structure of the Late Glacial as reconstructed from the SV1 record appears to be compatible with both the early ending of full glacial conditions in Antarctica and the steps toward full interglacial climates recorded in Greenland.
Late-glacial alpine reforestation and human peopling: a general overview

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Interdisciplinary studies carried out in the Alpine Chain demonstrate and explain how the Late-glacial reforestation was the main process that induced the paleolithic societies to colonize these new territories and to settle their seasonal camps at so different altitudes and so variable contexts. Starting from the LGM conditions when the fore-alpine regions were visited for ephemeral occupations and hunting parties, the climatic events that occurred during the deglaciation and in the Late-glacial interstadial induced human groups to follow the progressive displacement of the timberline towards the inner Alps. An integration of the archaeological data to the ecological framework provides various scenarios revealing with which rhythms, modalities and complexity this process acted and induces to discuss on natural-cultural interferences. The most detailed informations are taken from North-western Alps and Italian Eastern Alps, two regions where a huge amount of data on human ecology are available.
The early Holocene climate optimum: evidence from high-altitude peat deposits in the Italian Alps

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In the last decade, studies on the Holocene climate change in the Alps have been addressed to glacier oscillations, timberline fluctuations and lake level changes. These proxies suggest synchronous changes in the Alps and the northern alpine foreland, thus a scheme of cold/warm alternations has been established (Haas et al., 1998; Magny, 2004). The amplitude of these oscillations, however, remains uncertain. Mountain glaciers are a highly sensitive archive because their change in extension can be measured and dated through the study of relevant deposits implemented by indirect methods, e.g. the development of peat in the glacier foreland during phases of recession (e.g. Joerin et al., 2006). Several glacier systems provided information about phases of Holocene glacier extent smaller than today on the Alps (Porter and Orombelli, 1985; Hormes et al., 2001). Pollen and plant macrofossil records shows timberline fluctuations during the early and middle Holocene (Wick and Tinner, 1997; Gobet et al., 2004). Timberline and treeline ecoclines are climatically sensitive zones and the alitudinal position of their fluctuations during the Holocene reflect phases of climatic changes.

We carried out palaeobotanical investigations and related radiocarbon dating on peat deposits from high-altitude sites in the Italian Alps. The sites considered in the Ortles-Cevedale Massif are:
- the peat bog near Lago Nero (upper Val Camonica, 2395 m asl);
- the buried peat near Rif. Berni (Valle di Gavia, 2530 m asl);
- the Pian Venezia peat bog (Valle di Peio, 2270 m asl);
- the peat bog of Costa, actually the highest peat bog (2585 m asl) covering most of the Holocene so far known in the Italian Alps.

Pollen and macrofossil analysis show the establishment of forest at high altitude (150 m above the current tree limit) testifying to summer temperature higher than today in this part of the Alps between 9,100 and 7,300 cal BP. The site of Lago Nero is above the present-day treeline; Pinus cembra wood and seeds have been found and extensively dated in the peat bog, showing that the treeline altitude was at least 100 m above the bog (e.g. > 2,500 m asl). This result is further supported by the occurrence of wood in the lowermost succession of the Costa bog (2580 m), which is currently under dating. The maximum altitude reached by subalpine heats is also indicated by the upper boundary of podsols profiles on stable geomorphologic surfaces.

The succession of buried peat at the front of the Ruitor Glacier (Western Italian Alps, 2510 m asl) represents a unique archive because it recorded intervals of marked glacier contraction that affected the western Italian Alps during the early-middle Holocene. 33 radiocarbon datings and a new pollen diagram are now available from this site. Between about 9.2 and 6.5 ka cal years BP, deposition of peat in the valley floor in front of the Ruitor glacier was almost continuous. During this long pre-Neoglacial minimum, the Equilibrium Line Altitude remained over 2900 m, i.e. constantly over the LIA estimation of 2770 m and the current one at 2850 m. This interval of early to middle Holocene glacier contraction brackets the phases of higher timberline recorded in the Central Alps. The site also documents the subsequent advances related to the middle Holocene Neoglaciation.
The deposits considered in this work record a phase of climate optimum for altitudinal tree development and glacier recession between ca. 9,000 – 6,500 years cal BP. This phase has no counterpart in the remaining part of the Holocene. The evidence from Swiss Alps, both from glacier advances (Hormes et al., 2001; Joerin et al., 2006) and from timberline oscillation (Wick and Tinner, 1997; Tinner and Theurillat, 2003) are consistent with the new data here presented, although the latter data from Switzerland do not constrain properly the chronology and the amplitude of this warm phase.

References


Pleistocene records from polar ice cores: the atmospheric perspective

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Continental records represent the direct impact of the climatic variability on the Earth system, but generally with regional validity. Ice cores drilled in Antarctica and Greenland Ice Sheets permit to provide direct climatic informations of atmosphere. Recently the recovery of a deep ice core from Dome C, Antarctica provides a climate record for the past 740,000 years. For the four most recent glacial cycles, the data agree well with Vostok ice core, with four complete full glacial/interglacial cycles with most of the time during the colder conditions. The earlier period, between 740,000 and 430,000 years ago, was characterized by less pronounced warmth in interglacial periods in Antarctica, but a higher proportion of each cycle was spent in the warm mode. Besides, over the stable isotopes (oxygen and hydrogen), atmospheric chemistry and dust content, the ice core provides informations on the gas concentration of the main greenhouse gases (CO₂ and CH₄).
The Late Quaternary marine terraces in the Mediterranean coastal area of Syria: geochronology and neotectonics

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In order to provide a new information on the neotectonics and geodynamic properties of western part of Syria, the studies of marine terraces have been carried out during spring and autumn 2005, and spring 2006. The Mediterranean coastal area of Syria has a very dense population and the natural terraces were subjected to intensive recultivation and urban construction in many places that creates many difficulties for research. The quarries and artificial trenches along the roads were examined as well as altitudes of terraces were measured to get finally the lithological, geomorphological and paleontological evidence. One of the important purposes was to search the mollusk shells suitable for $^{230}$Th/U dating. The main attention was paid to the lower terraces in the range of 3 – 5 m to 30 – 35 m above sea level. According to the previous investigations, it was proposed that the Late Pleistocene terrace (Tyrrhenian terrace, Enfean transgression in Lebanese coast) is represented along the coastal area of Western Syria (Copeland, 1981; Sanlaville, 1981; Deviatkin and Dodonov, 2000), though the Geological Map of Syria, scale 1:200 000 (1963) shows only the terraces with indexes $Q_{1-2}$ and $Q_4$. According to publications, Strombus bubonius, a typical Tyrrhenian thermophilic mollusk, was mentioned in the sediments of the lower marine terrace near Banias, as well as from the Enfean formation of the Lebanese coastline.

The lower terraces were examined along the coastal area from Tartous in the south up to Lattaqie in the north, as well as the carbonate cliff on the Arwad Island located opposite of Tartous. The terrace of 20 – 30 m above sea level is widespread in the northern part of this coastal area. This terrace has an abrasional origin in the Lattaqie region, being not higher than 25–35 m. Only scattered, well-rounded marine gravel has been found on the surface of this terrace. Between Lattaqie and Jableh, the terrace of 25 – 30 m height is well represented. It lowers to the south and generally demonstrates an aggredational origin. For instance, in the Jableh area the height of this terrace is not more than 10 - 12 m a.s.l.

This terrace is composed of sands, gravels and carbonates, in some intervals limestones are recognizable in the sections. To the south of Jableh, the lowering of the terrace is observed. For example, 2 km south of the village of Arab el Mulk, the altitude of this terrace does not attain more than 3 – 5 m a.s.l. Here, the sediments of the terrace are represented by carbonated clays facially replaced by limestones. In Banias and southward of it a shoreline of the same terrace is uplifted up to 15 – 25 m a.s.l., being mostly abrasional with a thin 1 – 2 m cover of marine sandy gravel. The terrace is narrow here, not more than a few hundred meters in width. Southward of Tartous, the terrace is getting lower being not higher than 10 – 15 m with a general trend of lowering to the south. On the Arwad Island, the carbonate cliff of 5 – 7 m a.s.l. and consists of sandy fine carbonate detritus originated from relict accumulative forms like marine bars (or partially dunes).
Searching the mollusk shells for the $^{230}$Th/U dating we have to say that marine sediments of the lower terrace contain a very rare mollusk fauna, especially shells suitable for dating. Nine sites with shells were found. Shells of Ostrea sp., Taxodonta, Pectinidae and other remnants of bivalves were used for dating. Radiochemical analysis was carried out on the internal part of shells because it was proved that the internal fraction of a shell sample represents a relatively closed system concerning U and Th. $^{230}$Th/U dates were obtained by the Geochronological Laboratory of St. Petersburg State University (Table 1).

<table>
<thead>
<tr>
<th>N</th>
<th>Site</th>
<th>Shell material</th>
<th>Latitude N</th>
<th>Longitude E</th>
<th>Altitude, m</th>
<th>$^{230}$Th /U age, ka</th>
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<tbody>
<tr>
<td>1</td>
<td>Ramleh</td>
<td>Pectinidae</td>
<td>35 22°44.6&quot;</td>
<td>035 55' 11.5&quot;</td>
<td>10</td>
<td>119.0 + 11.3/-9.9</td>
</tr>
<tr>
<td>2</td>
<td>3.05</td>
<td>Ostrea sp.</td>
<td>35 27°04.5&quot;</td>
<td>035 54' 40.7&quot;</td>
<td>28</td>
<td>123.8 + 10.3/-9.2</td>
</tr>
<tr>
<td>3</td>
<td>10.05</td>
<td>Pectinidae gen.</td>
<td>35 25°03.0&quot;</td>
<td>035 55' 31.5&quot;</td>
<td>27</td>
<td>105.9 + 8.2/-7.4</td>
</tr>
<tr>
<td>4</td>
<td>12.05</td>
<td>Ostrea sp.</td>
<td>35 15°20.0&quot;</td>
<td>035 56' 02.2&quot;</td>
<td>4</td>
<td>128.5 + 10.4/-9.2</td>
</tr>
<tr>
<td>5</td>
<td>14.05</td>
<td>Ostrea sp.</td>
<td>35 18°56.8&quot;</td>
<td>035 55' 37.5&quot;</td>
<td>3</td>
<td>186.6 + 23.9/-19.1</td>
</tr>
<tr>
<td>6</td>
<td>Soukas 1</td>
<td>Ostrea sp.</td>
<td>35 18°41.2&quot;</td>
<td>035 55' 15.9&quot;</td>
<td>3</td>
<td>60.6 + 6.2/-5.6</td>
</tr>
<tr>
<td>7</td>
<td>Soukas 2</td>
<td>Ostrea sp.</td>
<td>35 18°41.2&quot;</td>
<td>035 55' 15.9&quot;</td>
<td>3</td>
<td>60.6 + 6.2/-5.6</td>
</tr>
<tr>
<td>8</td>
<td>48.05</td>
<td>Taxodonta</td>
<td>34 44°31.1&quot;</td>
<td>035 55' 57.5&quot;</td>
<td>3</td>
<td>7.8 + 1.3/-1.3</td>
</tr>
<tr>
<td>9</td>
<td>64.05</td>
<td>Pelecypoda</td>
<td>35 28°28.0&quot;</td>
<td>035 53° 10.1&quot;</td>
<td>29</td>
<td>83.4 + 4.6/-4.4</td>
</tr>
<tr>
<td>10</td>
<td>128.5</td>
<td>Peltocopa</td>
<td>45 28°28.0&quot;</td>
<td>035 53° 10.1&quot;</td>
<td>29</td>
<td>83.4 + 4.6/-4.4</td>
</tr>
</tbody>
</table>

**Tab. 1: The list of $^{230}$Th /U dates of the lower terrace in the Mediterranean coastal area of Syria**

Six dates are in the range of 85 – 130 ka, suggesting the age interval of the last interglacial or Marine Isotope Stage 5, that corresponds to the Tyrrhenian transgression in the Mediterranean Sea. These dates provide a geochronological control for correlation of the studied terrace. One date (186.6 + 23.9/-19.1) corresponds to the age prior to MIS 5, and another one reflects the Holocene age. Perhaps, due to the partial contamination by $^{232}$Th in the mineral material of shells from Soukas 1 and 2, results of dating for this site are not entirely adequate as shown in Table 1. In this case, some distortion of the age could not be excluded for final results. It is necessary to emphasize that more samples of shell material for dating from different sites of the lower terrace are desirable for a more reliable interpretation.

New dates on the lower terrace provide a basis for the stratigraphical and geomorphological interpretation. On the basis of geomorphological observation and neotectonic reconstruction, the following conclusions can be suggested. According to the geomorphological data and lithological composition of the Tyrrhenian terrace, two main uplifted blocks can be established. One of them coincides with the Lattaqie block, and another corresponds to the western margin of the Banias high volcanic plateau. In both cases uplifting of the Tyrrhenian terrace illustrates the active neotectonic development of the Lattaqie and Banias blocks. These blocks are divided by a subsided structure corresponding to the Nahr el Kebir graben. Geomorphologically, the Tyrrhenian terrace has a gradual inclination from the northern flank of the Nahr el Kebir graben to the south. At Banias, the Tyrrhenian terrace is uplifted demonstrating an abrasional type of section. The next subsided structure is developed south of Tartous. The amplitude of uplifting in the Lattaqie and Banias blocks reaches 15 – 20 m for the Late Pleistocene. The neotectonic factor resulting in the subsidence of the Tyrrhenian terrace should be considered as one of the factors that affected the submergence of the Middle and Late Paleolithic sites that have been discussed by archaeologists for coastal area of the Eastern Mediterranean in connection with regression and transgression.
phases during the Late Quaternary (Copeland, 1981). Presumably, the Tyrrhenian coastline was more off shore. Remnants of a relict accumulative forms (bars/dunes) at the Island of Arwad, dated to 100 ka, are a witness of the dramatic changes in the interaction between sea and land.

References


Late Quaternary sea level changes along the Northern Adriatic coast: an interdisciplinary approach

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We studied the last 2 ka sea level change along the Italian, Slovenian and Croatian coastlines (Eastern Adriatic Sea) using geomorphological and archaeological markers. Moreover, we used well connected sea level markers between Duino and S. Simonov, along the eastern part of the Gulf of Trieste. Moreover, we present ¹⁴C AMS analyses provided on lagoonal fossil shells comprised between 9.7 an 4.6 ka BP at altitude between - 1.3 and - 4.5 m in Istria. Many authors (Pirazzoli, 1980; Fouache et al., 2000; Benac et al., 2004) published geomorphological, archaeological and sismotectonic research works between the coast of Duino (Trieste) up to the central coast of Croatia (Zadar). Along the limestone coast, the authors revealed a quasi-continuous occurrence of a submerged marine notch at a depth between −0.5 m and −1.0 m. In addition, Roman age archaeological markers were measured at depths lower than −0.5 m and often lower than −1.0 m. Antonioli et al. (2004) provided geomorphological observations on marine notches in the Gulf of Trieste between −0.7 m and −1.9 m. Since the northern part of the Gulf is dominated by highly conservative limestone rocks, we provide new detailed geomorphological measurements, surveying a continuous marine notch in 11 different sites. In this area there are no archaeological remains related to sea level changes. On the contrary, since the southern coast between Stramare (Italy) and Izola (Slovenija) is dominated by Flysch, there are no notches but 5 submerged archaeological sites. The altitude of the marine notch varies between −0.65 m on the Miramare olistoliths and −0.9 m in Canovella de’ Zoppoli. The depth of the notch increases in direction of Duino, from −1.3 m close to the Sistiana Harbour to −2.55 m below the castle of Duino.

This situation highlights a clear SE - NW tilting versus in the Gulf of Trieste. Braitenberg et al. (in press), on the basis of tidal gauge data (over 110 years) and the movement of the last 30 years of the Grotta Gigante pendulum, hypothesized that NW movements could still be active. In the southern part of the Gulf, the mean values of the tide and pressure-corrected archaeological measurements (all provided by harbour stones) indicate a depth of - 1.6 ± 0.5 m for the 2 ky BP sea level (Roman age, I sec. A.D., dated with an amphora at the base of the stones), assuming the top of the wall of the harbours at an altitude of about - 0.9 m.

References


Palaeomagnetic Secular Variation Chronology compared to $^{14}$C Geochronology. An example from late Pleistocene and Holocene marine sediment from the Western Mediterranean Sea.

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Palaeomagnetic secular variation (PSV) curves spanning several $10^4$ years and valid on regional scales of 1000-2000 km have been established by means of direct measurements in the last 0-400 years and by proxy records from archaeological materials, lava flows, and lake and marine sediments. We have compiled a high-resolution sedimentologic, petrophysics, and paleomagnetic study of late Pleistocene and Holocene cored marine sediments from the inner shelf to the upper slope in the Gulf of Salerno, western Mediterranean Sea, to augment the existing record.

Our paleomagnetic data record well-defined ChRM, with very similar stratigraphic trends and distinct features of palaeomagnetic directions (declination and inclination) and normalized magnetic field relative paleointensities (ARM/NRM), which can be correlated between cores where they overlap in time. The correlation confirms especially well the palaeomagnetic record for the last 8,000 years previously obtained in the same area (Iorio et al., 2004). Moreover, the sedimentary sequence record includes several tephra layers from Mt. Vesuvius and the Phlegraean Fields that provide precisely dated tie-points and stratigraphic marker horizons. An age model anchored by radiocarbon dates and tephrochronology is proposed for the last 25ky, based on correlation of the obtained PSV curves with European master PSV curves and relative magnetic field intensity curves of the North Atlantic Palaeointensity Stack (NAPIS-75; Laj et al., 2000) and South Atlantic Palaeointensity Stack (SAPIS; Stoner et al., 2002). For two tephra layers attributed to Mt. Vesuvius, the calibrated palaeomagnetic curves were used to assign ages of about 1.3 and 3.0 kyr to the tephra. An estimate for PSV age uncertainties at a century scale in Holocene sequences, with relatively high sedimentation rates of 10-100 cm/kyr, also was obtained from a palaeomagnetic study of two companion gravity cores (Sagnotti et al., 2005). There is some evidence in the PSV curves that the Mono Lake and Laschamp geomagnetic excursions, at approximately 34,000 and 40,000 yrs B.P. respectively, are recorded. If confirmed, those brief but
large departures from expected palaeomagnetic field behaviour directions in the Brunhes Normal Chron will be excellent chronologic markers in the Mediterranean region. Comparison, for the last 25 ky, of our PSV age model with a radiocarbon geochronology obtained in sediments from the same locality (Buccheri et al., 2002) shows very good agreement with minor differences. The age model for the region gives important implications on the geologic and stratigraphic evolution of the Campania marine margin in a time period of global environmental, climatic, and anthropologic changes. Work in progress is designed to extend the results to other Western Mediterranean coastal margins.

References


Land-sea correlation of Holocene climatic events in the Sele Plain - Salerno Gulf area (southern Italy)

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Land-sea correlation of climato-stratigraphical events are often prevented by the lack of suitable chronological constraints especially for the Holocene period, where a high resolution is necessary to detail the complexity of climatic variations. The use of marine and continental proxies in the same sediment record could be the right solution to overcome this problem. For this purpose the Modern Analogues Technique (MAT) was applied to pollen and planctonic foraminiferal assemblages of GNS84-C106 core (14°42'24" E; 40°28'52" N, 292 m depth, 6.17 m long) in order to obtain a compared quantitative reconstruction of continental and marine climatic events during the Late Glacial and Holocene in the Sele Plain - Salerno Gulf area. The chronostratigraphical framework is based on eight AMS \(^{14}\)C dates and on the occurrence of the 79 AD Pompeii pumice (Buccheri et al., 2002). \(^{14}\)C ages were calibrated according to Fairbanks et al. (2005).

![Fig. 1: Studied area with location of the GNS84-C106 core](image)

The fossil pollen assemblages were compared with a modern database consisting of 1362 European, Asiatic and North African pollen spectra (EPD). In order to avoid misleading results due to the over-representation of Pinus in marine sediments, this taxon was excluded from the database and from the core assemblages. This procedure however, didn’t invalidate the method, since the exclusion of Pinus didn’t determine a significant change in the correlation coefficients between MAT estimated and measured parameters.

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Radiocarbon age</th>
<th>Calendar age</th>
<th>Calibration version</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>std dev</td>
<td>mean</td>
</tr>
<tr>
<td>140</td>
<td>3226.5</td>
<td>40.0</td>
<td>3240.0</td>
</tr>
<tr>
<td>200</td>
<td>5215.0</td>
<td>40.0</td>
<td>5361.0</td>
</tr>
<tr>
<td>260</td>
<td>7715.0</td>
<td>70.0</td>
<td>8496.0</td>
</tr>
<tr>
<td>276</td>
<td>7976.4</td>
<td>41.0</td>
<td>8965.0</td>
</tr>
<tr>
<td>310</td>
<td>9426.5</td>
<td>100.0</td>
<td>10670.0</td>
</tr>
<tr>
<td>370</td>
<td>12425.0</td>
<td>100.0</td>
<td>14489.0</td>
</tr>
<tr>
<td>470</td>
<td>18965.0</td>
<td>60.0</td>
<td>19765.0</td>
</tr>
<tr>
<td>565</td>
<td>25565.0</td>
<td>150.0</td>
<td>30760.0</td>
</tr>
</tbody>
</table>

**Fig. 2: AMS \(^{14}\)C ages and calendar ages (kyr BP)**

<table>
<thead>
<tr>
<th>Correlation coefficients</th>
<th>with Pinus</th>
<th>without Pinus</th>
</tr>
</thead>
<tbody>
<tr>
<td>measured vs. estimated Annual Precipitation</td>
<td>0.899</td>
<td>0.893</td>
</tr>
<tr>
<td>measured vs. estimated January Temperatures</td>
<td>0.935</td>
<td>0.925</td>
</tr>
<tr>
<td>measured vs. estimated July Temperatures</td>
<td>0.925</td>
<td>0.924</td>
</tr>
</tbody>
</table>
The planktonic foraminiferal fossil assemblages were compared with a modern dataset of 872 North Atlantic and Mediterranean coretop assemblages. The MAT was computed with PaleoAnalogs 2.0 (Therón et al., 2004), by adopting the squared chord distance as similarity measure. Although the GNS84-C106 core covers the last 32 kyr, the MAT was applied only to the last 16 kyr. In fact, the reconstruction of the atmospheric temperatures for the Last Glacial Period gives anomalous values due to no-analog conditions. In order to circumvent this problems a modification of MAT is under refinement.

Late glacial events were identified by both continental and marine proxies, with the coldest temperatures of the Younger Dryas recorded at about 12.3 kyr cal BP. The atmospheric evidence of the Younger Dryas stadial is primarily reflected in low winter temperatures. The Late Glacial - Holocene transition is clearly recorded in both the continental and marine realms: an increase in summer and winter SST’s is recorded of respectively 9°C and 6°C in about 1 kyr; the atmospheric temperature increase is more marked for winter, where an increase of about 7°C is recorded in 1 kyr. The Late Glacial - Holocene transition is also marked by a strong increase in precipitation, which passed from 600 mm/year at 12.3 kyr cal BP to 1000 mm/year at 10 kyr cal BP.

The record of Holocene temperatures shows distinct features in atmospheric and marine reconstruction. The atmospheric temperature record highlights several events correlated with the 1st to 4th Rapid Climate Changes of Majewsky et al. (2005). These events have no evidence in the marine record, characterised by slight SST’s variations during the early and middle Holocene, and by a substantial stability in the late Holocene. It is noteworthy, however, the warm winter condition recorded at 8 kyr cal BP, in correspondence with the first interval of the stagnation phase that lead to the deposition of sapropel S1 in the eastern Mediterranean.

References


The Ionian Stage: a proposal for the Middle Pleistocene chronostratigraphy

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According to the Stratigraphic Guides of Hedberg (1976) and Salvador (1994), the Pleistocene Series has to be considered and subdivided by means of GSSPs as any other chronostratigraphic unit. Therefore, subdividing the Pleistocene into formal units (i.e., Subseries and Stages) is firmly suggested. However, in spite of these guidelines, the definition of formal Pleistocene Stages is somewhat hampered by many researchers, which would rather prefer a simple subdivision of the Pleistocene into Subseries (Lower-, Middle- and Upper-). This scenario is rather surprising, because even the distant Paleozoic Era, for which the chronological resolution is low, is largely subdivided into formal Stages. The Italian community (C.I.S.) has recently purposed the definition of regional Mediterranean Pleistocene Stages, which would correspond to the informal subdivision of the Pleistocene into Subseries that is largely utilized so far. Specifically, for the Middle Pleistocene interval the “Ionian” Stage is proposed, which would encompass the time interval between the Matuyama-Brunhes magnetic reversal (B/MB), at some 0.78 Ma, and the base of the Upper Pleistocene (~ 0.125 Ma). In spite of its “regional” significance, the Ionian Stage is potentially employable as a formal Stage. Suitable sections for defining GSSP of the Ionian Stage are located in Southern Italy (Montalbano Jonico and San Mauro Marchesato) and Japan (Boso peninsula).

References


Scientific sessions

Wednesday
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High resolution climatic and ecological record 
of the new core of Les Echets (alt.: 267 m, Ain, France)


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Multiproxy and high resolution analysis are being processed on two new cores (a central core, EC1: 44 m long and a littoral core, EC3: 22 m long) extracted from the palaeolake of Les Echets (department of Ain, French Alps foreland). The researches are undertaken by several european specialists gathered in a scientific structure: Les Echets Working Group. The main results evidenced at this stage are:
- a russian lateglacial interstadial with a boreal forest;
- a following period, very cold, on the whole treeless, and climatically unstable; it is named “the Caluire event” and can be considered as the equivalent to the würmian Younger Dryas;
- an upper Eemian cooler period (decline of the fir forest and of the TOC; coming back of pine forest) followed by the last warmer episode of the Eemian, marked by a new expansion of the fir forest. This two-fold event is also recorded in all French eemian sequences;
- strong climatic oscillations accompanied by dramatic consequences on ecosystems are recorded all along the St Germain 1 (OIS 5c);
- a St Germain 2, characterized by a cooler climate and impoverished floristic associations;
- the beginning of the würmian pleniglacial (OIS 4) is biphasic: first milder and wetter (some tree still present), then colder and dry (maximum of steppic herbs, very few trees);
- loess blowings affect Les Echets region during glacial periods (Riss, Melisey 1 and 2, würmian pleniglacial) and the beginning of each temperate phase (Eemian, St Germain 1 and 2) while a deciduous but probably cleared wooded vegetation is installed in the surroundings of the site;
- strong climatic fluctuations (DO events type) concern the equivalent to OIS2 and 3. It is marked by an environment alternatively forested (pine woods) and open (steppe).

The improvement of the age model based on OSL datings is still in progress.
The Late Pleistocene pollen record of Azzano Decimo (southeastern alpine foreland)

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The long record of Azzano Decimo (Friulian plain, NE Italy) provides new data for the history of vegetation and climate in southern Europe during the last four major climatic cycles. This archive, possibly extending back to MIS 13, yields direct evidence of cyclic forest-steppe alternations and of several regressions and transgressions of the Adriatic sea, related to glacioeustatic oscillations. The succession shows an overall regressive trend and substantially constant terrigenous supply. The record of sea-level changes in the core is documented by repeated alternation of environments ranging from continental, paralic and to mid/inner shelf with an evident continental influence. The Azzano record offers the opportunity to detect the effects of orbital forcing both on the 100 ky frequency and of lower scale oscillations. The chronological frame relies on ¹⁴C datings (back to 50 ky BP), on the correlation of palynostratigraphical control points with coeval european pollen sequences and on the comparison of events evidenced in the pollen diagram with detailed North Atlantic ¹⁸O records.

The lowermost and the central parts of the Azzano Decimo core (78 – 260 m depth) display a complex succession of forested phases separated by phases of more open forest vegetation, combined to glacio-eustatic cycles (regression/transgression). The uppermost 78 m were deposited in continental settings; sedimentary environments are those typical of the evolution and aggradation of the distal part of an alluvial fan, being facies related to channel and overbank environments, the latter comprising deposits of levee, crevasse channel and crevasse splay, floodplains, ponds and marshes. Five buried paleosoils, named P9 to P13, sometimes displaying complete profiles and having different degree of development were described. Pollen data allow a direct comparison with well-known records from the northern alpine foreland (France, Germany, Austria) and the mediterranean region.

In this presentation we focus on the upper part (78 to 0 m, i.e. late Middle Pleistocene and Late Pleistocene) of the record. Pollen superzone S8 (77,92 – 60,09 m) yields evidences of an important phase of open vegetation, with the possible presence of Pinus (stomata occur in sediment) and the complete absence of termophilous broad-leaved trees. The age of this portion of the core is beyond the limit of the radiocarbon method, located at about 34.5 m (45,000 ± 3,000 ¹⁴C years BP). A sequence of forested phases of warm temperate climate separates pollen superzone S8 from the Last Glacial Maximum. Pollen superzone S9 (60,09 – 40,05 m) starts with a sequence of tree immigration considered to be typical of the last interglacial (Eemian, as traditionally referred to in the palynostratigraphic scheme of central-western Europe). A good correspondence is observed between the record of Azzano Decimo and some classical european eemian sequences. In particular, the curve of Picea at Azzano Decimo strongly resembles those from Mondsee (Drescher-Schneider, 2000) and Füramoos (Müller et al., 2003), while the abundance of deciduous oaks (Quercus) and termophilous broad-leaved trees (Corylus, Ulmus and Tilia) are comparable with the pollen record of Valle di Castiglione (central Italy: Follieri et al., 1988). The scarcity of Fagus supports a biostratigraphic correlation of the first part of pollen superzone S9 to the Eemian.
The Eemian is followed by a succession of stadial – interstadial phases, ending at ca. 40,05 m depth with the expansion of xerophytes of cooler and drier climatic conditions (Artemisia, Chenopodiaceae, Hippophae, Helianthemum, Ephedra). The comparison with other european pollen records suggests that this limit may be referred to as the transition MIS 5/MIS 4 and with the beginning of the cold phase related in the GRIP record with Dansgaard-Oeschger event D3 and with Heinrich event H6 (Bond et al., 1993; Genty et al., 2003).

According to this interpretation, the penultimate phase of major fluvioglacial aggradation, recorded in the Azzano Decimo core by superzone S8, may correspond to MIS 6. During MIS 4, regardless of evidences of continental climate, no phases of major fluvioglacial deposition are recorded. The LGM and the Late Glacial part of the pollen record testify to the presence of open areas, dominated by xerophytes and grasses (Gramineae), with rare Pinus and Betula. Ongoing work aims to a correlation with the GRIP record.

References


A new finding of the genus *Tanousia* Servain (Hydrobiidae) from the Piànico-Sèllere basin (Bergamo, N Italy): palaeoclimatic and chronostratigraphic meaning

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The Piànico-Sèllere basin is situated in the Orobie Prealps, district of Bergamo, northern Italy. A glacio-lacustrine succession, formed in a closed lake basin during the Middle-Upper Pleistocene (Moscariello et al., 2000) is cropping out. The first paleontologist who approached the Piànico deposits was Stoppani (1857). Sordelli (1896) first described the malacological fauna of the paleo-lake in his “Flora fossilis insubrica”. He found some genera of freshwater gastropods and bivalves that we also have recorded in the succession of the Piànico basin, such as *Lymnaea*, *Bithynia*, *Planorbis*, *Unio*, but he did not find the genus *Tanousia* Servain, 1881, the most important malacological discovery in Piànico.

The lacustrine deposits of the Piànico basin are mainly composed of turbiditic, clayey, sandy and varved sediments; a tephra layer, used for dating, is present. The deposits are well exposed in 9 sections described by Moscariello et al. (2000).

The samplings for malacological studies have been carried out in the “Main Section” in which two lithostratigraphic units have been recognised: the Varved Carbonate Bank (BVC) and the Member of La Palazzina (MLP). BVC is a regular succession of carbonate varve sediments in which turbiditic levels are interbedded; some slumps are also present. The tephra layer occurs in the upper part of BVC. MLP is a prevalently terrigenous unit, with some rhythmites. Most of the recorded mollusc fauna come from the basal part of the BVC in slump sediments, mostly containing the prosobranch species *Tanousia* ex gr. *T. runtoniana-stenostoma*. Rare findings of *Tanousia* are recorded in the upper part of BVC and in MLP.

The specimens from Piànico appear similar to two species of the genus *Tanousia*: *Tanousia runtoniana* (Sandberger) and *Tanousia stenostoma* (Nordmann) from the late Early and Middle Pleistocene of northern Europe (Schlickum, 1974; Meijer and Preece, 1996). Some morphological differences have been observed: Italian specimens appear thicker and of a greater size than both northern European species. However, the morphological shell characters of the specimens from Piànico show an intermediate variability between the two European species as regards the shape of aperture, growth lines, columellar callous, etc., with a best similarity to *T. stenostoma*.

*T. runtoniana* and *T. stenostoma* are usually found in channel sediments, accompanied by a fauna of well-oxygenated water (Meijer, 1988; Preece, 2001). In the Piànico deposits *Tanousia* is actually found in slumping and chaotic sediments, with some evidences of fluvial transport from a near water course.

In northern Europe *T. runtoniana* and *T. stenostoma* can be found in interglacial deposits and indicate a warm climatic phase. *T. runtoniana* is a typical Bavelian and Cromerian fossil (late Early – lower Middle Pleistocene), while *T. stenostoma* is only a Cromerian finding (lower Middle Pleistocene) (Meijer and Preece, 1996). The dating of the tephra layer gives at the upper part of BVC an age of 779 ± 13 ka (lower Middle Pleistocene) (Pinti et al., 2001); specimens of *Tanousia* from Piànico come from the basal part of BVC.

In conclusion we can consider *Tanousia* ex gr. *T. runtoniana-stenostoma* recorded in Piànico-Sèllere basin as a fluvial species, typical of an interglacial phase, characterizing the basal part of the Cromerian Complex. Statistical comparisons are in progress to understand if *Tanousia* from
Piànico is a different new species or belongs to the range of variability of the *Tanousia runtoniana-stenostoma* gr.

**References**


Large and small mammal biochronology and chronostratigraphy from the Late Pliocene to the Middle Pleistocene of the Italian peninsula

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A review on mammalian biochronology of the Italian peninsula is presented. Large and small mammal biochronological successions and their correlation to the geochronometric scale are discussed, according to the integrated methodology and data of Sala and Masini (2004), Masini and Sala (2004 and in press). The integration between the two scales has been done directly, through the localities which yielded a rich record of both large and small mammals, which represent a sort of “landmarks” for correlation. The different body size that distinguishes the “large” from the “small” mammals, however, strongly influences the taphonomy of the two groups, their recovery and the methods required during collection. For this reason localities with sound documentation of both large and small mammals are not so frequent, particularly in the Pliocene and the Early Pleistocene, with some noticeable exception. This results in a certain degree of uncertainty in some details of the proposed correlation framework. This integrated approach, on the other hand, allows the constraint of the sequence of large- and small- mammal events in a more reliable way, and therefore it results in a more detailed and consistent chronological use of mammalian assemblages. The biochronological framework has been integrated into a chronostratigraphical scheme by means of radiometric and magnetostratigraphical calibration and marine - continental correlations available from several sites (Fig. 1).

The Montopoli local fauna represents the basal fauna of the Middle Villafranchian, where important dispersals occur among large mammals (e.g. Equus and Archidiskodon), found just above the Gauss Matuyama transition and therefore correlated to the Middle – Late Pliocene transition. The Montopoli F.U. apparently correlates with the late part of the Mimomys polonicus zone of the Early Villanyian of the small mammal European chronology.

The large mammal assemblages of the Middle Villafranchian are not much represented in the Italian peninsula (Costa San Giacomo F.U.) and the transition to the Late Villafranchian is rather gradual. The Olivola F.U. (the first unit of the Late Villafranchian) records a change in faunal composition that yet retains continuity with the Costa San Giacomo F.U. In the Olivola F.U. Leptobos etruscus is the most widespread bovid, and Eucladoceros dicranios - ctenoides and Pseudodama nestii appear. The presence, among the carnivores, of Pachycrocuta brevirostris and Panthera gombaszoegensis are also notable. The upper part of the Middle Villafranchian and the first unit of the Late Villafranchian (Olivola F.U.) correlate with the Mimomys plioaeanicus zone (Late Villanyian). Remarkable small mammal localities are Montagnola Senese (Central Italy) and Rivoli Veronese (N-E Italy); in the latter locality M. plioaeanicus, Mimomys tomentis and Mimomys pitymyoides occur together with Ungaromys dehmi and Villanyia. Local faunas of the Olivola F.U. and faunas transitional to the next unit, the Tasso F.U., are rather common in the Upper Valdarno Basin. Magnetic investigations have allowed the correlation of these faunas to an interval that extends from the reverse polarity Matuyama Chron above the Reunion Event and the greater part of the Olduvai Subchron.
The subsequent Tasso F.U. includes some novel elements, such as the occurrence of *Praeovibos*, of a primitive lycaon (*Lycaon falconeri*), of a derived form of medium-sized deer (*Pseudodama eurygonos – farnetensis*), of *Equus stehlini* and of *Leptobos vallisarni*, a stouter relative of *Leptobos etruscus*. The transition from the Olivola to the Tasso F.U. is known from the Upper Valdarno Basin, where fossil-bearing sediments from the two stratigraphically superposed units are exposed. This transition has been correlated magnetostratigraphically close to the top of the Olduvai Subchron, which is around the basal Pleistocene boundary (GSSP at La Vrica Section, Fig. 1). The finds of *Mimomys savini* (a marker taxon of the Biharian) in two localities of the Upper Valdarno in sediments which are considered as the reference for the Tasso F.U. suggest that this unit can be correlated with the Early Biharian. The Villanyian - Biharian transition, therefore, approximately corresponds to the transition from the Olivola to the Tasso faunal units and to the Plio - Pleistocene boundary. *Microtus (Allophaiomys)*, another important taxon of the Early Biharian, became the most widespread arvicolid, often associated to *Mimomys pusillus* (Monte La Mesa, Venetia; Pietrafitta, Umbria; Cava Pirro, Apulia). Soave Cava Sud, Venetia represents a chronological succession of Early Biharian faunas.

The next important faunal changes are found in faunas correlated the Jaramillo Subchron and correspond to the beginning of the Galerian Mammal Age. The Colle Curti fauna (Central Apennines) is the first faunal unit of the Galerian Mammal Age; it records the first finds of...
Praemegaceros verticornis and of Bison (Bison). The most important small-mammal localities correlated with Colle Curti are Castagnone (Piedmont) and Monte Peglia (Umbria) where Microtus (Allophaiomys) burgondiae, Microtus (Allophaiomys) nutiensis, Mimomys savini, Mimomys blanci, Ungaromys nanus occur. Castagnone and Colle Curti are normally magnetised and are referred to the Jaramillo Subchron, confirming the correlation of the Colle Curti F.U. with the upper part of the Early Biharian. The Colle Curti F.U. and the later part of the Early Biharian, as above defined, foreshadow the most important faunal change of the Pleistocene. During this renewal, the Villafranchian taxa became extinct or, in some cases, gave rise to new species more adapted to arid, cold climates. Here the Galerian forms appear together with some of the direct ancestors of the "modern" faunal elements through a sequence of dispersal events.

Within the Slivia and the following Isernia faunal units many important large mammals events occur: e.g the spread of Bison schoetensacki, Capreolus, Cervus elaphus acoronatus, Crocuta crocuta, Panthera leo fossilis, Panthera pardus, Dama clactoniana, Hemibos galerianus, Praemegaceros solilhacus, Mammutthus trogontherii, Elephas antiquus, Stephanorhinus kirchbergenensis and Ursus deningeri. The Slivia F.U. correlates directly with the Late Biharian based on the occurrence of Microtus (Stenocranius) and Microtus (Terricola), associated with Mimomys savini. The Rifreddo locality (Basilicata) has yielded a slightly younger Late Biharian small mammal fauna, equated to the early part of the Brunhes Chron, which records the first occurrence of Microtus (Iberomys) and of Microtus (Terricola) arvalidens. The archaeological site Isernia La Pineta (Molise) correlates to the beginning of the Toringian for the occurrence of the "marker" vole Arvicola mosbachensis which, however, still retains some molars with incipient roots. Important large mammal taxa include Praemegaceros solilhacus, Hemitragus bonali, Dama clactoniana and Capreolus sp., while significant small mammal taxa include Pliomys episcopalis, Pliomys lenki, Microtus aff. arvalis, Microtus (Iberomys) brecciensis and M. (Terricola) ex gr. multiplex-subterraneus. The Grotta Valdemino fauna (Liguria) is a good example of a “warm assemblage” of the early Toringian - Middle Galerian, while the thick archaeological sequence of Visogliano Shelter (Friuli Venezia Giulia) records a warm to cold climatic oscillation of the Toringian - Late Galerian. Crocidura, Microtus (Terricola) cf. arvalidens, Macaca and fairly abundant Dama clactoniana occur in the temperate climate lower levels. Significant occurrences within the upper cooler climate levels are those of the narrow-skulled vole Microtus (Stenocranius) gregalis, the pika (Ochotona sp.), the suslik (Spermophilus sp.) and the argali (Ovis ammon).

References


Masini F., Sala B. - Large and small mammal distribution patterns and chronostratigraphic boundaries from the Late Pliocene to the Middle Pleistocene of the Italian peninsula. In progress.


The Late Pleistocene vertebrate bearing deposits at San Teodoro Cave (North-Eastern Sicily): preliminary data on faunal diversification and chronology

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Vertebrate bearing deposits in the wide San Teodoro Cave (Fig. 1) have recently been object of new excavations (Bonfiglio et al, 2001). The first trench (excavated in 1998) has interested sediments located at 8 m from the cave entrance (coordinates sq. 9 - 13) at depths from -2.43 m to -3.85 meters with respect to the altitude of reference (named “0” altitude).

The second trench (excavated in 2002 - 2004) is located at a distance of 29 – 34 m from the entrance, and interested the deposits at an elevation ranging from +0.9 m to -0.53 m (Fig. 2).

The two trenches both yielded fragmented and unarticulated skeletal remains of large mammals (*Elephas mnaidiensis*, *Bos primigenius siciliae*, *Cervus elaphus siciliae*, *Sus scrofa*, *Canis lupus*, *Vulpes vulpes*, *Equus hydruntinus*, *Bison priscus siciliae*), small mammals (*Microtus (Terricola) ex gr. savii*, *Apodemus cf. sylvaticus*, *Erinaceus cf. europaeus* and *Crocidura cf. sicula*), and fairly numerous bones of spotted hyena (*Crocuta crocuta spelaea*). The large mammal bones show important damages produced by the spotted hyena. A very large amount of coprolites occurs within the sediments of the two excavated trenches and within the sediments of some smaller pits excavated in different points of the cave floor (Mangano and Bonfiglio, 2005).
Some important differences, however, occur between the two trenches, as it is shown by the lithological features of the deposits, by the taphonomy of the elephant bones, by the mollusc fauna and also by biometrical analysis carried out on *Microtus (Terricola)* ex gr. *savii* teeth.

The sediments of both the trenches are made up by fine gravels, sands and silt, in which carbonatic blocks of different size fell down from the cave ceiling are included. In the 2002 trench, however, alternated carbonate “flowstone” levels are frequent. The carbonate concretions incorporate sediments as well as small sized fragmented mammal bones.

The elephant remains from the 1998 trench consist of small sized fragments of bones. Those found at some locations in the 2002 trench, on the other hand, are larger sized, poorly damaged by the hyenas, and in some cases partially articulated, even though in the same level coprolites are fairly abundant. This taphonomic peculiarity is unusual, and it has never been described in the literature concerning the fossil hyena dens (Fosse, 1997, with bibliography).

The structure of the molluscs assemblages from the 1998 trench, recognised as polytropic assemblages characterised by land taxa and few freshwater species in the lower levels, points to a cool climate evolving into a colder and arid phase. The assemblages from the inner and higher 2002 - 2004 trench, in which a decrease of land taxa is registered and the freshwater and hygrophilous elements prevail, show a probable more humid environment (Esu et al., submitted).

The wide distribution in the sediments of the freshwater elements points to the presence of a permanent spring or slowly running water inside the cave. Infact the lithology and the structural characters of the deposits in the 2002 - 2004 trench point to the presence of gravity flows which were probably located in the areas where concretioning processes occur.

For what regard small mammals, the Savi vole is the dominant form in 1998 and 2002 trenches, suggesting that a not densely forested landscape persisted in the area where the cave is located during the accumulation of the sediments. However, biometrical analysis on the molars of the same vole evidences statistically significant differences in size between remains from the two trenches. This observation supports the interpretation that the sediments of the two trenches likely were deposited during two not strictly coeval time intervals, in agreement with the interpretation of the molluscs assemblages.

The already investigated deposits in the San Teodoro Cave indeed represent only a small part of the huge quantity of sediments contained within the cave. Therefore, keeping also in mind that sedimentary-erosional processes in cave environments may produce rather complex and irregular sedimentary structures, a certain caution prevents us to attempt a correlation between the two trenches. The evidenced differences are, however, significant. They partially may be related to microenvironmental differences due to the different position of the trenches with respect to the

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**Fig. 2:** Profile of the S. Teodoro Cave floor from the entrance (sq. 1) to the inner of the cave and location of the excavated trenches with correlation of the stratigraphic units. The symbol “+” indicates the landmark (quote ‘0’). The numbers indicate the distance (m) from the entrance. A = Unit A; B = unit B; C = unit C; R = recent level (from Esu et al., submitted).
entrance of the cave. However, they probably also reflect environmental changes related to the effects of some minor climatic fluctuations during the glacial phase of the late Pleistocene.

A significant piece of information, eventually, is given by the radiometric dating carried out with the \(^{230}\text{Th}/^{234}\text{U}\) method on a concretion intercalated with two clayey levels within the 2002 trench, which yielded an age of 32,000 ± 4,000 yr. This geochronometric date, which will be tested by further dating on the other carbonate concretions present in the deposits, is a first result that significantly contributes to a firmer chronological assessment of the San Teodoro Cave faunal assemblage, an important landmark for the palaeobiology and biogeography of the Sicilian Island.

Contributes:
- Bonfiglio L. and Mangano G.: excavations, large mammals, stratigraphy
- Esu D.: molluscs
- Masini F. and Petruso D.: small mammals
- Tuccimei P. and Soligo M.: radiometric dating

References


The evolution of European mammal assemblages during Late Pleistocene-Early Holocene transition

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The huge amount of information about European mammal distribution and diversity during the period - 25 to - 8 kyr has been united as part of a NW0-RFBS project. The Dutch and Russian teams include Dr. A. Verpoorte, Dr. I. Mol, Dr. S. Bonkhe, Prof. N. Smirnov, Dr. A. Puzachenko, Dr. P. Kosintsev, Dr. A. Simakova and Dr. I. Golovachev as well as the authors of this abstract.

The complex data from about 400 European mammalian sites with a Late-Pleistocene – Early Holocene age have been studied. Mammal localities dated by \(^{14}C\) were subdivided into 5 temporal intervals: Last Glacial Maximum (LGM) (24,000 – 17,000 yr BP); Late Glacial Transition (LGT) (17,000 – 12,400 yr BP); Bölling - Alleröd Interstadial complex (BAIC) (12,400 – 10,900 yr BP); Younger Dryas (YD) (10,900 – 10,200 yr BP); Preboreal - Boreal (PB-BO) periods of the Early Holocene(10,200 – 8,000 yr BP).

GIS and a complex of mathematic methods were used to construct the maps with the distribution of mammal species as well as mammal assemblages, and also to reconstruct the European palaeo-ecosystems and the related climatic conditions during the five different intervals.

The huge territories of Europe located between the Scandinavian ice sheet and ~ 48°N during the LGM were covered by the different variants of the "Mammoth complex". Five mammal assemblages characterize the variants of the Mammoth complex: periglacial tundra, periglacial tundra-forest steppe (2 variants) and periglacial forest-steppe (2 variants). All of these assemblages have an unique structure and have no modern analogues. They include animals of different ecology, which now inhabit different natural zones. The animal composition reflects the mosaic structure of the European environment during the LGM. Continues forest zone did not exist during that time. This explains the wide distribution of steppe animals to the north and to the west of Europe. The influence of the Late Valdai (= Weichselian) ice sheet was very strong, permitting typical tundra species to penetrate till the 46-48°N. The forest species migrated to the south and survived also in refugia in river valleys, mountain and uphill regions with specific local conditions. The analysis of mammal distribution shows that the manifestation of the European natural zonality was week during LGM. The species composition of localities indicates a non-analogues, “mixed” faunas, and includes the mammals from the different natural zones. Southward the 45°N the structure of mammal assemblages practically didn’t reflect the influence of ice sheet.

The reconstructions also permit to conclude that the principal structure of the mammal assemblages during the Late Glacial transition (LGT) was similar to that during the LGM. This indicates the persistence of cold and rather arid climatic conditions in northern and central Europe. The main features of the LGT assemblages are the existence of huge territories with species that nowadays occur in different natural zones: tundra, forest and steppe. Many tundra species had a huge range during that time, as well as during the LGM, which indicates cold climatic conditions and the distribution of periglacial types of vegetation in northern and central Europe. Steppe species also had a wide range and penetrated far to the north as well as to the west. Open landscapes favour such a wide distribution. Forest species are concentrated mainly in the southern
mountain regions of Europe. Only assemblages located in the southern regions of West and East Europe indicate a very weak influence of the ice sheet during the LGT. Mammal assemblages during BAIC: I - periglacial tundra-steppe assemblage; II - periglacial tundra-forest-steppe assemblage (north variant); III – periglacial tundra-forest-steppe assemblage (West European variant); IV - periglacial forest-steppe assemblage; V - mountain forest and forest-steppe assemblage. The study of BAIC mammal assemblages demonstrates that the non-analogue faunas prolonged to exist in the central and northern regions of Europe. The reconstructed picture of the BAIC mammal assemblages indicates the very beginning of the destruction of “mammoth” steppes or periglacial hyper-zone between 12,4 - 10,8 ka BP, which reflects a climatic warming. The typical tundra-adapted animals occurred southward till 52-54°N, but their density and ranges decreased compare to the LGM and LGT. The presence of forest species even in the northern part of Europe confirms the increase of the forested areas in that region. They alternated with open tundra-steppe environments which also occurred in these territories. Steppe animals distributed far to the west between 12,4 - 10,8 ka BP, indicating the existence of open periglacial tundra-forest-steppe, forest-steppe and steppe even in West Europe, but the areas became smaller after the beginning of the Bölling Interstadial and probable had a patchy character. Typical representatives of the European “mammoth” complex are mammoth, woolly rhinoceros, *Bison priscus, Bos primigenius, Megaloceros giganteus* and others. But their finds became rather rare during BAIC. Some of them survived only in the mountain regions (cave lion). The influence of Scandinavian ice sheet became very insignificant in the Mediterranean. The fauna of the Central Massive Mountains, the Apennines and Pyrenean Peninsula had no noticeable traces of the cooling. Later, during the YD the combination of tundra and steppe elements in the faunas was registered only in the north and mountains of Western Europe, and in the sites of the Middle Urals, but the tundra species there indicated the decreasing of their dominance. The steppe mammals were still found further northwards from their modern ranges. Forest elements had not formed the zonal complex yet, but their role already turned noticeable in the elevated regions. The analysis of Preboreal - Boreal mammal species composition has revealed significant changes in the mammal distribution and diversity. Most of the communities show the early stages of the appearance of the main zonal mammal assemblages: steppe, boreal forest and complex of broad-leaved forest and forest-steppe. The typical Late Pleistocene relicts survived only in restricted areas. Forest species became an important part of the communities, indicating a wider distribution of different types of forests in Europe. Thus a broad picture of mammal evolution during the Late Pleistocene - Holocene transition was revealed. The large amount of cartographic data clearly show the spatial changes of the mammal assemblages between 25 - 8 kyr.
Palaeobotanical investigations at the mammoth site of Niederweningen: a further step to the understanding of the Middle Würmian environment and stratigraphy on the Central Swiss plateau

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Since 1890 Niederweningen, a village 20 km Northwest of Zürich is well-known for its mammoth finds. In 2003 a well preserved skeleton of a male mammoth was found (Furrer et al., accepted). It had been embedded in a 80 – 100 cm thick peat layer. This (middle or mammoth) peat is intercalating lake sediments, enclosing two other, thinner peat layers (upper and lower peat). The complete section was carefully sampled for palaeobotanical studies (pollen, plant macrofossils and wood remains) and for beetles analyses.

According to the pollen record, the middle peat layer had been developed during an interstadial, characterised by an open forested tundra with *Picea abies* (wood), *Larix europaea*, *Pinus cembra* on the surrounding slopes and by *Pinus mugo* and *Juniperus* at higher altitudes. The local vegetation started with an overgrowth process and led to a wide wetland complex with different mire associations, partly dominated by *Betula nana* (wood) and with small stands of *Picea abies*, *Salix* (wood) and *Pinus mugo* (Drescher-Schneider et al., accepted). The pollen spectra of the younger peat layer are characterised by a very open *Pinus* forest. *Picea* is already disappeared. The local vegetation is similar to the mire complex in the mammoth peat. The lake sediments had been deposited during cold climatic conditions. Arboreal pollen is very rare and the herb pollen taxa are dominated by Poaceae, *Artemisia*, other Compositae, Brassicaceae and Ranunculaceae. Both the pollen spectrum as well as the radiocarbon dating (Hajdas et al., accepted) place the mammoth sequence into the Middle Würmian (MIS 3). It is significantly younger than the peat layers in two nearby cores investigated by Welten (1988). Its correlation with the pollen record of the Gossau-Interstadial-Complex (Schlüchter et al., 1987) will be discussed.

References

Drescher-Schneider R., Jacquat C., Schoch W. - Palaeobotanical investigations at the mammoth site of Niederweningen (Kanton Zürich, Switzerland). Quaternary International, accepted.

Furrer H., Graf H.R., Mäder A. - The Mammoth Site of Niederweningen, Switzerland. Quaternary International, accepted.

Hajdas I., Bonani G., Furrer H., Mäder A., Schoch W. - Radiocarbon chronology of the Mammoth site at Niederweningen, near Zurich, Switzerland. Results from dating bones, tooth, wood and peat. Quaternary International, accepted.


Results from the pollen and lithopedological study of Upper Pleistocene deposits are obtained for the western foothills of the Ukrainian Carpathians (the Sokirnytsa, Shayan and Gat’ sites, located on high terraces of the Tyssa river), as well as for their eastern slopes and foothills (the Drybka, Mykulychyn, Sadzhavka and Lunka sites, located on the Prut river terraces). The archaeology of the Sokirnytsa and Shayan multilayered Mousterian and Upper Paleolithic sites are studied (Usik et al., 2004). The Quaternary framework for Ukraine (Veklitch et al., 1993) is applied to subdivide the stratigraphic sequences.

At the end of the formation of the Dnieper unit (Saalian), represented by non-soil gleyed loam, a cold continental climate existed in the area, which was occupied by meadow - steppe and sparse arboreal vegetation with boreal and arcto-boreal elements. *Picea* occurs in the Eastern Carpathians. The transition to the Last Interglacial started with the spread of pine forest, which is palynologically recorded at the base of the Kaydaky unit. In Central Ukraine, this unit has been recently correlated with the Eemian (Mikulino) (Rousseau et al., 2001; Haesaerts and Gerasimenko, 2002). In the Carpathians it is represented by a thick Luvisol, strongly enriched in clay and iron. Such phases of the Interglacial are traced: pre-temperate: *Pinus + Betula* (E1), *Pinus* with small admixture of broad-leaved trees (E2); early-temperate Quercetum mixtum (E3); climatic optimum – polydominant broad-leaved forest with high share of *Carpinus* and *Corylus* (E4); late-temperate: *Carpinus + Alnus + Corylus* (E5), broad-leaved forest with *Abies* and *Picea* (E5-6); and the beginning of a post-temperate phase: strong increase in *Picea* and decrease in broad-leaved species (E6a). The presence of *Fagus* through phases E3-E6 is characteristic for the western foothills of Ukrainian Carpathians. *Fagus* pollen have been previously found in the Last Interglacial soil of the Korolevo site, Transcarpathia (Adamenko et al., 1989). In the Eastern Carpathians *Picea* is constantly present in small numbers, whereas *Quercus* and *Carpinus + Alnus + Abies* phases are well separated. At Sokirnytsa the Middle Paleolithic artifacts have appeared at the end of the Last Interglacial, when the forest became lighter.

In the overlying Tyasmyn (ts) and Pryluky (pl) units, two interstadials and two stadials are revealed. The interstadials occur in the ‘pl1’ and ‘pl3’ subunits, both represented by thin gleyed Luvisols (the upper one with podzolic features). The stadials occur in non-soil loamy beds (‘ts’ and ‘pl2’), which in their upper part were later re-worked by downward pedogenic translocation. Deep frost wedges in a row open from the bottom of both stadial beds and cryogenic platy structure was formed. A drastic reduction of forests and disappearance of broad-leaved trees occurred during the stadials. Meadow-steppe and meadow-forest ecosystems of arcto-alpine type took over, with considerable participation of cryptophytes (*Lycopodium lagopus*, *Diphasium alpinum*, *Botrychium boreale* and *Betula* sect. Nanae et Fruticosae). The significance of grasses and sedges increased, and Chenopodiaceae occurred, whereas Polypodiaceae disappeared.

During the Pryluky interstadials considerable expansion of forests occurred, dominated by *Pinus* in the western foothills of Ukrainian Carpathians and by *Picea* on the eastern slopes. An admixture of broad-leaved trees appeared, more significantly during the first interstadial ‘pl1’, when *Carpinus*
and Fagus were present alongside with Quercus. During the second interstadial ‘pl3’, broad-leaved species were strongly redacted, and Picea spread further (also Alnus in the western foothills). The climate of the interstadials was southern-boreal, and, during the ‘pl1’ optimum, transitional to temperate (though no interglacial succession were observed).

The Pryluky interstadials are correlated with two Early Glacial interstadials, whereas the Tyasymn and ‘pl2’ stadials are compared with the Early Glacial stadials, as it has been previously done in Central Ukraine (Rousseau et al., 2001). The end of the ‘pl3’ interstadial (with disappearance of broad-leaved trees and podzolic soil processes) might correspond to the transition to the Early Glacial. At the Sokirnytsa site the Middle Paleolithic population existed during the first interstadial and at the beginning of the second. It disappeared during the wet Picea + Alnus phase of the latter.

In the Pleniglacial succession three stadials, separated by two interstadials, are revealed. During the first stadial, related to the Uday non-soil unit, a sharp reduction of forest occurred, as compared to the end of the Early Glacial. Arcto-alpine meadow and meadow-steppe expanded into the area. The maximum spread of Botrychium boreale and arcto-alpine species of Lycopodiaceae, and the distribution of shrub birches indicate periglacial environments. In the western foothills, the Uday upper sediment levels are re-worked by the later Vytachiv pedogenesis, but cryogenic features are preserved in the platy structure of these lower layers of Vytachiv soils, as well as in the deep frost-wedges that open, in a row, from the bottom of the Uday unit. This cold stadial is correlated with the Early Pleniglacial. On the river terraces of the Eastern Carpathians it is represented by loesses. In the lower-mountain Drybka site, an interphasial is revealed in the lower part of the Uday loess, characterized by meadow-forest ecotones with spread of Picea and single occurrence of broad-leaved trees.

The Middle Pleniglacial interstadial occurs in the Vytachiv soil, which has been 14C dated between 38.2 ± 0.45 and 42.1 ± 0.5 ky BP at Sokirnytsa. Birch-pine forests expanded in the studied area, but less extensively than during the Early Glacial interstadials. The small admixture of broad-leaved trees in the forest indicates a southern-boreal climate, which was more continental than during the Early Glacial interstadials (with an absence of mesophyllic trees and much wider spread of birch and of meadow-steppe associations). Small amount of Picea occurred in the Eastern Carpathians, but disappeared at the end of the interstadial which was represented here by Cambisols. The Upper Paleolithic layers correspond to this interstadial.

During the next Bug time unit loesses were formed on river terraces of the eastern Carpathians and, in the western foothills of the Ukrainian Carpathians, silt beds were accumulated. The Upper Paleolithic layers within the latter have been 14C dated to the first half of the Late Pleniglacial, between 29.7 ± 0.8 and 19.8 ± 0.4 ky BP (the Shayan site). At this time, a sharp reduction of arboreal vegetation, disappearance of broad-leaved species and expansion of periglacial meadows and meadow-steppes happened. Erosion, colluviation and cryo-deformation of the Vytachiv soil occurred, arcto-boreal species of Lycopodiaceae extensively spread, and in the Eastern Carpathians Betula sect. Nanae et Fruticosae and Alnaster fruticosus grew instead of Pinus and Picea.

The incipient soils and pedosediments of the Dofinivka interstadial (between 19 and 15 ky BP) have been revealed only in the Prut river valley. A strong domination of Betula was a characteristic feature of arboreal vegetation, which generally prevailed over non-arboreal groups. Nevertheless, Betula sect. Nanae et Fruticosae frequently was a dominating element during the Dofinivka time, and the vegetation evidently closely resembled a periglacial shrub tundra with mesophytic herb cover and abundant Bryales and Lycopodiales on gley soils. The two phases of a stronger humus accumulation were marked by an increase in pine population.
On the river terraces of Eastern Carpathians the overlying loesses of Prychernomorsk unit were formed under tundra-steppe, with a higher proportion of non-arboreal vegetation than during the Dofinivka time. Shrub *Betula* was constantly present in significant number and *Alnaster fruticosus* also grew. *Ephedra distachya* appeared, and, on the higher terrace of the Prut river (the Sadzhavka site), *Artemisia* became significant. This gives evidence of an increase in aridity which is typical for the end of the Late Pleniglacial (Bolikhovskaya, 1995), a possible correlative of the Prychernomorsk unit.

References


Palynostratigraphy of some Pleistocene deposits in the Western Alps: a review

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It was often assumed that mountain glaciers fluctuated synchronously with polar continental ice sheets as glacial expansions were triggered by global cooling temperatures and changes in the general atmospheric moisture. However, while the chronology of some continental ice sheets indicate that maximal ice extents were contemporaneous with the Last Glacial Maximum, some mountain glaciers might have discordant dynamics throughout the Last Würmian Pleniglacial. The longstanding controversy around the time and extent of late Pleistocene glaciers continues in spite of large multi-proxies studies particularly for the Alps.

It must be noticed that generally glaciers records are hindered by a lack of datable material and by advances during the LGM which eroded and/or covered evidence of earlier advances. Records spanning pre-LGM glacial extensions are therefore very exceptional and there is no uninterrupted record of glaciation. In such context, chronological assignment of remaining Quaternary deposits can be problematic. Moreover, considering the limits of the $^{14}$C dating method, age of pre-LGM episodes might be underestimated.

By chance, some outcrops and cored sequences located in the field area ranging from Lyon to Evian provided sedimentary profiles datable by palynostratigraphy in a highly-documented geomorphological context.

We propose:

1) to overview several palynological sequences studied in this large area;
2) to place them into a general chronostratigraphical pattern related to the glaciers dynamics since MIS 5 sensu lato. Particular attention is paid on palynostratigraphical evidence, whose relevance is tested with systematic comparisons with long reference European pollen sequences spanning several glacial cycles.

Finally, the review attempts to propose minimum ages for non glacial episodes corresponding to the deposits studied.
Palaeobotanical data for a biostratigraphy of the Last Glacial Maximum in the Venetian Plain

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Large portions of the northeastern Po Plain formed during the late Pleistocene (Castiglioni, 1999; Bondesan et al., 2002; Marchetti et al., 2004; Fontana et al., in press). This period was characterised by large sedimentary activity of the Adige, Brenta, Piave and Tagliamento rivers, which received fluvioglacial outwash from the eastern Alps glaciers and formed coalescent alluvial megafans. In the Venetian-Friulian low plain, thick sequences of minerogenic layers (silt and sand) alternated with frequent thin organic layers (peat and organic silt). In the last fifty years many authors reported pollen data from organic layers drilled in the Venetian-Friulian low plain (detailed references in Miola et al., 2003 and Ravazzi et al., 2004; Serandrei Barbero et al., 2005). Radiocarbon dates of these organic layers in the topmost 20 - 30 m of the Late Pleistocene alluvial series span 23,000 to 14,000 yr BP. Extension and frequency of organic layers and palaeobotanical records indicate wide areas of wet environments. In a previous research the origin and features of these environments were ascertained through sedimentological analysis, pollen, non-pollen palynomorph (NPP) and plant macrofossil analyses on organic sediments obtained from new cores drilled in the eastern Po Plain (Miola et al., in press). In this work the different layers are correlated according to their biological content and radiocarbon datings. In fact sequences from different sites of the plain cannot be easily correlated using lithological data because of the lateral discontinuity of the layers.

The microfossil content in the minerogenic layers is quite poor, and this excludes a biostratigraphic approach to correlate this kind of sediments. The microfossil assemblages of the thin organic layers do constitute almost the only chance to correlate layers from different sites.

Our research aims at the correlation of the organic layers obtained from about 20 cores drilled in the Venetian Plain from the area of the Euganean Hills to the Tagliamento river in order to propose a regional biozone based on pollen records. The 80 samples or so come from organic layers less than 20 - 30 cm thick. They are embedded within alluvial sequences which are mostly composed by overbank fines, with frequent, scarcely interconnected, 1 - 2 m thick sandy channel bodies. The organic layers consist of peat and organic silt. Twenty-four samples of peat, organic silt and terrestrial plant material were selected from the cores and processed for conventional and AMS radiocarbon dating. Their age spans between 26,000 and 15,000 yr BP. In order to detect similarities among the samples and to provide a synthetic and low-dimensional presentation of the pollen spectra, multivariate statistical analysis was carried out on the set of the pollen spectra from all the cores. Percentage pollen data have been used. They were based on different pollen sums, including and excluding the local component, to value the importance of the local herbaceous communities in the definition of the regional vegetation. Pollen spectra with a sum of less than 200 have been excluded. Total pollen concentration has been estimated by means of Lycopodium method.

At least one regional pollen biozone can be detected. It is characterized by very low total pollen concentration and low values of arboreal pollen percentage. Pinus and Betula are the most common trees. Pinus is always present but its percentage values are generally low (average 17%).
Picea is only sporadically present and its percentage value is less than 3%. Sporadically present are also Larix and Salix, Juniperus and Ephedra. Abies, Fagus, broadleaf trees and shrubs are very rare. Statistical analysis differentiates the pollen spectra of sediments younger than about 18,000 yr BP which are characterised by higher percentage of Pinus and Picea. By contrast, the sediments older than 22,000 yr BP present pollen spectra with higher arboreal percentages including many broadleaf trees as well as Picea. The comparative inspection of pollen and NPP spectra and macrofossil contents shows that the different sites have similar pollen background and similar local aquatic plant communities. The wide extension of organic layers suggests that wetland plant communities were a very important component of the regional vegetation.

References


Pedostratigraphic correlation of loess-paleosol sequences in East and Central Asia with Central Europe – a second attempt

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As recent small climatic fluctuations on a $10^2 - 10^3$ years time scale can be correlated worldwide and represent a decline of mean annual temperature of only $< 1 \, ^\circ C$, major climatic changes on at least a $10^5$ years scale (glacial – interglacial cycles) and probably a $10^4$ years scale (the approximate length of an interglacial) must be of similar ages throughout the temperate climatic belt of the Northern Hemisphere. This concept allows pedostratigraphical correlations. Detailed knowledge of the genesis of paleosols is needed to establish loess-paleosol stratigraphies that can be used for paleoclimatic reconstruction. Most paleosols, however, are truncated and largely recalcified from overlying loess. Micromorphological studies allow primary and secondary carbonates to be distinguished and provide unequivocal evidence of clay illuviation. This enables the recognition of typical loess, weathered loess and the recognition of different genetic soil horizons, such as CB, BC, Ah, Bw, B and Bt horizons. For the Brunhes Epoch the sequence at Karamaydan, Tadjikistan, shows a very good correlation with the deep-sea oxygen isotope record, which includes the development of an accurate astronomical time scale. It allows a detailed chronostratigraphical subdivision of the loess-paleosol sequence in Karamaydan, which therefore should be regarded as a key sequence for reconstructing the climatic history of the Brunhes Epoch. The correlation of the pedocomplexes in Karamaydan with the composite section of Czechia (Fig. 1) is much easier than e.g. in the Carpathian Basin. Control points of the correlation are the Brunhes/Matuyama boundary and the lower soil of the PK I in Karamaydan and the lower soil of the PK III in Czechia, equivalent to stage 5.5 in the OIS.

legend of Fig. 1a and 1b

1) after Bassinot et al. (1994), adjusted
Fig. 1a: genesis of paleosols and pedostratigraphic correlation between the sections of Karamaydan (Tadjikistan) and the composite section of Czechia in the Brunhes chron. PK I – PK III (Karamaydan) with PK II – PK V (Czechia)
Fig. 1b: genesis of paleosols and pedostratigraphic correlation between the sections of Karamaydan (Tadjikistan) and the composite section of Czechia in the Brunhes chron. PK IV – PK IX (Karamaydan) with PK VI – PK X (Czechia)
Extent and chronology of late Cenozoic glaciations

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The goal of the INQUA Commission on Glaciation Work Group 5 “Extent and Chronology of Glaciations” was to assemble glacial chronologies from around the world to better understand ice sheet volumes and extents at various times, and to compile a GIS-supported database for past ice sheet extents. The project involved the contribution of over 200 scientists working in more than 60 countries and territories. The resulting compilation represents the most complete survey of evidence of glaciation ever attempted. The results are published in three volumes; “Europe”, “North America” and “South America, Asia, Africa, Australia, Antarctica” (Quaternary Glaciations - Extent and Chronology, Part I: Europe, 2003a; Quaternary Glaciations - Extent and Chronology, Part II: North America, 2003b; Quaternary Glaciations - Extent and Chronology, Part III: South America, 2003c), each of which contains a series of maps in digital format accompanied by an explanatory text which includes discussion of the type and quality of data used.

The main purpose of the project was, as far as possible, to compile the recent knowledge of the extent and chronology of Quaternary glaciations on a global scale. Examination of the evidence accumulated in the project volumes demonstrates the current state of knowledge. For nearly two centuries the Quaternary has been considered synonymous with extensive glaciation of the mid-latitudes. Although there were local precursors, significant glaciation began in the late Oligocene (ca. 30 my) in eastern Antarctica. It was followed by glaciation in mountain areas through the Miocene (in Alaska) and later in the Pliocene (e.g. in the Alps). Today the evidence from both the land and ocean-core sequences demonstrates that the major glaciations, rather than occurring throughout the 2.5 my of the Quaternary, are in fact restricted to the last 1 my - 800 ky or less. This is not to say that glaciation did not occur earlier, indeed glaciation limited to higher latitudes or mountain massifs certainly occurred throughout the period, particularly in the Rocky Mountains, but also in eastern North America. Moreover, evidence of extensive ice-rafting, an indication that glaciers reached sea-level, is found from the earliest cold stage - the Praetiglian (2.6 - 2.4 my) and its equivalents, in the North Atlantic Ocean. Glaciation on Iceland began substantially earlier, in the Miocene, whilst Neogene-age ice-rafted debris is found in ocean-sediment cores from the Barents Sea, off-Norway, off-northern North America and Antarctica.

Recent discoveries from North America and from the Alpine region demonstrate that cold stages including extensive glaciations were far more frequent than previously assumed (e.g. in N. Italy and NW Canada). However, in most regions very few traces of these early glaciations have been preserved. This is particularly the case in Europe but is even more acute in central regions of North America. In order to discover more about the early parts of the Pleistocene glacial history, research will have to focus on more remote areas, including the Yukon, Siberia and southernmost South America.
Correlation of the Holsteinian/Hoxnian Interglacial of Northern Europe with the Middle Pleistocene deep-ocean record

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The deliberations of IGCP Project 24 (Sibrava et al., 1986) suggested that the Elsterian glacial Stage was represented by MIS 12 in the deep-ocean record, and that the succeeding Holsteinian Interglacial fell within MIS 11. This has been widely accepted by Quaternary research workers, though some authors have suggested correlations for the Interglacial with MIS 9 or even MIS 7. Most recently Geyh and Müller (2005) have proposed a correlation with MIS 9, on the basis of revised method of calculating $^{230}$Th/U dates, which they feel invalidates all contrary opinions. Nevertheless, the stratigraphical evidence, particularly from southern Britain, France and Russia, cannot be so lightly dismissed, nor can that from various branches of palaeontology, from relative dating methods, such as the amino-acid racemisation results from Britain and the Netherlands, and, of course, the actual palynological records from deep-sea cores. The suggestion that the Holsteinian/Hoxnian Interglacial has a rather uniform and easily recognisable vegetational succession across Northern Europe, analogous to the situation during the Eemian Interglacial, is also open to question.

References


Progress in late Pleistocene stratigraphy and paleoclimatology of the Alps based on speleothems

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Recent years have seen three emerging fields of Quaternary research in the Alps, exposure age dating of boulders in moraines (MIS 2-1), optically-stimulated luminescence dating of (glacio)fluvial and lacustrine sediments (MIS 7-1), and U-series age dating of speleothems (MIS 9-1). All three methods are providing critically needed chronological data, albeit of variable accuracy and precision. Speleothems have three distinct characteristics that make them particularly useful, (a) their settings (caves) are much less affected by erosional processes than surface sediments, (b) U-series dating offers superior age control, and (c) their stable isotopic composition provides an additional proxy signal that can be directly compared to other archives, including ice cores.

Results from ongoing studies of speleothems in alpine and perialpine caves will be presented that highlight two important research directions: firstly, speleothems allow to place precise space and time constraints on the extent of ice during the Pleistocene, e.g. at the end of MIS 5.5, at the MIS 5/4 transition, and during MIS 3. Secondly, isotope data of millennial-scale speleothem deposition provide an unprecedented record of climate change during the late Pleistocene. Examples include warm periods during MIS 7, the last glacial inception and Dansgaard-Oeschger events during MIS 5 and MIS 3.
Constraining the timing of glacier variations in the European Alps with cosmogenic nuclides: summary and new results

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More than a century and a half of detailed mapping both in the Alps and on the forelands provides a unique opportunity for exposure dating with cosmogenic nuclides in a well-constrained field situation. We use both boulder dating as well as bedrock dating to constrain the time periods of glacier expansion. The timing of the onset of deglaciation of the northern arm of the Rhône Glacier is recorded by exposure ages from boulders on the outermost moraines at Wangen a.d. Aare (Switzerland). Gschnitz stadial moraines mark the first clear post-LGM readvance of mountain glaciers, when glacier termini were already situated well inside the mountains. Ages from the type moraine of the Gschnitz stadial (Austria) lie in the early Lateglacial (pre-Bølling) time range. Glacier advance during the Younger Dryas led to formation of Egesen moraines as confirmed by exposure age data from several Egesen sites. Exposure ages from Egesen II sites pinpoint the timing of the change over from dominance of glaciers to dominance of rock glaciers which underlines the severity of the continuing cold but dry conditions at the Pleistocene/Holocene transition. Minor early Holocene advances reflect intermittent periods of “glacier-friendly” conditions. Preliminary results from samples taken from the Ivrea morainic amphitheatre and related upvalley sites will be presented. Sampled sites include the Serra d’Ivrea, Piccola Serra and stadial moraines of LGM, as well as bedrock from Colli d’Ivrea and Donnas in the lower Aosta Valley. The new data will be discussed in the context of the existing data set from the northern Alpine regions.
Optical dating of proglacial sediments from the river Riss valley, northern Alpine Foreland

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The northern Alpine Foreland is the classical region for Quaternary investigations. The origin of glacial research is located along the rivers Iller and Mindel around the city of Memminger. In this region the system of four Quaternary glaciations correlated with terrace sequences was developed. Terrace stratigraphy according to Penck and Brückner (1901/1909) is based on the assumption that older deposits are situated at higher elevations compared to younger deposits which are situated closer to the valley floor. As four different terraces were found in the rivers Iller and Mindel region, Penck and Brückner (1901/1909) established four different glaciations. Starting with the oldest glaciation they are called Günzian, Mindelian, Rissian and Würmian, named after rivers in the Alpine Foreland.

In the river Riss valley, which presents the key location for the penultimate glaciation, two terraces were accumulated during the Rissian Glaciation. The older and upper one is called “Ältere/Obere Hochterrasse”, the younger one is called “Jüngere/Untere Hochterrasse”. Samples for optical dating presented here were taken from outcrops along the river Riss Valley.

Sediment dating by Optically Stimulated Luminescence (OSL) enables the reconstruction of past environmental changes by dating terrestrial depositional ages of sediments. To determine the intensity of the luminescence signal in the laboratory, samples are stimulated by light. The signal recorded represents the amount of absorbed radiation since the last sunlight exposure during sediment transport. The natural luminescence intensity is compared to laboratory luminescence signals induced by known laboratory doses. The result of this comparative measurement is called ‘equivalent dose’ (ED). The main limitation in dating proglacial sediments is incomplete bleaching of the OSL signal prior to burial. Insufficient exposition to daylight results in an overestimation of the sediments age. The application of the Single-Aliquot Regenerative-Dose (SAR) methodology enables to identify incompletely bleached samples (Murray and Wintle, 2000). The distribution of repeated ED measurements reflects the degree of bleaching prior to deposition: scatter and skewed values characterize incomplete bleaching.

For each sampling site, we investigated coarse grain quartz and feldspar minerals using blue light and infrared stimulation, respectively. First results showed diverging quartz and feldspar ages for the particular samples. To ascertain the reason we investigated the bleaching characteristics and the different luminescence signal components of the samples.

References:


The principles of optically stimulated luminescence and its application to the dating of sediments from the Po Plain, northeastern Italy

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The dating of sediments using optically stimulated luminescence (OSL) offers an independent dating tool and has proved particularly useful in situations devoid of the organic component used in radiocarbon dating. It is used to identify when a sample was last exposed to daylight by estimating the amount of ionizing radiation absorbed since burial. Free electrons, excited by environmental radiation, become trapped within the crystalline defects of minerals such as quartz and feldspar, and continue to accumulate during burial. On re-exposure to daylight the electrons are evicted and are attracted back to the holes created by the ionization. This recombination creates energy which is emitted in the form of photons, and is referred to as luminescence, which is able to be measured in the laboratory following stimulation of the sample by light. By administering a series of known laboratory radiation doses to the same sample, and measuring the resulting luminescence it is possible to estimate the equivalent dose ($D_e$) of absorbed radiation needed to create the initial signal measured. Measurement of the radionuclides present within the surrounding sediment enables determination of the annual dose rate ($D_r$) of ionising radiation that the sample was subjected to and allows the estimated age to be calculated using the equation $D_e/D_r$. This equation does not illustrate the many other factors that should be considered before identifying the two values but, through considered sample collection and stringent preparation and analysis, it is possible to produce ages with an accuracy of between 5 and 12\% using OSL. Both the sand and silt fraction of sediments are suitable for OSL dating and have been used to successfully date loess, lacustrine, aeolian, fluvial and glacial sediments.

The number of traps within the mineral effectively dictates the point at which a sample will become saturated with a signal and so reach the limit of its dating range. Quartz has been used for dating to at least 200 ka, while feldspar has produced dates of several hundred thousand years but requires more involved analysis to ensure confidence in any results. The different properties of quartz and feldspar mean that they are effectively two completely independent dosimeters that can be studied within the same sample. Feldspar further offers the opportunity to measure a variety of different wavelength emissions, and identify those which are more stable. This can also be useful in identifying whether a sediment was completely bleached prior to burial, and the luminescence clock re-set to zero.

Work has now started on the application of OSL to lacustrine and alluvial sediments collected from the Valeriano Creek in the Friulian area of northeastern Italy. These sediments are important for the correlation of deposits in the foothills of the Prealps to the north, with those that lay to the south on the Venezian-Friuli and Po Plains, where updating of the official geological map of Italy has made available several long cores for the description and characterisation of Quaternary deposits. Northern Italy is an important area for the study of European climate change and vegetational history, and these long sequences rely on radiocarbon and pollen sequences for their correlation with other European sequences. The use of OSL offers the opportunity to date beyond the radiocarbon limit and provide absolute dates to these pollen sequences.
By taking fresh samples from the Valeriano Creek, enough material is available for experimenting with both quartz and feldspar, in both the coarse and fine grain fractions, as well as studying different emissions in the feldspar. It is intended to first establish the appropriate OSL methods to use by working on the younger samples supported by radiocarbon dates, before applying the same methods to the older samples that have no other chronological constraint. Once it can be shown that the methods are successful, it would then be hoped to apply these same procedures to the dating of the long cores further south, where limited material would not allow such extensive experimentation before the dating protocols are applied.
Climate variability at the Plio-Pleistocene transition recorded in laminated U-Pb dated alpine speleothems

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Here we present one of the first absolutely dated high-resolution climate records from two alpine cave sites in the Northern Calcareous Alps, dated by U-Pb isochron techniques. Three speleothems yielded ages of 2.105 ± .018/-.022, 2.31 ± .04/-.05 and 1.76 ± .04 million years and have formed under vadose conditions in a dolomitic karst area. Despite their high ages we found no evidence for diagenetic alteration in these samples, but the caves are clearly in a state of collapse and erosion.

The pollen spectrum extracted from one flowstone comprises Late Pliocene and Early Pleistocene taxa, which is in good agreement with the isotopically derived age of 2.1 million years for this sample. Speleothem palynology and the abundance of organic substances in these samples further argue for vegetation cover in the groundwater infiltration area during the time of speleothem formation.

All samples reveal regular lamination visible under the epifluorescence microscope for which we suggest an annual origin. We use long continuously laminated sequences to tie high-resolution isotope records to a lamina-counting chronology and performed spectral analyses of lamina-thickness data. We conclude that these speleothems were deposited during interglacial growth periods lasting for at least several millennia. Stalagmite samples suggest a minimum duration for Late Pliocene interglacials of about 7000 years, with long-term temperature trends in the order of 1 - 1.5°C only deduced from oxygen isotope data.

The lamina-thickness record reveals dominant periods at 8, 12 - 14 and 22 - 25 years and spectral power is strongest at periods of 50 to 70 years and their harmonics of 100 to 130 years, respectively. These oscillations correspond to well known regular climate fluctuations which are affecting the entire North Atlantic sector, e.g. the variability of sea-surface temperatures and sea-surface pressure as well as the North Atlantic Oscillation. These findings provide one of the first direct insights into North Atlantic climate forcing on precipitation at the northern rim of the Alps during the Plio-Pleistocene transition.
Egesen stage moraine dated in the Western Alps
by means of cosmogenic beryllium-10

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The Argentera Massif (SW European Alps) underwent several extensive glaciations during the Pleistocene and Holocene. Despite its proximity to the Mediterranean Sea (40 km), 6 small glaciers still exist with an average ELA of 2800 m asl.

Several erosional and depositional landforms can still be recognized along the slopes and valley bottoms. Frontal moraines, mapped at different elevations, account for various glacial phases. Previous geomorphological analysis focused on key areas with well-preserved frontal moraines that were considered suitable for reconstructing Lateglacial phases. However, the relative chronology of these deposits has never been constrained by absolute dating.

The advent of new chronological tools, such as cosmogenic radionuclides, makes it possible to determine the exposure age of boulders found on top of moraine crests. This method has already been successfully applied in other alpine settings, i.e. Great Aletsch and Julier Pass Egesen moraine (Ivy-Ochs et al., 1999; Kelly et al., 2004).

Among the various potentially-Lateglacial moraines recognized in the Maritime Alps, the Gias del Praiet moraine was chosen for its well-preserved morphology and the abundance of boulders suitable for cosmogenic dating. It is a frontal moraine located at an elevation of 1850 m asl within the Gesso della Barra Valley, on the NE flank of the Massif, immediately downvalley of the Gelas glacier. The moraine crest has boulders up to 4 - 5 m height and exceeding 5 - 6 m in maximum diameter. The reconstructed ELA calculated for this glacier stage is located at 2385 m, 415 m lower than the present value. Five samples of about 1 kg each were taken from the largest migmatitic gneiss blocks found on the crest. Quartz was isolated and beryllium-10 was measured by accelerator mass spectrometry at the PRIME Lab of Purdue University (Indiana, USA). By applying a scaled production rate of 21.8 at g⁻¹ yr⁻¹, we obtained an averaged age of 10822 ± 594 yr BP, with values ranging from 9916 to 11474 yr. The dates we obtained are interpreted as minimum ages of formation of the moraine. They constrain Gias del Praiet moraine construction within the Egesen stage, a glacial advance that has been correlated with the Younger Dryas cold period. Within this stage, the Gias del Praiet moraine may represent the Kromer event, last of three main glacial events that usually characterize the Egesen stage in the Alps. The Gias del Praiet ages closely match ages of the Great Aletsch and the inner Julier Pass moraine dates, when production rates are scaled to a common base. These ages represent an improvement in understanding the effect of the Younger Dryas cold phase throughout the European Alps.

References


94
Characteristics of quartz-luminescence from Eastern Alpine glacigenic sediments

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Our current understanding of the Quaternary history of the Eastern Alps is largely based on a limited radiocarbon chronology. This lack of chronological data is due principally to the scarcity of suitable material for radiocarbon dating, but also because of the paucity of suitable sites where other methods such as U-series, Ar-Ar or cosmogenic dating may be applied. Furthermore, the applicability of radiocarbon is limited not only by age range but also because much of the sedimentary Quaternary archive was deposited during advancing and recessional glacial periods, when the presence of organic materials was climatically restricted.

In recent years advances in determining the depositional age of fine-grained siliclastic sediments using luminescence techniques have been made, to the stage where this dating method is now considered a routine chronological approach for many Quaternary deposits. The vast majority of sediments in the valleys and basins within the greater Quaternary realm are siliclastic in origin, furthering the attraction of applying luminescence dating techniques in this region.

We have begun analysing quartz extracted from glacigenic sediments from the Inn and Ötz valleys in Tyrol and the Brixen Basin in South Tyrol. We will discuss characteristics of blue-diode stimulated luminescence from these quartz minerals including aspects of the continuous-wave optically stimulated luminescence (CW-OSL), linearly modulated OSL (LM-OSL) and fundamental tests of reliability for dating protocols.
Poster sessions
Late Glacial and Early Holocene vegetation changes in the Northern Pirin Mountains (Southwestern Bulgaria) – palynological data from Lake Popovo

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The key position of the Pirin Mountains in Southwest Bulgaria with its several lakes in glacial cirque provides opportunities for understanding the Late Glacial and Holocene vegetation development in southern Europe. New pollen and macrofossil analyses of high stratigraphic resolution combined with well controlled time-depth curves for Lake Besbog and Lake Kremensko-5 permit the firm identification of the Late Glacial interstadial interval (Bølling-Allerød), dated at 13.8 - 12.6 ka cal BP at Lake Besbog and 14.1 - 12.8 ka cal BP at Lake Kremensko-5 and correlated with the Greenland Interstadiatal GI-1 (NGRIP, 14.5 - 12.6 ka cal BP) (Stefanova et al., in press). The core of Lake Popovo-2, another of the cirque lakes in the Northern Pirin Mts. also contains sediments dating back to more than 18,400 cal BP and the pollen stratigraphy can also be correlated with the stadial/interstadial cycle of the Late Glacial. The investigated site Lake Popovo (41°42’N, 23°31’E) at 2047 m asl is in the highest part of the Northern Pirin Mountains in Precambrian metamorphic rocks (Boyadjiev, 1959). The Pirin Mountains belong to the Continental-Mediterranean area of the subtropical climatic zone (Nikolova, 1997). The present vegetation consists of seven altitudinal belts (Veltshev, 1997). Lake Popovo is located near the timberline formed by Pinus mugo, Juniperus sibirica and single trees of Pinus peuce.

The pollen-analytical results record the vegetation development during the last about 18,400 cal. years BP in the vicinity of Lake Popovo. Comparison of the Late Glacial and early-Holocene chronology is possible with that for Lake Besbog and Lake Kremensko-5 in the same part of the mountains. The initial stage of the vegetation development began before 18,400 cal. BP with distribution of open herb communities dominated by Artemisia and Chenopodiaceae accompanied by Asteraceae, Ranunculaceae, Ephedra distachya, E. campilopoda and Juniperus.
In the Popovo diagram a clear maximum of Pinus Diploxylon type occurs together with Betula, Quercus, Corylus, Alnus etc., dated at 13,272 cal. BP and well correlated with the Late Glacial interstadial interval (Bølling-Allerød), dated at 13.8 - 12.6 cal. BP at Lake Besbog and 14.1 - 12.8 cal. BP at Lake Kremensko-5.
Temporary expansion of NAP (Artemisia, Chenopodiaceae and Poaceae) in the Younger Dryas follows the Bølling-Allerød interval. At Besbog and in the Kremensko-5 diagram, this herb maximum is equally strong in the Younger Dryas.
The Holocene at Lake Popovo starts with a decrease in Artemisia and Chenopodiaceae, and an increase in Pinus Diploxylon type and Betula, along with increases in Quercus, Tilia, Ulmus, Corylus and Alnus, which had been present sporadically in the Late Glacial.

References


Stefanova I., Lazarova M., Wright H.E. – Elevational gradient during the Late-Glacial/Holocene vegetational transition in southern Bulgaria. Vegetation History and Archaeobotany, in press.

Vegetational and climatic changes recorded in lake-peat sediments located in the subalpine altitudinal belt of the Kuznetski Alatau mountains in the south of Western Siberia

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Lake-peat sediments from Chudnoe Lake, located in the subalpine zone of the Kuznetski Alatau mountains in the south of Western Siberia were investigated by pollen and radiocarbon methods. Kuznetski Alatau mountains are located in the middle of the Eurasian continent at the eastern limit of penetration of Atlantic cyclones. They extend in north-south direction and join the West Siberian plain with the Altai Mountains. These comparatively low mountains form a barrier for moisture carried by Westerly cyclones. Because of the moisture in these air masses the mountains are covered by thick dark coniferous forests, even though they are located at the latitude of the steppe zone developed on the surrounding plains. Such a boundary position makes this areas especially interesting for investigation of past changes of vegetation and climate.

Pollen analyses of 3 m of lake gyttja overlain by 3 m of peat recorded five clear stages in the development of vegetation in the study area since Late Glacial time. The first stage (Ch-1), with age older than 9960 $^{14}$C yr BP represents Late Glacial time. It reflects a landscape with no analogues in modern vegetation of Siberia. It was characterized by patches of spruce forests with *Picea obovata* alternating with wide areas covered by *Artemisia* - Chenopodiaceae steppe. The climate was dry, but local soil moisture was enough for growth of spruce in the valleys and around numerous melt water lakes. During the second stage (Ch-2) the previous type of vegetation landscapes changed to thick forests formed exclusively by *Pinus sibirica*, which dominated from 9960 till 8000 yr BP. Obviously this stage was initiated by a sharp increase in affective moisture due to increased precipitation. The next stage (Ch-3) was characterized by absolute dominance of *Abies sibirica* in the forests with an under layer of ferns. *Abies sibirica* is the most thermophilous and methophyllous tree species among Siberian trees. And it seems, that the time interval from 8000 to 5000 years before present was the most humid and warm period since Last Glacial period. After 5000 yr BP (Ch-4) the amount of precipitations decreased, *Abies* forests changed to *Abies - Pinus sibirica* forests, and the lake turned into a mire. Finally, during stage Ch-5, which began at about 1000 yr BP, *Pinus sibirica* became dominant again.

Taking into account the ecology of the tree species dominant in the paleovegetational changes described, one can conclude that they reflect the dynamics of climate from dry and cool conditions in the Late Glacial to moist and cool in the Early Holocene, then to moist and temperate in the middle Holocene, and finally to moist and cool semicontinental climate in the late Holocene. This scenario was apparently caused by the development of the Atlantic cyclonic system in northern Eurasia after the last glacial period. Forests first started to cover areas near modern timberline, both in Kuznetski Alatau and in Altai mountains and only later at lower altitudes. These areas of the modern timberline in the mountains of southern Siberia showed by their early forestation the first signs of strengthening of the Atlantic cyclonic system in early Holocene, 10000 year ago.
Recent environmental evolution in the metropolitan area of Como (Northern Italy): a new perspective from the Como Drilling Project

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The purpose of the ongoing Como Drilling Project is to provide a reconstruction of the LGM to Holocene stratigraphy of the Como urban area, and explore the implications for reconstructing the recent environmental evolution of the whole Lake Como (or Lario, N Italy). At the same time, the Project is aimed at understanding the origin of the subsidence affecting the downtown area, its trend through the time and also the possible future scenario. This twofold aim is therefore achieved through a multidisciplinary approach and analysis conducted on the urban subsurface sediments and the surrounding geological setting. The urban area of Como in general, and the lakeshores in particular, are affected by ground sinking. From 1955 to 1975 values of ground lowering higher than 20 mm/yr have been measured in the districts close to the lakeshore, presumably induced by the indiscriminate ground water exploitation. Then, with the reduction of water pumping in the Como plain, the subsidence rate slowed down to mean values of 1 - 2 mm/yr in town, even if along the lakeshore the ground continued to rapidly sink, for example 6 mm/yr in Piazza Cavour (data refer to 1981 – 1997 period). Since 1946 the Lake Como water level is artificially controlled by a dam located at the end of the eastern branch of the lake. The coastal areas are recurrently damaged by floods. Therefore, the subsidence along the lakeshore of Como and its surroundings increases the vulnerability of this intensely urbanized area to Lario inundations. To clearly define the controlling factors of these phenomena it is important to take into account the role of all the different natural and human components in the environmental post glacial evolution of the Como sedimentary basin.

A more detailed knowledge of the Holocene stratigraphy, associated with an accurate geotechnical investigation, aimed at the characterization of the mechanical behaviour of the recent deposits filling the Como basin, are therefore the main objects of the Project. A better knowledge of the physical environment of the Como metropolitan area (including Cernobbio and the Chiasso area in Ticino, Switzerland) can lead to a more accurate urban planning and territorial management of this highly developed Alpine region with strategic environmental value. Como provides indeed a privileged point of view for understanding the post glacial evolution in the Alpine Italian setting, because it preserves a high resolution, continuous, and datable archive of environmental data. After the LGM, this area has been occupied by a hydrologically-closed branch of Lake Lario, with a relatively high sedimentation rate of fine-grained and organic deposits, and with limited erosional phenomena.

Firstly, we collected in a database and interpreted the stratigraphic, hydrogeologic and geotechnical information resulting from about 100 boreholes located in the entire urban area. Then we conducted a detailed analysis in 3 zones of the town (S. Abbondio site, Ticosa’s area and Valleggio Street). In particular, we drilled three new shallow boreholes at the S. Abbondio site in 2003. In these sites we collected samples for sedimentologic, stratigraphic, palynologic, mineralogic and radiocarbon analyses that allowed us to develop a climatic and environmental
evolution model for the area after the LGM. On the basis of previous data (Comune di Como, 1980; Castelletti and Orombelli, 1986; Apuani et al., 2000) and our new analyses, we worked out a preliminary 3D geological model describing the spatial geometry of sedimentary deposits, and then we interpreted the stratigraphic succession of Como subsurface from the palaeoenvironmental point of view.

According to our model, we infer that during the Holocene the ground subsidence in the urban downtown area had an average rate of few mm/yr, with a maximum of 4 mm/yr near the lakeshore. These long-term values seem in agreement with the short-term estimates of subsidence rates obtained by archaeological data (ca. 2000 years), and also by geodetic and PSI (Persistent Scatterer Interferometry) data, respectively available for the years 1928 - 2004 and 1992 - 2003 (Comerci et al., 2005).

Two new boreholes (S1 and S2) about 70 m deep were drilled in October - November 2005 in Piazza Verdi site, near the Duomo of Como. These 2 boreholes have been instrumented for monitoring water table fluctuations and soil compaction through time. A piezometric survey, planned for the next 3 years, of the new boreholes and other 30 wells located in the urban area will provide new data for modelling underground aquifer architecture and behaviour.

We are carrying on a detailed stratigraphic and geotechnical analysis of the S1 and S2 cored sediments, including the analysis of 1) pollen, 2) charcoals, and other paleobotanical macroremains, 3) radiocarbon, 4) diatoms, 5) borehole radioactivity and 6) geotechnical properties. First results are:

1) the preliminary diagram reveals an increase in pollen concentration and organic debris above 33 m, in agreement with the macroremains data and the $^{14}$C dating. Pollen curves display a diversified interglacial flora in the upper 26 meters. Different phases of the vegetational development will be detected by detailed investigations;

2) a large number of plants remains (macrofossils) were cored from the depth of 2,55 m to 31,95 m: they consist of fragments of wood, leaves, needles, seeds, fruits, moss and very small charcoals. Below the depth of 31,95 m the amount of plant macroremains in the sediment drops dramatically;

3) the charcoal rich sample we collected at the depth of 31,95 m has yielded a $^{14}$C age of 15140±70 yr B.P. (GrA - 30878 sample, Rijkuniversiteit Groningen);

4) a preliminary survey of the fossil diatoms from the depth of 24.85 m forward along the core, pointed out their presence at the depth of 24.85 m (P30 sample), suddenly disappearing going in depth. This community was mainly composed by the planktonic species Cyclotella comensis, Fragilaria construens and F. pinnata, typical of oligotrophic environments;

5) the Gamma-Ray analysis performed in the S2 borehole shows three main stratigraphic intervals with homogeneous gamma styles: high values between 16,5 m and 29,5 m, for the abundant presence of organic matter; uniform values between 29,5 m and 48 m; oscillating trend between 48 m and 70 m for the alternation of sand and silt strata;

6) all the analysed samples show low dry unit weight and high void ratio, agreeing with the recent deposition of sediments, and an increase of soil density with depth. By means of in situ SPT tests we evaluated the stress-strain behaviour of sediments. On 15 undisturbed samples we assessed the physical properties (unit weight, density, water content and derived), the shear strength (by means of direct shear test and triaxial test), the compressibility (oedometer test), the permeability and the organic and carbonates content. The sediments appear normally or unconsolidated even if the strength properties are not poor, the deformability is high as well as the organic content.
We expect that the final set of results will allow us 1) to verify the inferred Holocene subsidence rates and understand their fluctuations through time, 2) to better constrain the recent evolution of the Como physical environment, and 3) to calibrate realistic models of interaction between natural processes and human impact in this sector of the Lake as well as in the whole Lario Basin.

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References


Limestone Lowering Rates Surveying: Water or Ice/snow Erosion?

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Surface erosion surveying is one of the most important topics to understand the evolution of the actual and relict morphologies. Many authors measured limestone erosion in different environments, e.g. marine (Stephenson and Kirk, 1998; Cucchi et al., in press) and inner Karst (Forti, 1981; Cucchi et al., 1995) or the erosion of different lithologies, e.g. gypsum (Cucchi and Forti; Dalmonte et al.), but there are no direct comparisons of the same lithology at different altitudes. In this work we present data about in situ measurements using a “traversing-micro erosion meter” (t-MEM; estimate precision: 1 µm) in 18 sites set along two altitudinal transects, from 0 to 2500 m asl, along the Classical Karst – M.te Canin (Alpi Giulie, Northeast Italy) axis, and in the Maiella Mountain (Apennines, central Italy). Six MEM stations have been set in each site on flat surfaces colonized by endolithic lichens and two stations on white surfaces, obtained by mechanical and shear rupture. Another station is obtained on a micritic limestone taken from Borgo Grotta Gigante (near Trieste) in order to compare the same lithology at different altitudes. Limestone samples collected at each station have been used to identify the lichen species and to prepare the thin section to describe the bedrock and the weathering of the surfaces.

Measurements are collected using the MEM, Micro-Erosion Meter (High and Hanna, 1971) or t-MEM (traversing-MEM). These instruments allow to repeat lowering measurements readings on an electronic dial gauge, exactly in the same location and at pre-set time intervals. The traversing-MEM can acquire a large amount of data for some years. Our t-MEM has an electronic dial gauge with 0.001 resolution. Data can be downloaded directly on a PC or handtop.

First year of measurements will be compared with 25 years of similar measurements on the limestone surfaces of Northeastern Italy.

References


Dalmonte C., Forti P., Piancastelli S. - \textit{The evolution of carbonate speleothems in Gypsum Caves as indicator of microclimatic variations: new data from the Parco dei Gessi Caves (Bologna, Italy).} Gypsum Karst areas in the Word., Istituto Italiano di Speleologia, Memoria XVI, s.II: 65-82.


103
Vegetation response to the Late Pleistocene-Holocene transition: 
a new high resolution Pre-Boreal pollen sequence from Southern Adriatic

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To get new information about climate changes and paleocirculation in the Adriatic region during the last 125 ka, some cores were collected in the Southern Adriatic within the EUROSTRATAFORM project. On their sediments multiproxy analyses are in progress such as oxygen and carbon isotopes, mineralogy, foraminifera and palynology. In this study, vegetation history during the Pre-Boreal is reconstructed, based on a high resolution pollen analysis performed on about two metres of sediments from the SAO3-1 core.

The comparison of the pollen assemblages of Adriatic SAO3-1 core with other Adriatic cores (Rossignol Strick et al., 1992; Rossignol Strick, 1995; Lowe et al., 1996; Zonneveld, 1996; Asioli et al., 2001) suggests that the analysed samples may date from the end of the Younger Dryas/early Pre-Boreal to the late Pre-Boreal. Foraminiferal remains confirm the pollen relative datation. Pinus and Quercus are the dominant taxa in the pollen record. At the beginning of the Pre-Boreal Pinus was dominant, but Quercus and other thermophilous broadleaf trees and shrubs (Q. ilex, Corylus, Ulmus, Tilia and Carpinus) were present as well. From the Younger Dryas to the end of the Pre-Boreal, generally Pinus decreased, while Quercus and the other thermophilous plants increased. This general trend is not continuous and the pollen record shows some rapid changes in the vegetation which can express variability of climate during the Pre-Boreal. At least two short-term cold oscillations can be recognized in two phases with increasing values of Juniperus type, Artemisia, Ephedra and decreasing values of Quercus robur group. The same cold oscillations recorded by pollen are detected by foraminifera and clay mineral analyses on the SAO3-1 core as well (Asioli et al., 2006). At the end of the Pre-Boreal, oak forest became dominant, Corylus rapidly increased and increasing pollen percentage values of Fagus, Picea and Abies suggest a warmer and wetter climate. In the upper part of the sequence some pollen types produced by Olea europaea and Pistacia lentiscus were recorded, indicating the presence of some elements of the Mediterranean vegetation in the Southern Adriatic area during the end of the Pre-Boreal.

The SAO3-1 pollen sequence seems to be very important for the reconstruction of climatic oscillations during the Pre-Boreal, as other marine and continental cores of the South-European area don’t give the same high resolution record for this period.

References


Plio-Quaternary stratigraphical reconstruction of the Castellamonte area, Torino Province, Italy

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In the frame of a systematic revision of the Canavese Zone, a 1:15,000 geologic map of the area near Castellamonte, Torino Province, Italy, was produced. The Canavese zone is a tectonic unit about 2 km wide and about 40 km long, exposed in the internal Western Alps. Two tectonic lines oriented about SW - NE, named internal and external Canavese lines, separate the Canavese zone from the Ivrea zone and the Sesia zone, outcropping in the SE and NW sectors, respectively. During the Alpine orogeny the Canavese rocks experienced polyphase ductile to cataclastic deformation associated to a very low grade metamorphism.

In the studied area, the Canavese rocks occur as a number of tectonic slices which include Variscan metamorphic rocks, a Permian rhyolitic cover, and a Triassic to Cretaceous sedimentary sequence. The abundance of a continuous Plio-Quaternary cover up to about 100 m thick, particularly developed in the Southern and Western sectors, allowed us to reconstruct the more recent evolution of this area, so far poorly constrained. In particular, a detailed survey allowed us to define the sedimentary sequence which results more complex with respect to the literature data. The Plio-Quaternary sequence has been distinguished on the basis of allostratigraphy criteria and each Unit has been identified by the name of the type-locality where the most significant outcrop is exposed. Locally, within a single unit, several lithofacies have been distinguished on sedimentological ground, which are characterised by the same stratigraphic position and degree of soil alteration. On the basis of these criteria, two main sedimentary complexes have been distinguished that consist of marine sediments (the lower one) and of glacial and fluvial sediments (the upper one). The Lower Complex consists of Lower to Middle Pliocene fine-grained sediments bearing plant remnants. These sediments, which originally occurred as continuous bodies, were later dissected by steep and deep valleys. They consist of deformed and deeply argillisated sediments, which may be subdivided into two superimposed units. The lower Ponte dei Preti Unit is characterised by sandy sediments of coastal-sea environment, corresponding to the “marine Pliocene” of the geological literature. The upper Vespia Unit (Fig. 1) consists of prevailing sandy and sandy-silty fan-delta sediments, known as “Villafranchian” in the geologic literature. We have paid special attention to describe the location of the sites most promising economically, where the layers rich in clay minerals may be exploited as raw material for making the ceramics (cfr. the famous Castellamonte ceramics). The Upper Complex includes different Units and consists of undeformed and scattered Middle to Upper Pleistocene coarse-grained sediments. This terraced succession is related to some paleo-collectors or to former trends of the present rivers. The present hydrographic network dissects the sediments and originates valleys characterised by gentle slopes and scanty outcrops. The pedogenesis of these sediments is variable, but systematically lighter than that of the Lower Complex. The Colleretto Castelnuovo Unit (CCU) (T. Piova basin) and the S. Defendente Unit (T. Malesina basin) are widespread in the area and consist of several deeply weathered lithofacies (Fig. 1).
Fig. 1: Profiles through the Castellamonte area showing the relationships among the Plio-Quaternary sequence. Vertical exaggeration x2.

In particular, the CCU consists of silty sediments with rare clasts, coarse-grained sediments with angular clasts, and gravelly sediments corresponding to lodgment till, ablation till, and outwash sediments, respectively. Locally, sandy sediments of ice-marginal waterlain flowtill are recognised. It is to point out that glacial deposits are never reported in this area. The Case Musso Unit (T. Piova basin) and Pagliero Unit (T. Malesina basin) are stratigraphically overlying the CCU and the S. Defendente Unit, respectively. They are poorly exposed in the area and consist of slightly weathered gravelly alluvial fan sediments (Fig. 1). The top of the Plio-Quaternary stratigraphic succession is represented by the S. Giovanni Unit (T. Chiusella basin) and the Parella Unit (R. Dora Baltea basin) that outcrops only in the North-Eastern edge of the area and that consists of weakly weathered sediments related to the Morainic Amphitheater of Ivrea. In particular, the S. Giovanni Unit is characterised by alternating sandy and silty sediments of ice-marginal waterlain flowtill, whereas the Parella Unit consists of silty sediments with rare clasts and gravelly sediments corresponding to lodgment till and outwash sediments, respectively.

The overlap relationships among the different bodies of the Lower Complex and their remarkable thickness suggest conditions of subsidence. Besides, the extent of the Veschia Unit and its SW-NE elongation indicate the presence, during the Pliocene, of wide basins oriented parallel to the Canavese Line. On the contrary, the terracing relationships among the Units of the Upper Complex and their small thickness indicate that, during the Middle-Upper Pleistocene, differential uplifts have been established in the area, promoting the development of many basins, oriented about NW-SE, dissecting the Lower Complex. The ridges separating these basins consist of thick and deeply weathered rocks of the Canavese substratus, preserved from erosion.
Application of OSL dating for stratigraphic study of Late Glacial - Holocene sand levels in the Po Plain near Imola

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The Po Plain is a late Tertiary foredeep basin filled up by sediments since about 1 Ma (Marabini, 2004). The OSL (Optically Stimulated Luminescence) dating of about ten silty-clay samples have been performed in the 14 meters thick succession cropping out at the Bubano quarry (Mordano, Bologna province) (Ravazzi et al., in press). For luminescence dating the samples were wet sieved and treated with concentrated HCl to eliminate carbonates. Successively organic matter and colloidal Fe - Mn oxides were removed, respectively, with hydrogen peroxide and a sodium hydrosulphite solution. Using a heavy liquid separation method, quartz and K-feldspars were separated and concentrated. The composition of quartz and K-feldspar samples was checked by X-ray powder diffraction quantitative phase analysis. Finally the pure quartz and K-feldspar samples were dated by OSL. For some samples radiocarbon (14C) dating were also carried out (Ravazzi et al., 2006). The results are shown and discussed.

References


New cronological and stratigraphical data on the Morainic Amphiteatre of Ivrea (Piedmont, Italy)

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The Morainic Amphiteatre of Ivrea is the clearest manifestation of Quaternary glacialism of the Dora Baltea basin, coinciding with the Aosta Valley (Northwest Italy): with a surface of 505 km², it is one of the bigger Italian morainic amphiteatre, after the Garda and Verbano amphiteatres. Its terminal morains are about 110 km far from the actual fronts of the Monte Bianco glaciers. The deposits of the amphiteatre were so far differentiated into three groups, on pedostratigraphic and geomorphological basis (Carraro et al., 1991), nearly corresponding to Mindel, Riss and Würm of previous authors (Sacco, 1927; Carraro et al., 1975): the S. Michele – Borgo Group and the Serra Group are allogroups, since they comprise deposits developed during several glaciations of the Middle Pleistocene, while the Bollengo Group is an alloformation related to the last glacial episode of the Late Pleistocene (LGM).

New geological survey in the Morainic Amphiteatre of Ivrea, carried out by one of the authors (F.G.), have increased the knowledge of geomorphologic, sedimentologic, stratigraphical and chronological features of this important element of piedmont landscape. First of all, on the stratigraphical point of view, we have found paleosols and lacustrine - palustrine deposits with organic matter, as intercalations in glacigenic deposits, indicative of interglacial conditions: this elements, supplemented by pedostratigraphical and chronological data, have till now permitted to distinguish 7 allounits related to at least as many glacial episodes. Also facies analysis has yielded new elements to stratigraphical reconstruction and to interpretation of forms (Forno and Gianotti, 2005). On the whole the lateral morainic sectors are largely constituted of marginal glacial deposits (above all gravity flow till, both subaerial and subaqueous). Subglacial deposits outcrop locally: they are melt-out till and only subordinately lodgement till, usually in close association. We emphasize that lodgement till is usually not very thick and, in the proximal sector of the amphiteatre, it rests directly on rocky substratum; moreover it has to be correlated mainly with marginal glacial deposits located in more external position (Fig. 1C).

The topic of the present work is mainly the stratigraphy of the most recent units related to late Middle Pleistocene and Late Pleistocene. Through morphological study, supplemented by facies analysis, the glacial margin fluctuations in the various times of its evolution have been exactly positioned (marginal glacial deposits) or supposed (subglacial deposits) and characterized. In particular the identification of alignment of typical forms of glacial margin (moraines and kame terraces) has allowed to recognize 9 principal LGM cataglacial stades (4 of which are stades in amphiteatre and 4 stades in the Dora Baltea Valley) and to reconstruct the modality of glacial retreat from the amphiteatre to the present day cirques.

At last, we propose a different stratigraphic and chronological reconstruction, beginning from the data of the Alice Superiore drilling reported in Arobba et al. (1997): in this borehole (Fig. 1) a peaty layer, dated > 43 ka BP (¹⁴C) and post-Eemian (palinology), separates the deposits of the Serra Group from those of the Bollengo Group. Moraines correlated to Serra of Ivrea are now referred to the last glacial episode of the Middle Pleistocene, and not to the Late Pleistocene, as previously indicated, on the basis of the following elements: (i) identification of a different morostratigraphic
unit (Rebbia Unit), interposed between the two cited groups in both lateral sectors of the amphitheatre; (ii) separation of the Rebbia Unit from the Bollengo Group on the basis of marked differences in the thickness of C horizon alteration profile; (iii) separation of the Rebbia Unit from the Serra Group, owing to analysis of stratigraphical relationships in the Alice Superiore section (Fig. 1); (iv) attribution of the peaty level to Marine Isotope Stage 5c (maybe also MIS 7a), on the basis of palynological correlation (C. Ravazzi, pers. comm.) and according to pedostratigraphical data. The various indications support the hypothesis that the Serra Group has to refer to the glacial episode correlated to MIS 6 and the Rebbia Unit to MIS 4. In this case the importance of glacial episode of MIS 4 would be attested: in the Morainic Amphitheatre of Ivrea it would have reached a greater expansion than the LGM one, but by far lower than the expansion reached in the preceeding glacial episode, the last of Middle Pleistocene (MIS 6).

A few analysis of surface exposure dating with the cosmogenic isotopes method are in progress (S.I.-O.) on erratic blocks from Serra of Ivrea crest (two erratics), Piccola Serra (the greatest moraine of the Bollengo Group: one erratic) and stadial moraines of LGM (five erratics), from which necessary confirmations on the Serra of Ivrea age are expected. Others exposure ages, referred to rocky substratum outcrops (two samples from the Ivrea Hills, Forro et al, 2005a, 2005b, and two samples near Donnas in the lower Aosta Valley), will constitute further source of chronological data and control element on the age inferred from erratics, and would provide important elements on the erosional deepening of the Dora Baltea glacier (Fig. 2) during the LGM.
Fig. 2: Quaternary glaciations of the Dora Baltea Basin

References


The abrupt 8200 cal. BP cold event and long-term climatic changes in the Eastern Alps: vegetation reactions and possible triggers

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The $\delta^{18}$ data from the GRIP and GISP2 ice cores show that the present interglacial, the Holocene, was a climatically stable period. However, various climate proxies from the North Atlantic realm and Europe indicate that significant climatic oscillations and transitions took place during the Holocene epoch.

Subfossil pollen from two bogs in temperature-sensitive, high-altitude regions were analysed in order to reconstruct early- and mid-Holocene summer temperature fluctuations in the Eastern Alps (Kofler et al., 2005). The palaeotemperature interpretations of the pollen profiles were founded on a modern calibration data set, based on airborne pollen deposition over a 17-yr period, as recorded by a Burkard pollen trap near the present-day treeline and climate data (mean monthly temperature and monthly precipitation sum) from the same site.

The pollen records showed four centennial-scale cold phases (ca. 6250 - 6350, 6750 - 7100, 7400 - 8400 and 8700 - 8900 cal. BP) with low growing-season temperatures, resulting in decreasing pollen production and/or lower treeline position during the period 9000 - 6000 cal. BP.

For the first time, the abrupt 8200 cal. BP cold event and an equivalent to the Misox cold phase in the Swiss Alps were detected in the Eastern Alps. The cold and brief oscillation recorded in the Brunnboden (2640 m a.s.l.) pollen curves for Swiss stone pine ($Pinus cembra$) and sedges (Cyperaceae) lasted ca. 175 calendar years and matches, in time and magnitude, the $\delta^{18}$ excursion in the Greenland GRIP ice-core record as well as sea surface cooling in the North Atlantic at 8200 cal. BP. Furthermore the pollen diagram indicates that the 8200 cal. BP cold “flip” is superimposed on a long-term cold phase, the Misox cold period (ca. 8400 to 7400 cal. BP).

The close congruence between the pollen records covering 3000 years and climate proxy-data from both Hemispheres (ice-rafted debris from the North Atlantic region, chironomid and pollen data from the Swiss Alps, nitrogen dioxide (NO$_2$) from the Antarctic Dome C) possibly indicates that the pollen curves reflect a common temperature signal for the North Atlantic region. Large-scale environmental changes, probably caused by North Atlantic freshwater pulses and/or fluctuations in solar variability caused decreases in pollen production and/or treeline shifts in the Alps.

References

Sedimentary dynamics in glacial and proglacial domains: Combe d'Ain, Jura (France), during the Last Glacial Maximum

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During the last glacial period, the Jura Mountains were covered by an ice sheet. Short ice tongues flowed southeastwards toward the Rhone glacier, whereas longer ice tongues extended down the northwestern slopes. On these slopes, the ice tongue tips dammed topographic depressions, which were then occupied by proglacial lakes, as in the Combe d'Ain area. Sediments were transported by glacial meltwater and were deposited as a series of sedimentary complexes in the lake infill. In contact with the moraines on the eastern edge of Combe d'Ain are a number of coarse delta-type deposits (braided Gilbert-type deltas). Laminated fine sediments occupy the remainder of Combe d'Ain and are evidence of distal glaciolacustrine sedimentation. Glacial deposits are preserved on the Champagnole plateau (east of Combe d'Ain). The aim of this study is to define the sedimentary dynamics of glacial and proglacial domains. We based our work on cartographical and sedimentological analyses to determine the sedimentary processes for each different domain. By mapping glacial and proglacial deposits on the western slopes and, more particularly, in Combe d'Ain and on the Champagnole plateau, it has been possible to reconstruct the paleogeography of the glacial front in the area, at the time of maximum advance. The landform types that have been mapped are glacial lineations, end moraines, end moraine complexes, hummocky moraines, eskers, and glaciofluvial accumulations. By mapping attenuated bedforms (i.e. drumlins, flutes and "roches moutonnées"), ice flow directions have been identified. These maps show that drumlin swarms are associated with claystone bedrock. Directions of attenuated bedforms on the Champagnole plateau show that fast-flowing outlet glaciers must have existed here. The sedimentological approach allowed us to reconstruct the sedimentary dynamics of each glacial and proglacial domain. For the proglacial domain, we describe braided Gilbert-type delta deposits, waterlain moraines and rhythmites. For the glacial domain, we describe various tills such as end moraines (push moraines, ablation moraines), lodgement tills, drumlin and esker facies associations, and erosional forms. This coupled approach (sedimentology and geomorphology) allowed us to determine the impact of ice flow dynamics on deposit environment distribution. Large glaciolacustrine deltas are situated at the terminus of the main ice tongue. Drumlin swarms are indicative of rapid ice flow with high debris transport capacity. The principal deposit systems in glacial context show a specific distribution pattern associated with ice flow dynamics. These sedimentological characteristics associated with ice flow dynamics allow us to suggest a deposit model for the Combe d'Ain area integrating spatial sedimentary distribution for both glacial and proglacial domains.
Identification and Analysis of Holocene Avalanche Events: new possibilities for the determination of avalanching processes in the Ziller Valley, Austria

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Logs of trees were recently found at Schwarzenstein-Bog near the Berliner Hut in the Ziller Valley Alps as mute testimony of prehistorical avalanche events. In order to understand the millennial history of these avalanche events the Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW), Department Natural Hazards and Alpine Timberline has started the programme HOLA (german abbreviation for “HOlozane LAwinereignisse”) in close collaboration with the University of Innsbruck. The presented research is the first research on prehistorical avalanches worldwide and is first of all based on the fact that Schwarzenstein-Bog is lying exactly within an avalanche track and at the position of an up- and down slope migrating timberline, such as to allow the boggy sediments to conserve tree logs (and other organic compounds such as pollen) fallen into the former mire and conserved under water saturated conditions for millennia. The project relies on the long, regional dendrochronological dating curve obtained for cembran Pine (\textit{Pinus cembra}) by K. Nicolussi allowing year-dating of Holocene tree trunks found within the bog (Nicolussi et al., 2004). Finally, the project profits of the unique 3-dimensional avalanche modelisation programme SAMOS (Sailer et al., 2002) from the Department Natural Hazards and Alpine Timberline. Such prerequisites do allow assessing the recurrence and effects of extreme avalanche events on our environment. This may help to foresee risk areas within regional zone management and to plan possible actions in case of an avalanche crisis.

It deals with modern avalanche analysis and modelisation SAMOS, as well as palaeoclimatological methods such as dendrochronological and radiocarbon dating, as well as pollen and extrafossil (non-pollen palynomorphs) analysis. The research area lies below 800 - 900 m of ice during the last Ice Age such as to leave today's mountain tops as nunataks (van Husen, 1987). Within the sediments of Schwarzenstein-Bog 270 tree stems were found and sampled for dendrochronological analysis. Up to now 225 of these logs were dated to the year of their death. Major avalanche events occurred at 4055, 3834, 2787, 2774, 168 BC, as well as at 505 AD.

References


Correlation of Upper Pleistocene localities of southern Istria (Croatia): problems and progress

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Seven Pleistocene sites of study in progress are discussed in this paper. Sites Kršine, Portić, Karigador and Veli Munat are open sections of Pleistocene sediments, Marlera I and Marlera II are fossil caverns, and Gradina is a cave, primarily an archaeological site as well as Karigador. Marlera I and Marlera II are rich in paleontological findings.

One of the aims of the study is the stratigraphic correlation of Pleistocene sediments in Istria, especially those in open-air sites with those in caves or fossil caves/caverns. Specific microclimatic conditions in caves commonly influence sedimentation and diagenetic processes, making the correlation harder. Cave sediments usually contain abundant fossil fauna, which is rare in open sites. If present, archeological findings also provide elements for correlation. Regarding the sites here discussed, it seems that loess and loessoid sediments, identified within the sediment profiles, can be used for correlation. Sediment samples from Gradina cave, Marlera I and Marlera II, Karigador and Veli Munat have been analyzed in detail, while sediment samples from Portić are still in process for TL dating.

MARLERA I and MARLERA II are fossil caverns completely filled in with sediment, opened during exploitation in a quarry, and rich in Upper Pleistocene fossil fauna (Brajković et al., 2005; Brajković et al., 2006). Both sites are still under investigation. In the middle of nearly 10 m thick sediment succession of Marlera II, there is about 10 cm thick interval of laminated greenish clayey silt (2.5YR4/4) with millimetric sized black nodules that are being analyzed. The two samples (one taken in Marlera I and another in Marlera II below the laminated greenish clayey silt interval) differ in chemical, mineral and grain-size composition. Marlera I is clayey silt with ca. 50% of calcite, and Marlera II is silty clay with highest content of amorphous matter, but indistinct percentage of calcite. Presence of other minerals is more or less the same, and also high content of iron. Marlera II has a much higher content of goethite and hematite, and has significant dark orange-red color. Higher content of Fe-oxides in Marlera II can explain the increased presence of heavy metals. Marlera II contains also boehmite, indicating resedimented bauxite particles in sediment.

A very thin (2-5 cm) greenish layer (5YR6/4 /wet sample/), similar to one of Marlera II, was recognized also at the KRŠINE section, but at the moment the comparison is based only on macromorphological characteristics.

The cave GRADINA near Premantura is an archaeological site of Roman times (Brajković et al., 2002); sedimentary analyses have also been performed on seven samples taken in three exploration trenches. Four samples were taken in the third trench from the oldest sediment of the cave, and are here discussed. Based on the results of mineral and grain size analyses, we tentatively propose that the dominant components of cave sediments are loess and paleosoil/soil developed on loess substrate. These materials were probably affected by multiple redeposition and brought into the cave by wind and water. As documented by archeological findings, these sediments have also been affected by human activity. Sediments have been more or less influenced also by surface and groundwater processes (fluctuation of water table) as indicated by
quantity of $\text{Fe}_2/\text{Fe}_1$ and $\text{Mn}_2/\text{Mn}_1$ (repeated processes of oxidation and reduction). The loess origin is clearly indicated by the mineral composition, especially the clay-size which is very similar to loess in Istria (Durn, 1996). Concentration of Co, Ni and Pb (except one sample) in cave sediments are within a span of values as determined in terra rossa deposits of Istria (Durn, 1996), while the content of Cu, Cd and Zn is higher than in terra rossa. Extremely high concentrations of Zn and Cu in samples from trench - 3 is probably due to weathering of Roman coins found in the cave.

At the KARIGADOR site three samples were taken, and two at VELI MUNAT. Mineral and grain-size composition of samples taken from the corresponding archaeological layers at Karigador and at Veli Munat show clear similarity to the composition of loess in Istria (Durn, 1996), however, they do not contain dolomite. The lack of carbonates is probably due to dissolution during soil formation processes. Sediment is sandy-clayey silt and sandy silt, which corresponds to loess in Premantura (Durn, 1996). Presence of amphibol also indicates the aeolian origin of sediment. The iron content is low in both samples, indicating a low grade of weathering. In fact 30% of iron in samples is present in form of Fe-oxides (hematite, goethite, ferihydrite) and 70% in other mineral phases (like chlorite, amphibol etc.). The samples from the older corresponding archaeological layers at Karigador and Veli Munat are different in mineral and grain size composition. The sample from Karigador is a loess sediment corresponding to loess of Savudrija (Durn, 1996), while the sample from Veli Munat is sandy-silty clay of lower grade of weathering.

The sedimentary complex of the PORTIĆ site is the thickest one in the area (more than 7 m). Preliminary studies of only macroscopic characteristics showed that this complex consists of a clayey paleosol (5YR3/4 - 10R3/4) lying on Cretaceous limestone substrate, 5 - 10 cm of gravel and sandy clay, 5 cm thick yellow - greenish sandy/silty clay very similar to the one at Kršine, about 1 m thick laminated interval (alternation of silty sand and clayey silt), and more than 2 m of thick planar cross-bedded sand dune, also similar to the Kršine sand interval. Samples from the whole profile were taken for TL dating, which is currently in progress.

The common characteristic of all open-air sites in Istria is that loess or loessoid sediment never occurs directly on carbonate rock substrate but appears above terra rossa (Durn, 1996) or similar type of clayey paleosol, like at Kršine and Portić. Durn (1996) compared terra rossa with very weathered loess of Middle Pleistocene age from northern and central Italy and assumed that the majority of terra rossa is actually weathered loess of Lower or Middle Pleistocene age. Therefore loess and loessoid sediments from the sites here discussed are likely of Upper Pleistocene age, actually Würm, which is in agreement with data based on faunal analyses of Marlera I, Marlera II, Gradina and other paleontologic sites in Istria (Paunović et al., 1999; Brajković et al., 2005; Brajković et al., 2006). Palynological analyses document the presence of Larix type (today grows above 500 m asl) in all samples from Marlera I and from the lower section of Marlera II. Presence of Acorus calamus and Alnus sp. in the upper and in the lower part of Marlera I, and Potamogeton type from Gradina indicate more humid conditions in the area.

So far, the results of all the investigations indicate different paleoenvironmental and paleoclimatic conditions in the area during the Würm, but stratigraphic and lateral correlation of different facies is not yet clear. Further investigations should, hopefully, provide data for detailed stratigraphic correlation of the open-air and cave sediments, that could enable reconstruction of contemporaneous paleoenvironments/microenvironments during the Upper Pleistocene in Istria.

References


Pleistocene sediments at Novigrad sea:
evidence of glaciation of coastal Adriatic (northern Dalmatia, Croatia)

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On the southern coast of the Novigrad sea an outcrop of Pleistocene sediments is exposed. The base rock are thick bedded Cretaceous limestones, whereas Pleistocene sediments occur as a 3 km long coastal terrace. The exposure is very good due to the cliff-type coast, about 10 m high at most. However, the total thickness of Pleistocene sediments is still unknown, because of outcrop limitations and lack of boreholes. Along this section significant facies changes occur, and the following were differentiated: diamictons, conglomerates, calcarenites, fine-grained sediments s.str., and paleosols.

Diamictons are genetically interpreted as basal moraines, and two stratigraphically superimposed moraines are differentiated (Older and Younger moraine respectively). The Older moraine attains a thickness of 5 m but its base is below the sea level, so the total thickness must be greater. It is discontinuously exposed on a distance of about 1,5 km and shows hummocky relief. This moraine is mainly a grain-supported conglomerate, composed of very poorly sorted limestone clasts with a wide variety of grain sizes, spanning from gravel to boulders of more than 10 m in diameter. Boulders are rounded and more or less spherical, some fasetted, some elongated or platy. Glacial striae or grooves were found on some boulders, and some have pitted surface. The interspaces between large clasts are filled with gravel which acts as a “matrix” and can be well cemented. The moraine seems to have been locally washed out as indicated by secondary sorting. The upper part of the Older moraine is commonly inverse graded, so the largest boulders are well sorted on top of an un-sorted interval, even imbricated. The Younger morane is a thinner and massive matrix-supported conglomerate. The unsorted debris, ranging from gravel to boulder size, is floating in the fine grained matrix. The debris is medium to well rounded, commonly spherical. The Younger moraine overlies the Older moraine or the glacial lake sediments, which indicates an episode of glacial readvance and significant amount of erosion.

The debris in both moraines is of similar lithologies, represented by various types of limestone (mainly of Cretaceous age). Blocks of rudist limestone and finer debris of Paleogene foraminiferal limestone were found in the Older moraine.

Flat-pebble conglomerates occur on top of the glacial lake sediments or a paleosol. They are stratified in 10 - 50 cm thick layers. It is predominantly a grain-supported conglomerate. The size of pebbles varies from 1 to 10 cm. Zones of vertically oriented flat pebbles or high angle imbrication in various directions are typical features of these conglomerates. Such random and vertical orientation of flat pebbles is the effect of freezing of interstitial water, characteristic of periglacial areas. On the other hand, zones of clear low angle imbrication indicate accumulation and reworking of pebbles in a lake beach zone.

Glaciolacustrine sediments form about 1 km long coastal cliffs. Their visible thickness reaches locally ca. 10 m. Two intervals are differentiated: lower varved-like calcisiltites with dropstones, and upper wave-ripple dominated calcarenites. These sediments overlap the Younger moraine and fill depressions between moraine hummocks. Proglacial lake sediments locally occur in contact with the Older moraine, due to erosion during glacial readvance. The lower varved-like sediment is a very fine grained homogenus sediment, with indistinct bedding. Two levels with dropstones have
been recognized. They are 2 to 15 cm in diameter, rounded, spherical or faceted. The upper rippled sediments are alternating calcarenites and calcisiltites with dominating wave-ripples indicating shallow water environment. Current ripples, starved ripples, parallel lamination and convolution also occur. Significant characteristic of this interval are linguoid structures, which occur radially around kettle-like forms, and are interpreted as a product of high-density sediment flows. Kettle forms are boal-shaped features, 2 - 3 m in diameter and 30 cm to 1 m deep, with flat or concave bottom, which occur in rippled calcarenites.

Sediment wedges occur both in the upper zone of lake sediments and in moraine zone, probably the Younger moraines. The wedges, which occur in lake sediments, are filled with either fine grained sediment, even layered, or with fine gravel. They can be about 2 m wide and 3 - 4 m deep, or up to 0.5 m wide and less than 1 m deep. The wedges occurring in the moraine zone are either 1 - 2.5 m wide and 2 - 3 m deep, filled with coarse gravel of ca. 10 - 20 cm in diameter, or filled with fine grained sediment, which appears like frozen high-density sediment flow between blocks and boulders.

Glaciofluvial/fluvial sediments are conglomerates and calcarenites partly well cemented. After the retreat of glaciers and infilling of the lake basin, fluvial processes took place, leaving fluvial channels well visible at three locations along the Novigrad section. Conglomerates, representing channel lag deposit visible in one section, and calcarenites filled in the channels (up to 6 m thick). The channel size is generally unknown, but one was measured to be 22 m wide and 5 m deep with well developed point bar infill. The analyses of channel cross sections revealed that the stream was at least two meters deep in a low sinuosity river which has been flowing along the Novigrad coast.
The “out-of-place” layer of Il Pilone dune ridge (Brindisi, south Italy): genesis and age determination

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The 6 km long pocket beach between Torre Canne and Il Pilone is characterized by the presence of a continuous vegetated dune ridge. It is up to 9 m high and it is compound by the superimposition of three different aeolian units that developed since the Mid-Holocene.

The oldest unit is made of cemented yellow-grey sands, with well-developed high-angle cross lamination, in some places grading downward to beach deposits. This aeolian unit covers red soil deposits containing fireplace remains that have been dated back to 6900 ± 90 years BP. The unit contains remains of land snails (Theba pisana and Cernuella virgata shells) that yielded a radiocarbon age ranging from 6185 ± 20 to 6084 ± 52 years BP. A discontinuous soil of 4330 ± 40 years BP separates this unit by the second generation of aeolian deposits. This last one is represented by loose grey-brownish sands marked by numerous brown soil levels very abundant in pulmonate gastropods represented mainly by Cernuella virgata and Rumina decollata. ¹⁴C dating performed on these gastropod shells indicates an age ranging between 2909 ± 90 and 2110 ± 70 years BP. The last generation of aeolian deposits is probably linked to the last evolution of the beach system which started at the end of the Middle Ages and ended at the middle of the last century in response of the numerous dams built on main rivers.

At Il Pilone locality, in the south-eastermost part of the pocket beach, the stratigraphical sequence of dune ridge is cut by an erosive surface placed at about 150 cm on the biological mean sea level through the first levels of the second aeolian unit. The surface is covered by grey bioclastic sands marked at the base by a mixed assemblage of terrestrial and marine remains. In fact, 1 - 2 cm large layer of pumices, charcoals, seeds (Solanum sodomum L.), shells of pulmonate gastropods (Helix, Rumina and Pomatia), large cuttlebones and bivalves fragments have been found. Grey laminated sands closed by pumices 3 cm large and charcoals follow upward. The entire level, about 30 cm thick, is closed by a millimetric layer of oxidized grains. The stratigraphical sequence continues upward into loose aeolian sands with discontinuous soil levels and abundant land snails, in good relation to the second generation of dune deposits. After ¹⁴C analyses the conclusion is that the 30 cm thick "out-of-place" layer could be not older than 200 years BP.
The Late Pleistocene of Illegio hollow (Friuli, NE Italy): trees buried by landslide 34 ka before the last maximum glacial advance in Tagliamento valley

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The Illegio hollow is located in the small valley of the Frondizzon stream, a tributary to the Bût stream which belongs to the Tagliamento river catchment in the Southeastern Alps. At this site, Late Pleistocene deposits yielded new data regarding the last maximum advance of the Tagliamento glacier. The facies architecture of sedimentary deposits cropping out within the area provides a basis for inferring the dynamics of sedimentation during the last glacial advance inside the catchment of the Tagliamento River. A geological survey of these Quaternary deposits was made for the Project "History and Archaeology in the area of Illegio", which investigated the entire hollow bounded by the Strabût, Amariana and Giadeït massifs, which rise more than 1100 m asl.

The bottom of the depression covers about 8 km² and has an average altitude of 550 m asl.; it is cut by Trambe creek and Frondizzon stream in the northern sector. During the survey, two buried trunks were found at the base of the main outcrop, which is located along the central segment of the Frondizzon valley. The stratigraphy is well exposed at this site, where the sedimentary succession exceeds 100 m in thickness and the units exposed represent different phases of the last glacial advance. The basal unit of the succession is a palaeolandslide deposit that contains the tree remains. This landslide deposit is a 10 m thick matrix-supported diamicton with monogenic angular clasts in a muddy matrix. It overlies an erosional surface on the Triassic carbonate and clastic units.

The first tree fossil is a larch that is 1,5 m long and 37 cm in diameter. It was discovered in vertical position, but incomplete exposure prevents the determination of in situ status. The bark and part of the trunk were not preserved, which suggests transport within the landslide. The other trunk is a pine, 1,2 m long and 27 cm in diameter. It was found in a horizontal position that permitted the complete removal of the specimen. Radiometric dating of the larch yields a date of 34,890 ± 800 14C yr BP (40,497 ± 875 cal yr., calibrated according to Fairbanks et al., 2005). This date indicates that the landslide occurred before glacial advance into the valley. The discovery of two tree trunks at the base of the succession provided a means to date the onset of this glacial history. In the Austrian and Swiss valleys of the Alps, several wood fragments and organic sediments have yielded radiocarbon dates older than 30 kyr 14C BP (Fliri, 1973; Van Husen, 1990; Preusser et al., 2003). The fossil trees of Illegio, presently located at about 650 m asl., indicate that a widespread arboreal vegetation was present in the Alps before the onset of valley glaciers activity, about 30 cal kyr BP according to Preusser (2004). On the larch stem a 191 tree-rings sequence is preserved. Dendrochronological analysis carried out by the Dendrodata Laboratory in Verona (Italy) allowed to recognize an irregular tree-ring series, with recurring sharp growth reductions. Unfortunately it is impossible to attribute them to bud moth gradations with certainty.

The landslide deposit is cut by an erosional surface overlain by 3 - 4 m of sandy gravel that probably represents fluviatile cut-and-fill into the gravity flow. These two sedimentary bodies are covered by the lodgement till of Bût glacier. During the glacial maximum, an ice tongue covered the Illegio hollow and the Frondizzòn valley. The end moraine of this ice tongue is visible in the southern part of the hollow near Prà de Làt. Lodgment till is readily visible, at present, in deeply
incised stream valleys, while melt-out till is exposed along the mountain sides at about 650 - 700 m asl. Big, erratic boulders of quartz conglomerate are often associated with the till. The widespread glacial deposits came from Bût - Chiarsò catchment and not from the local glacial basin, fed by the Palavierte - Sernio massif; therefore, the inferred thickness of Bût glacier probably did not exceed 200 - 250 m inside Illegio hollow, though a tongue of it filled the Frondizzon valley for about 3 km. These deposits derive from the maximum advance that reached the end of the Tagliamento valley at 22 - 18 kyr 14C BP (27 - 22 yr cal BP).

Deglaciation happened after 18 kyr 14C BP (Monegato et al., 2005); but the timing of events after the glacier withdrawal from the morainic amphitheater has not yet been determined. Glacial retreat from the Illegio hollow began with the Fondizzon Valley tongue and is represented by a lacustrine succession behind the terminal moraine. Fluvial input and alluvial deposits of the Frondizzon stream soon filled the basin of the little lake. With the complete withdrawal of the glacier from the hollow a bigger and deeper lake developed inside the hole, according to Venturini (2003). This larger lake was dammed by the currently active Bût glacier, which at that time was approximately 270 m thick in the main valley. The lake was progressively filled with alluvium from Frondizzon stream, as displayed in the Trambe creek incision (Feruglio, 1929). Clastic deposition from the Frondizzon stream produced a Gilbert-type delta in the northeastern part of the hollow. The deltaic deposits are overlain by a sandy-gravel alluvium; this entire complex is about 15 m thick.

Glacial damming established a base level for local streams at a high elevation, reducing stream gradients and allowing the Frondizzon stream to develop a meandering style. The aggradation of these sediments ended with the collapse of the valley glacier and this event caused a sudden drop of base level. Frondizzon stream has subsequently entrenched its meanders through the alluvium and almost 70 m into the underlying Carnian rocks. The lateral position of the hollow has allowed the preservation of this succession from the reshape happened in the main valleys during the late-glacial and post-glacial time.

References


Glaciers, climate and vegetation
during the Last Glacial Maximum in the Friulian Prealps (NE Italy)

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During the Last Glacial Maximum (LGM, i.e. 18 - 30 ka cal BP), large valley glaciers developed in the South-Eastern part of the Alps, even if the drainage basins were smaller and lower if compared to Western and Central Alps, the maximum altitude being 2800 m asl. In spite of these orographic conditions, the Tagliamento glacier reached the upper plain forming a large end moraine system (Monegato et al., 2005). In the the eastern Carnian and Julian Prealps, many local glaciers grew on the northern side of the mountains although these mountains do not reach 2000 m asl. The valleys of the Arzino and Torre streams do not seem to have lodged a valley glacier, but only cirque glaciers on the highest massifs. The basins of the Cellina and Meduna streams instead settled a valley glacier during the LGM (Zenari, 1926; Feruglio, 1929; Venturini, 1985), which never reached the plain.

Recently the geological mapping of the CARG - FVG Project allowed to investigate in detail the Julian Prealps. Several end moraines allowed reconstructing the LGM glaciers in the massif of Chiampòn – Cuel di Lànis Chain, between the valleys of the Tagliamento and Torre rivers. These mountains form a continuous ridge almost 9 km long, reaching an elevation of 1500 - 1800 m. During the LGM an accumulation zone occupied the northern bank of the chain and originated several ice tongues which flew down along the steep valleys of the northern slope. The westernmost glacier tongue may have reached the Tagliamento glacier, although the coalescence is not yet documented by relevant deposits. On the eastern side a glacier flew towards the basin of the river Torre, but probably didn’t reach the main valley. The southern slope of the mountain chain was likely ice free, and only the highest portion near the eastern bank of Mt. Chiampòn is supposed to have hosted a small cirque glacier. A continuous and thick talus deposit accumulated at the southern foreland of this mountain ridge. The Tagliamento glacier reached thickness of 400 - 450 m at its local maximum culmination. On the eastern side it dammed several ice-free tributary valleys. One of them, the Orvenco stream valley, hosted a small lake soon filled by the discharge of glacial spillways and of local creeks. The pollen analysis of these lacustrine deposits shows that south-exposed slopes of the Prealps supported woody vegetation even during the LGM.

An ELA of around 1300 m above the present sea level (a.p.s.l.) has been calculated for the Chiampòn massif considering glacier extension and thickness. This estimation is in agreement with Desio (1926) for the nearby Fella basin, but it is lower if compared to estimated ELA in the Veneto Prealps, i.e. about 1400 m a.p.s.l. (Carraro and Sauro, 1979). The lower altitudes obtained for the Friulian Prealps could depend both on geomorphology of ice basins (very steep slopes), and on the climatic features of the region. It must be remarked that the modern rainfall of this part of the Italian Alps is the highest of the whole alpine chain (Gentilli, 1964).

The reconstruction of wind circulation over the alpine area (Florineth and Schlüchter, 2000) suggests high snowfall rates that may explain the low ELA. In turn, wet conditions supported woody vegetation, the remains of which have been found buried by the glacial deposits. Indeed,
pollen and macroremains data from the Tagliamento glacial amphitheatre and the outer fluvio-glacial fans testify to the occurrence, during the LGM, of dwarf pine stands (*Pinus mugo*) in the pioneering vegetation of the coarse-sized megafan deposits. Pollen spectra from dated sites as well as the long pollen record from the Azzano Decimo core suggest that the uppermost megafans were occupied by pinewoods and partially by pioneer xerothermic vegetation (with *Artemisia*, *Chenopodiaceae*, *Helianthemum*, etc.), while thermophilous broad-leaved woody taxa did not occur. Distally, silty-sandy sediments supported herbaceous and chamaephytic vegetation dominated by steppic elements and Gramineae. Local marshes, Cyperaceae-dominated, developed in depressed areas with peat accumulation.

A model of altitudinal vegetation belts has been attempted, on the basis of geocryological and ecological relationships plants - habitat. The model relies on the comparison between Glacier Equilibrium Line and Treeline altitudes, and on the evaluation of climate continentality (see Gorbunov, 1978, and Ravazzi et al., 2004 for details). We considered both the palaeobotanical record available for the LGM in Central Friuli and in the surrounding areas as well as the potential vegetation. The potential thermic treeline altitude is estimated at 700 - 800 m a.p.s.l. (actually about 800 - 950 m above the LGM sea level). However this potential altitudinal area occupied by trees was strongly reduced by slope activity. The potential altitudinal limit of alpine grasslands and steppes is estimated to 1500 a.p.s.l. on sunny slopes, but on north-facing slopes it is supposed to be much lower due to the extent of permafrost and of related gelification.

References


Micromorphological characterization of a loess-paleosol sequence along the northern slope of the Ligurian Alps

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In the framework of a larger study, focused on the Quaternary evolution of selected areas of the Ligurian Alps (Northern Italy), one representative loess-paleosol sequence has been identified and characterized in detail, by routine and micropedological analyses, in order to identify weathering processes and related environmental changes. Loess deposits in northern Italy are widespread on the Pleistocene terraces contouring the Po Valley fringes and they have been subdivided by Cremaschi (1990a) according to main areas of deposition, thickness of loess deposits, and polygenetic soils developed on them.

In the Apennine range of Liguria, loess deposits have been identified on pediments and erosion surfaces, but they are never recognized along the Ligurian Alps. The described loess-paleosol sequence has been identified nearby Palo (SV), at about 710 m asl, along a gentle slope of the Beigua Massif dipping to the Po river basin. The profile is constituted by three different units: the deeper one, developed from the calc-schist parent material shows a strong geochemical weathering; the overlying units are developed from loess blankets reworked by running water or slope processes (solifluction). The identified horizons are (fig.1):

O grass and roots;
A 0 - 15 cm, strong brown 7.5 YR 4/6, common dark grayish brown 2.5 YR 4/2 mottles, fine granular structure weakly developed, no coarse fragment, silty-clay loam, common pores, many fine and medium roots, clear linear bottom boundary;
B 15 - 25 cm, strong brown 7.5 YR 4/6, no mottles, medium subangular blocky structure moderately developed, scarce fine gravel, silty clay, scarce pores, many fine and medium roots, gradual linear bottom boundary;
BC 25 - 45 cm, strong brown 7.5 YR 4/6, no mottles, medium subangular blocky structure moderately developed, common medium gravel and charcoal fragments, silty clay, scarce pores, common fine and medium roots, clear wavy bottom boundary;
2Bt 45 - 55 cm, dark yellowish brown 10 YR 4/6, no mottles, medium angular blocky structure weakly developed, no coarse fragments, abundant charcoal fragments, sandy-silt loam, scarce fine clay coatings on the surface of the pores, scarce pores, scarce fine roots, gradual linear bottom boundary;
2BC 55 - 70 cm, dark yellowish brown 10 YR 4/6, no mottles, medium angular blocky structure weakly developed, abundant coarse gravel, sandy-silt loam, scarce fine roots, clear linear bottom boundary;
2C 70 - 85 cm, strong brown 7.5 YR 4/6, no mottles, fine angular blocky structure moderately developed, common fine gravel, sandy-silt loam, scarce pores, scarce fine roots, clear irregular bottom boundary.
3B 85 - 100 cm, yellowish red 5 YR 4/6, scarce yellowish brown 10 YR 6/8 mottles, medium/fine angular blocky structure moderately developed, abundant fine/medium gravel, clay loam, scarce fine clay coatings on the surface of the peds, frequent pores, scarce fine roots, diffuse linear bottom boundary

3BC 100 + cm, yellowish red 5 YR 4/6, scarce yellowish brown 10 YR 6/8 mottles, medium/fine angular blocky structure moderately developed, abundant medium gravel, clay loam, scarce fine clay coatings on the surface of the peds, frequent pores, scarce fine roots, bottom boundary.

Micromorphology is the better way to understand the pedological history of this profile. The main micromorphological features of deeper unit are frequent limpid yellowish and reddish clay coatings and dense infillings, locally fragmented. The whitish yellow clay coatings are characterized by interference colors of first order (1:1 clay minerals, e.g. kaolinite). The reddish fine fraction, mainly composed of clay, shows stipple-speckled b-fabric and locally a dotted limpidity. The coarse sandy and fine gravel fraction is abundant (porphyric single-spaced c/f relative distribution) and it mainly consist of angular quartz aggregates (metamorphic) with irregular linear and intermineral weathering and mica flakes with parallel linear weathering. The few planar voids produces a moderately developed and weakly separated primary angular blocky microstructure with intrapedal vughy microstructure. Finally we observed tipic blackish disorthic Mn nodules strongly impregnated which present sharp boundaries. The loess-units are characterised by a moderately developed primary angular blocky microstructure with clear porous crumbs and granular intrapedal aggregates, indicative of strong biological activity. The coarse fraction of groundmass comprise common quartz grains (fine/medium sand) and mica flakes (fine sand and silt) while the yellowish clay micromass has a dotted limpidity and stipple-speckled b-fabric. The groundmass is rich of organic components (roots fragments, tissue residues and amorphous material) and often coarse charcoal fragments are present. The most striking pedofeature is the presence of brown orthic Fe-hydroxides nodules (200/500 µm) with clear boundaries followed by Fe-hydroxides hypocoatings along the planes surface. In conclusion the described profile is the result of multiple weathering processes, affecting different parent materials and driven by environmental condition and, of course, by allochthonous material input. The deeper unit was produced by a strong pedogenetic phase, involving the bedrock parent material and leading to the development of pedogenetic body showing characteristics like present day strongly weathered subtropical to tropical area soils (i.e. fersiallitic to ferrallitic soil sensu Duchaufour, 1977). The development of this kind of soils needs specific climatic and environmental conditions which can be connected to past warm periods, like the ones occurred in Italy before the glacial Pleistocene (Late Tertiary and Early Pleistocene - Cremaschi, 1987; Cremaschi and Ginesu, 1990) or during the Middle Pleistocene interglacials (Magaldi et al., 1985; Magaldi and Bidini, 1991).

As regards the upper units, it is clear that multiple erosional events, followed by depositions of material developed from loess blankets, have took place. These materials shows features which
are comparable to Lateglacial interstadial soils of central Europe, which were not erased by the present day pedogenesis. So it is possible to state that the older and stronger pedogenetic phase was interrupted during glacial dry periods, and the profile was then truncated and covered by loess sediments, as described in Northern Italy, Spain and France by authors (i.e. Cremaschi, 1987; Vidic, 1994; Cremaschi and Busacca, 1995). In conclusion, the present work on loess-paleosol sequences in the Ligurian Alps is very important because it extends the eolian sedimentation basin between the Alps and the Mediterranean region, already studied (Cremaschi, 1990a, 1990b, 1990c) and because such sequences are regarded as some of the best terrestrial equivalents of marine-sediment records of Quaternary enviromental change (Catt, 1991). Furthermore, we must specify that the work on Palo loess-paleosol sequence is just a preliminary study; next analyses (bulk and clay mineralogy by XRD, magnetic properties, heavy minerals) will be carried out in order to understand better the pedogenesis of the deeper weathered paleosol and the buried soil within a loess unit, and to obtain a correct chronological and pedosedimentary reconstruction.

References


Cremaschi M. (1987) - Paleosols and Vetusols in the Central Po Plain (Northern Italy); A study in Quaternary Geology and Soil development. Milano, Unicopli. 316 pp.


Magaldi D., Bidini D. (1991) - Microscopic and submicroscopic characterization of a well developed plinthite in a buried Middle Pleistocene soil in Northern Tuscany (Italy). Quaderni Scienza del Suolo, III: 31-44.

Multivariate analysis on the petrography of gravel from outcrops and cores: a case study from the Lombardian “Ceppo” facies (Northern Italy)

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The potential of gravel petrography in provenance studies is biased by the limited transport range of gravel relative to its source areas, which results in the sedimentary record of local provenance signals. This problem is largely overcome if the study area is restricted to the outlet of mountain valleys hosting high-energy rivers and streams. In the present study, multivariate analysis is applied to gravel samples from the Late Pliocene–Early Pleistocene conglomerates of the northern Po Plain (Ceppo) in a study area extending, West to East, from the Lura Stream south of Como to the Brembo River (Western Bergamo Province). A companion study is in progress also for the Serio, Oglio, Mella, and Chiese river valleys.

Since the pioneering work of Orombelli and Gnaccolini (1978), a wealth of quantitative data has been produced on outcropping conglomerates in the study area. However, no efforts have been done to run a multivariate analysis on these data, with the notable exception of Bini et al. (1989), who tested the method on glacial deposits.

Core and outcrop data have different specific strengths and shortcomings. Analyses on core samples were obtained in long, complete stratigraphic successions and are not biased by inconsistencies between operators, but in many samples the number of countable pebbles was small due to limited bed thickness and core diameter; in those cases, no statistical sampling of pebbles was possible, and in several intervals all the available pebbles were counted. Published outcrop data are mainly biased by inconsistencies between operators; nonetheless, they were commonly obtained through statistically meaningful counting methods (e.g. line method).

The original datasets for cores and outcrops displayed different (but not incompatible) petrographic variables. An effort was made to homogenize the different variables in a single matrix 100 (samples) x 11 (variables).

After a preliminary transformation of the original compositional data into an open multidimensional space values (Pawlowsky-Glahn and Buccianti, 2002), multivariate analysis followed a two-step process: 1. classification, 2. discrimination.

Classification: the result of this step was the separation of the samples into “natural” groups by using cluster analysis as an exploratory tool;

Discrimination: the aim of this step is finding one or more functions that maximize differences among the previously-classified groups, displaying in 2D a provenance map, and allocating new samples of unknown pertinence into one of the established groups.

The multivariate analysis allowed us to distinguish at least six petrofacies indicative of provenance from six different source areas:
- the Brembo River source area;
- an ancient catchment with source area similar to the present Valsassina;
- the ancient Adda River catchment passing through the Como branch of Lake Como;
- an ancient catchment limited to the foothills of the South-Alpine margin;
- the present Adda River catchment passing through the Lecco branch of Lake Como;
an ancient catchment with source area in the surroundings of the Lugano Lake. Provenance interpretation on gravels was enhanced by ongoing petrographic analyses on framework grains and heavy minerals from the associated sand (Vezzoli et al., 2006). In the analyzed cores the six petrofacies are represented at different stratigraphic levels. This fact allowed us to subdivide the cores into superposed “petrologic intervals” (Dickinson and Rich, 1972), each of them documenting a definite stage in the evolution of the South-Alpine drainage during the Pleistocene.

References


The vegetation during the Last Interglacial - Glacial cycle
based on the palynological materials of the Southern Russian Plain

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New palynological investigations on Late Pleistocene deposits of the loess/soil sections Roxolany, located in the Dniester River lower reaches (Dodonov et al, 2001), Biriuchia balka, Semibalki, Beglitsa, located on the Northern Azov Sea coastal areas are available and they allow to carry out a more realistic reconstruction of the paleovegetation history of the southern Russian Plain during the Last Interglacial - Glacial cycle. The analysis of collected palynological materials made it possible to study temporal dynamics of indicator plant species distribution and vegetation paleophytocoenoses during the second part of the Late Pleistocene and Holocene.

During the Last Mikulino (Eemian) Interglacial warming, the Mezin pedocomplex was formed under forest-steppe landscape on the coastal areas of the Black Sea and Azov Sea. Broad-leaf forests occurred in the river valleys, and patches of pine forests were growing on the uplands and terraces. Meadow - steppe plant communities occupied the open territories. The phase of climate optima of the Mikulino Interglacial, corresponding to the lower part of chernozem horizon of Mezin pedocomplex, is identified by the presence of broad-leaf species such as *Carpinus, Ulmus, Corylus, Ulmus, Fraxinus, Quercus* and *Tilia* in the forest coenoses. The final stage of the pedocomplex formation occurred during colder and more continental climate conditions. *Picea* and *Pinus* subgen. *Haploxylon* appear and the amount of broadleaf species decreases in pollen spectra. During the formation of the upper paleosoil of the Mezin pedocomplex, meadow steppe in combination with patches of coniferous small-leaf forest were dominant in the Southern Russian Plain. The pollen spectra of the overlying pedocomplex loess deposits show the wide spreading of forest steppe and cold steppe plant communities. During the Briansk Interstadial (33 - 24 ka BP), the formation of the Briansk soil formation in the Roxolany section occurred under cryoxerophytic conditions with a wide distribution of forest steppe landscapes, with a combination of *Artemisia* and Chenopodiceae, grass - herb steppe and mixed forest with *Pinus, Alnus, Betula, Carpinus, Fraxinus, Quercus* and *Tilia* participation. On the coastal areas of the Northern Azov Sea, periglacial meadow steppe and Chenopodiceae - grass communities with "islands" of pine - spruce and small-leaf forest associations prevailed on the Southern Russian Plain south of 49° - 50°N. Within the limits of the steppe zone, forest - steppe landscapes were located in the Donetsk highland and in the river valleys (Markova et al., 2002; Simakova, 2006). A further climate cooling of the second part of the Valdai (Weichselian) epoch (24 –12,4 ka BP), corresponding to the loess deposits, was reflected in the development of meadow-steppe and steppe communities with *Pinus, Betula* and *Salix* participation, tundra species and semidesertic elements on the seaside territories of the Russian Plain (Markova et al., 2002). During the Bølling–Allerød Interstadial complex, warming (12,4 - 10,9 ka BP) *Artemisia* - Chenopodiceae steppes were gradually replaced by herb - grass steppes. In the river valleys forests of willow, birches, pines, alder and sallow-thorn occurred (Simakova and Puzachenko, 2005). During the Younger Dryas Stadial cooling (10,9 - 10,2 ka BP), paleophytocoenoses with meadow, grass-herb, and *Artemisia* - Chenopodiceae steppes with patches of mixed forest occurred in Southern Eastern Europe. Forest-steppe landscapes persisted in the Donetsk highlands and in the Don River valley (Grichuk, 1982).
During the Early Holocene (10,2 - 8 ka BP), grass - *Artemisia* and *Artemisia* - Chenopodiaceae steppes occupied the south of the Russian Plain. The northern limit of the former steppe zone coincided with that of the modern herb and bunchgrass steppe. The reconstructions of dominant plant assemblages suggest a drier and perhaps somewhat cooler climate in Eastern Europe during the Preboreal - Boreal interval if compared with the present-day climate.

Xerophytic forest-steppe communities were widespread on the southern seaside areas during the Atlantic optimum of the Holocene (6 - 4,8 ka BP). The southern boundary of the Black Sea, Azov Sea, present-day Crimean steppes, western Caspian Sea regions were occupied by a forest steppe where feather–grass and wermuth–grass steppes alternated with hornbeam and oak, broad-leaf forests of alder, filbert, and pine groves. Steppe and semidesert assemblages occupied the Caspian Sea region and the lower reaches of the Volga River (Markova et al., 2003).

Thus, during the Last Interglacial - Glacial cycle the abrupt climatic fluctuations caused changes in the structure and distribution of paleophytocoenoses and reorganization of vegetative zones, due to a reduction of forest coenoses and possible migration of tundra and steppe elements toward south and north of the continent during the cold periods, forming new plant associations. South of 50° N in the lowland territories of the Russian Plain the boundary of the reconstructed vegetation types shifted slightly and was rather conservative. However the significant reorganization of paleovegetation structure occurred within the limits of reconstructed provinces during the different periods of the Late Pleistocene - Holocene. The dissected territories (the highlands, the mountain systems and the large river valleys) were centers of high biodiversity both during cold and warm periods. The inheriting of forest refugia during all the intervals is indicated.

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References


Lateglacial and Holocene Palaeoenvironment and Vegetation History in the Northwestern Rila Mountains, Bulgaria

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Pollen analysis of lacustrine sediments from the cirque of the Seven Lakes in the Northwestern Rila Mountains, supported by radiocarbon chronology and complemented by geomorphological evidence, allowed the reconstruction of the palaeoenvironmental conditions and vegetation development at high altitudes in postglacial time. The sites investigated are the glacial lakes Sedmo Rilsko (2095 m) and Trilistnika (2216 m). The geomorphological mapping and observations suppose that the moraine materials in the research area were deposited during the last three glaciations. The exact time of the Würm deglaciation and the position of the snow-line are still under discussion. The lakes studied were free of ice before 15,000 cal. BP when accumulation of grey silt started. The reconstruction of the lateglacial vegetation is linked for the first time to a chronological framework of the time interval 15,000 – 11,500 cal. BP. A characteristic feature is the delimitation of an interstadial/stadial cycle analogous with the Bølling/Allerød – Younger Dryas of Western Europe, correlated with the GISP2 \(^{18}\)O and CH\(_4\) records (Lake Trilistnika). Mountain-steppe vegetation composed of \textit{Artemisia}, Chenopodiaceae, Poaceae, with isolated stands of \textit{Pinus} and \textit{Juniperus} - \textit{Ephedra} shrubland, dominated the landscape. From a biostratigraphical point of view the interstadial conditions were marked by the rise of \textit{Pinus} and the spread of deciduous trees at lower altitude from their refugia. The Younger Dryas climatic deterioration is documented by the re-advance of the mountain-steppe vegetation.

The initial stage of afforestation in the Early Holocene (11,000 – 9,000 cal. BP) when the climate started to improve, was characterized by the spread of \textit{Betula pendula} shaping the tree-line with groups of \textit{Pinus}, and oak forests with abundant \textit{Corylus}, \textit{Tilia}, \textit{Ulmus} below them. The change in the environmental conditions towards more humid and cooler climate ca. 7,500 cal. BP favoured the vertical migration of conifers, particularly of \textit{Abies alba}. A coniferous belt dominated in its upper part by \textit{Pinus} (\textit{P. sylvestris}, \textit{P. peuce}) was shaped. The establishment of \textit{Fagus sylvatica} and its distribution on the Northwestern Rila Mountains took place after 5,200 cal. BP. Beech formed pure or mixed stands either with \textit{A. alba} or with \textit{Carpinus betulus}. The last tree immigrant in the study area was \textit{Picea abies} which started to colonize areas dominated by \textit{A. alba} between 4,300 and 3,400 cal. BP and reaching its first expansion maximum after 2,700 cal. BP. The late arrival of spruce in the high Bulgarian mountains suggests the existence of its main glacial refugia in the northern parts of the Balkans (Slovenian Alps, Carpathian arch). The last stage of the vegetation development in historical times reflects also the human interference (livestock-grazing and agricultural activity) proved by the appearance of pollen anthropogenic indicators (\textit{Triticum}, \textit{Secale}, \textit{Plantago lanceolata}, \textit{Rumex}). The tree-line was artificially lowered as parts of the coniferous forests and stands of \textit{Pinus mugo} were destroyed in order to extend pasture areas.
A Pliocene fossil forest between Alps and Po Plain Gulf (north-western Italy)

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The Fossil Forest of the Stura di Lanzo river is exposed 5 km apart from the present fringe of the Alps, 20 km north of the town of Turin, where a thin cover of Quaternary sediments hides a thick continental succession of Pliocene sediments (up to 250 m). The outcrop extends for two kilometres and permits a detailed reconstruction of the ancient depositional environment and its lateral variation. Stratigraphical and plant taphonomical analyses of the succession clearly results that the palaeoenvironment was a clastic rheogenous swamp, laying nearby one or more active fluvial or deltaic channels, in which coarse cross-bedded sands were deposited.

The integrated magnetobiostratigraphic approach, carried on both outcropping sections and subsurface deposits, permitted to attribute the Fossil Forest to the Kaena subchron (Middle Pliocene). The geological setting and facies associations suggest that the coastline was not far from the Forest, while it was growing up. Thus, the coastal swamp was most probably located few meters above sea level, in a plain not far from the mouth of a river.

An analogous depositional environment has been reconstructed for a limited deposit cropping out at 600 m a.s.l. (Momello-Lanzo), at the end of the alpine valley of the Stura di Lanzo river. Palaeobotanical evidence indicates that the age of the two deposits is comparable (Middle Pliocene), which would imply that the fringe of the Alps in this sector was uplifted for nearly 500 m in the last 3 My. For the Fossil Forest site (330 m a.s.l.), already laying in the Po Plain, a minor uplift of about 300 m can be estimated.

The Po Plain, the most considerable Plio-Pleistocene continental basin in Italy, during the last 3 My constantly received large amounts of clasts from the Alps, due the rise of this mountain chain and its consequent erosion. After the Middle Pliocene the Fossil Forest was covered and preserved under a thick succession of fluvial sediments. Comparing the terrace escarpments on opposite sites of the Stura di Lanzo valley, it turns out that at least 60 meters of sediments weighted down on this palaeobotanical deposit, which is also proved by the strong compression of mummified fossil trunks that lay in horizontal position.
Quaternary terraces and coarse deposits are an important clue to the recent uplift of the Alps and to the massive erosion operated by the Stura river, that was able to remove enormous volumes of coarse sediments, thus exposing the Middle Pliocene silts and sands in which the Fossil Forest lays.

Recently in the Fossil Forest outcrop the following features were mapped: position of stumps and horizontal trunks, distance between stumps, orientation of the horizontal trunks. Most of the objects were georeferred by using GPS. Length and diameter of each trunk and size of the stumps were measured. The bigger one (D3, on the right riverbank) has a diameter of 320 cm. The diameter of stumps specimens is generally much larger than the trunks’ one: the reason is clear in comparing this fossil entities to the modern bald or swamp cypress of North America (\textit{Taxodium distichum}).

The following map shows distribution of the preserved stumps of this Middle Pliocene Forest and the position of fallen down trunks, that crop out on both riverbanks of the Stura di Lanzo river. The outcrop is limited by the fluvial deposits that hide the fossil remains and by the Stura di Lanzo erosion in the middle part.

The map also shows the outcrop boundaries of the Fossil Forest bed (in red), comprised between a palaeosol top at the bottom and a lignite seam at the top.
Map of the distribution of the main fossil stumps and horizontal trunks cropping out on both riverbanks on June 2006. The size of dots is proportional to the diameter of each stump. Distances are expressed in cm.
### Authors index

<table>
<thead>
<tr>
<th>Author</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aceti A.</td>
<td>48</td>
</tr>
<tr>
<td>Alberto W.</td>
<td>15</td>
</tr>
<tr>
<td>Ali O.</td>
<td>51</td>
</tr>
<tr>
<td>Alimbekova L.,</td>
<td>36</td>
</tr>
<tr>
<td>Al-Kafri A.-M.</td>
<td>51</td>
</tr>
<tr>
<td>Andö S.</td>
<td>109</td>
</tr>
<tr>
<td>Andrieu-Ponel V.</td>
<td>8, 63, 80</td>
</tr>
<tr>
<td>Angeli N.</td>
<td>39</td>
</tr>
<tr>
<td>Antonioli F.</td>
<td>54</td>
</tr>
<tr>
<td>Arpenti E.</td>
<td>39</td>
</tr>
<tr>
<td>Atanassova J.</td>
<td>97</td>
</tr>
<tr>
<td>Auricemma R.</td>
<td>54</td>
</tr>
<tr>
<td>Bachmanov D.M.</td>
<td>51</td>
</tr>
<tr>
<td>Banino R.</td>
<td>64</td>
</tr>
<tr>
<td>Bavec M.</td>
<td>5</td>
</tr>
<tr>
<td>de Beaulieu J.-L.</td>
<td>63, 80</td>
</tr>
<tr>
<td>Belmecheri S.</td>
<td>63</td>
</tr>
<tr>
<td>Benn D.I.</td>
<td>35</td>
</tr>
<tr>
<td>Berra F.</td>
<td>9</td>
</tr>
<tr>
<td>Biella G.</td>
<td>9</td>
</tr>
<tr>
<td>Bini A.</td>
<td>9</td>
</tr>
<tr>
<td>Björck S.</td>
<td>63</td>
</tr>
<tr>
<td>Blavoux B.</td>
<td>80</td>
</tr>
<tr>
<td>Blyakharchuk T.</td>
<td>99</td>
</tr>
<tr>
<td>Bonfiglio L.</td>
<td>71</td>
</tr>
<tr>
<td>Borgatti L.</td>
<td>28</td>
</tr>
<tr>
<td>Borsato A.</td>
<td>44</td>
</tr>
<tr>
<td>Bortenschlager S.</td>
<td>113</td>
</tr>
<tr>
<td>Bozilova E.</td>
<td>133</td>
</tr>
<tr>
<td>Bradwell T.</td>
<td>35</td>
</tr>
<tr>
<td>Brajković De.</td>
<td>116</td>
</tr>
<tr>
<td>Brjaković Dr.</td>
<td>116</td>
</tr>
<tr>
<td>Brauer A.</td>
<td>21</td>
</tr>
<tr>
<td>Bronger A.</td>
<td>83</td>
</tr>
<tr>
<td>Brulhet J.</td>
<td>63</td>
</tr>
<tr>
<td>Budillon F.</td>
<td>56</td>
</tr>
<tr>
<td>Buoncristiani J.-F.</td>
<td>114</td>
</tr>
<tr>
<td>Caielli G.</td>
<td>9</td>
</tr>
<tr>
<td>Calcagnile L.</td>
<td>121</td>
</tr>
<tr>
<td>Calic J.</td>
<td>14</td>
</tr>
<tr>
<td>Capelletti S.</td>
<td>100</td>
</tr>
<tr>
<td>Capraro L.</td>
<td>61</td>
</tr>
<tr>
<td>Caramiello R.</td>
<td>38</td>
</tr>
<tr>
<td>Carcano C.</td>
<td>29</td>
</tr>
<tr>
<td>Cavallin A.</td>
<td>26</td>
</tr>
<tr>
<td>Cerutti A.K.</td>
<td>134</td>
</tr>
<tr>
<td>Cheddadi R.</td>
<td>58, 63</td>
</tr>
<tr>
<td>Chiesa S.</td>
<td>19</td>
</tr>
<tr>
<td>Cliff R.A.</td>
<td>93</td>
</tr>
<tr>
<td>Coe R.</td>
<td>56</td>
</tr>
<tr>
<td>Comerci V.</td>
<td>100</td>
</tr>
<tr>
<td>Como Drilling ProjectTeam</td>
<td>100</td>
</tr>
<tr>
<td>Compagnoni R.</td>
<td>107</td>
</tr>
<tr>
<td>Corsini A.</td>
<td>28</td>
</tr>
<tr>
<td>Cucchi F.</td>
<td>44, 54, 103</td>
</tr>
<tr>
<td>Cyr A.J.</td>
<td>94</td>
</tr>
<tr>
<td>Danukalova G.</td>
<td>36</td>
</tr>
<tr>
<td>de Franco R.</td>
<td>9</td>
</tr>
<tr>
<td>Deltsheva M.</td>
<td>97</td>
</tr>
<tr>
<td>Di Donato V.</td>
<td>58</td>
</tr>
<tr>
<td>Dodonov A.E.</td>
<td>51</td>
</tr>
<tr>
<td>Donegana M.</td>
<td>28, 64, 124</td>
</tr>
<tr>
<td>Drescher-Schneider R.</td>
<td>76</td>
</tr>
<tr>
<td>Dupuy D.</td>
<td>8</td>
</tr>
<tr>
<td>Durr G.</td>
<td>116</td>
</tr>
<tr>
<td>Ehlers J.</td>
<td>86</td>
</tr>
<tr>
<td>Eremeev A.</td>
<td>36</td>
</tr>
<tr>
<td>Esposito P.</td>
<td>58</td>
</tr>
<tr>
<td>Esu D.</td>
<td>66, 71</td>
</tr>
<tr>
<td>Faivre S.</td>
<td>54</td>
</tr>
<tr>
<td>Favaretto S.</td>
<td>81, 105</td>
</tr>
<tr>
<td>Federici P.R.</td>
<td>94</td>
</tr>
<tr>
<td>Ferrando S.</td>
<td>107</td>
</tr>
<tr>
<td>Fiebig M.</td>
<td>3, 90</td>
</tr>
<tr>
<td>Filippi M.L.</td>
<td>39</td>
</tr>
<tr>
<td>Floraso G.</td>
<td>15</td>
</tr>
<tr>
<td>Firpo M.</td>
<td>126</td>
</tr>
<tr>
<td>Fontana A.</td>
<td>22, 81, 122</td>
</tr>
<tr>
<td>Forno M.G.</td>
<td>107, 110</td>
</tr>
<tr>
<td>Forti F.</td>
<td>103</td>
</tr>
<tr>
<td>Fouache E.</td>
<td>54</td>
</tr>
<tr>
<td>Friedrich M.</td>
<td>33, 34</td>
</tr>
<tr>
<td>Frisia S.</td>
<td>39, 44</td>
</tr>
<tr>
<td>Furlani S.</td>
<td>54, 103</td>
</tr>
<tr>
<td>Galli A.</td>
<td>109</td>
</tr>
<tr>
<td>Gandouin E.</td>
<td>63, 80</td>
</tr>
<tr>
<td>Genty D.</td>
<td>44</td>
</tr>
<tr>
<td>Gerasimenko N.</td>
<td>77</td>
</tr>
<tr>
<td>Ghilardi M.</td>
<td>54</td>
</tr>
<tr>
<td>Gianolla D.</td>
<td>66</td>
</tr>
<tr>
<td>Gianotti F.</td>
<td>89, 110</td>
</tr>
<tr>
<td>Giardina F.</td>
<td>29</td>
</tr>
<tr>
<td>Giardino M.</td>
<td>15</td>
</tr>
<tr>
<td>Gibbard P.</td>
<td>86</td>
</tr>
<tr>
<td>Gillot P.-Y.</td>
<td>19</td>
</tr>
<tr>
<td>Graf H.</td>
<td>1</td>
</tr>
<tr>
<td>Granger D.</td>
<td>94</td>
</tr>
<tr>
<td>Guglielmin M.</td>
<td>9</td>
</tr>
<tr>
<td>Guiter F.</td>
<td>8, 63, 80</td>
</tr>
<tr>
<td>Haas J.N.</td>
<td>115</td>
</tr>
<tr>
<td>Heiri O.</td>
<td>39</td>
</tr>
<tr>
<td>Iorio M.</td>
<td>56</td>
</tr>
<tr>
<td>Ivanova T.P.</td>
<td>51</td>
</tr>
<tr>
<td>Ivy-Ochs S.</td>
<td>89, 110</td>
</tr>
<tr>
<td>Jacquat C.</td>
<td>76</td>
</tr>
<tr>
<td>Kaiser F.</td>
<td>34</td>
</tr>
<tr>
<td>Keravis D.</td>
<td>63</td>
</tr>
<tr>
<td>Kerschner H.</td>
<td>89</td>
</tr>
<tr>
<td>Klasen N.</td>
<td>90</td>
</tr>
<tr>
<td>Knipping M.</td>
<td>93</td>
</tr>
<tr>
<td>Kofler W.</td>
<td>113</td>
</tr>
<tr>
<td>Kovačić V.</td>
<td>54</td>
</tr>
<tr>
<td>Kramers J.</td>
<td>88</td>
</tr>
<tr>
<td>Krapf V.</td>
<td>113</td>
</tr>
<tr>
<td>Kromer B.</td>
<td>33, 34</td>
</tr>
<tr>
<td>Kubik P.W.</td>
<td>89</td>
</tr>
<tr>
<td>Kukla G.</td>
<td>63</td>
</tr>
<tr>
<td>Kuznetsov V.Y.</td>
<td>51</td>
</tr>
<tr>
<td>Lallliers-Verges E.</td>
<td>63</td>
</tr>
<tr>
<td>Laratte S.</td>
<td>114</td>
</tr>
<tr>
<td>Liddicoat J.</td>
<td>56</td>
</tr>
<tr>
<td>Livio F.</td>
<td>29</td>
</tr>
<tr>
<td>Lowick S.E.</td>
<td>91</td>
</tr>
<tr>
<td>Lukas S.</td>
<td>35</td>
</tr>
<tr>
<td>Luzian R.</td>
<td>115</td>
</tr>
<tr>
<td>Mackay A.</td>
<td>63</td>
</tr>
<tr>
<td>Maggi V.</td>
<td>50</td>
</tr>
<tr>
<td>Mangan G.</td>
<td>71</td>
</tr>
<tr>
<td>Mangili C.</td>
<td>21</td>
</tr>
<tr>
<td>Mangini A.</td>
<td>88</td>
</tr>
<tr>
<td>Marchesini A.</td>
<td>124</td>
</tr>
<tr>
<td>Marchetti M.</td>
<td>28</td>
</tr>
<tr>
<td>Marjanac L.</td>
<td>116, 119</td>
</tr>
<tr>
<td>Marjanac T.</td>
<td>119</td>
</tr>
<tr>
<td>Markova A.</td>
<td>74</td>
</tr>
<tr>
<td>Marsella E.</td>
<td>56</td>
</tr>
<tr>
<td>Martinetto E.</td>
<td>134</td>
</tr>
<tr>
<td>Martini M.</td>
<td>109</td>
</tr>
<tr>
<td>Masini F.</td>
<td>68, 71</td>
</tr>
<tr>
<td>Mastronuzzi G.</td>
<td>121</td>
</tr>
<tr>
<td>Mauch Lenardić J.</td>
<td>116</td>
</tr>
<tr>
<td>Meyer M.</td>
<td>88, 93</td>
</tr>
<tr>
<td>Menkovic L.</td>
<td>14</td>
</tr>
<tr>
<td>Michetti A.M.</td>
<td>29, 100</td>
</tr>
<tr>
<td>Milivojevic M.</td>
<td>14</td>
</tr>
<tr>
<td>Minini H.</td>
<td>51</td>
</tr>
</tbody>
</table>

INQUA-SEQS 2006 “Quaternary Stratigraphy and Evolution of the Alpine Region in the European and Global Framework”, Milano
<table>
<thead>
<tr>
<th>Authors</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miola A.</td>
<td>81, 105</td>
</tr>
<tr>
<td>Monegato G.</td>
<td>24, 91, 122, 124</td>
</tr>
<tr>
<td>Motella S.</td>
<td>100</td>
</tr>
<tr>
<td>Morley D.</td>
<td>63</td>
</tr>
<tr>
<td>Morozova E.</td>
<td>36</td>
</tr>
<tr>
<td>Moscariello A.</td>
<td>21</td>
</tr>
<tr>
<td>Mozzi P.</td>
<td>22, 81</td>
</tr>
<tr>
<td>Mueller K.</td>
<td>29</td>
</tr>
<tr>
<td>Muttoni G.</td>
<td>32</td>
</tr>
<tr>
<td>Nicolussi K.</td>
<td>115</td>
</tr>
<tr>
<td>Nicoud G.</td>
<td>8, 63, 80</td>
</tr>
<tr>
<td>Oberhuber W.</td>
<td>113</td>
</tr>
<tr>
<td>Oddone E.</td>
<td>27</td>
</tr>
<tr>
<td>Offenbecher K.-H.</td>
<td>88</td>
</tr>
<tr>
<td>Ortu E.</td>
<td>38</td>
</tr>
<tr>
<td>Panzeri L.</td>
<td>109</td>
</tr>
<tr>
<td>Pappalardo M.</td>
<td>94</td>
</tr>
<tr>
<td>Pasuto A.</td>
<td>26, 27</td>
</tr>
<tr>
<td>Peyron O.</td>
<td>38</td>
</tr>
<tr>
<td>Peresani M.</td>
<td>47</td>
</tr>
<tr>
<td>Petruso D.</td>
<td>71</td>
</tr>
<tr>
<td>Piccin A.</td>
<td>9</td>
</tr>
<tr>
<td>Piccazzzo M.</td>
<td>126</td>
</tr>
<tr>
<td>Pignatelli C.</td>
<td>121</td>
</tr>
<tr>
<td>Pindur P.</td>
<td>115</td>
</tr>
<tr>
<td>Pini R.</td>
<td>64, 124</td>
</tr>
<tr>
<td>Pinti D.L.</td>
<td>19</td>
</tr>
<tr>
<td>Pinti P.</td>
<td>63, 80</td>
</tr>
<tr>
<td>Portier E.</td>
<td>114</td>
</tr>
<tr>
<td>Possnert G.</td>
<td>133</td>
</tr>
<tr>
<td>Preusser F.</td>
<td>1, 35, 63, 90, 91</td>
</tr>
<tr>
<td>Quarta G.</td>
<td>121</td>
</tr>
<tr>
<td>Quidelleur X.</td>
<td>19</td>
</tr>
<tr>
<td>Radović S.</td>
<td>116</td>
</tr>
<tr>
<td>Radtke U.</td>
<td>90</td>
</tr>
<tr>
<td>Raisberg L.</td>
<td>19</td>
</tr>
<tr>
<td>Ravazzi C.</td>
<td>7, 9, 19, 28, 64, 124</td>
</tr>
<tr>
<td>Reille M.</td>
<td>63</td>
</tr>
<tr>
<td>Reitner J.</td>
<td>41</td>
</tr>
<tr>
<td>Rellini I.</td>
<td>126</td>
</tr>
<tr>
<td>Ribolini A.</td>
<td>94</td>
</tr>
<tr>
<td>Rigollet C.</td>
<td>114</td>
</tr>
<tr>
<td>Rioual P.</td>
<td>63</td>
</tr>
<tr>
<td>Roghi G.</td>
<td>105</td>
</tr>
<tr>
<td>Rogledi S.</td>
<td>29</td>
</tr>
<tr>
<td>Romanelli L.</td>
<td>121</td>
</tr>
<tr>
<td>Rossi A.</td>
<td>103</td>
</tr>
<tr>
<td>Rossi P.M.</td>
<td>109, 126</td>
</tr>
<tr>
<td>Rossi S.</td>
<td>100</td>
</tr>
<tr>
<td>Rukieh M.</td>
<td>51</td>
</tr>
<tr>
<td>Russo Ermolli E.</td>
<td>58</td>
</tr>
<tr>
<td>Sagnotti L.</td>
<td>56</td>
</tr>
<tr>
<td>Sailer R.</td>
<td>115</td>
</tr>
<tr>
<td>Sala B.</td>
<td>68</td>
</tr>
<tr>
<td>Sansò P.</td>
<td>121</td>
</tr>
<tr>
<td>Scarano A.</td>
<td>58</td>
</tr>
<tr>
<td>Scardia G.</td>
<td>32, 129</td>
</tr>
<tr>
<td>Schaub M.</td>
<td>34</td>
</tr>
<tr>
<td>Schöne B.R.</td>
<td>93</td>
</tr>
<tr>
<td>Schlüchter C.</td>
<td>1, 35, 89</td>
</tr>
<tr>
<td>Schiunnach D.</td>
<td>9, 32, 129</td>
</tr>
<tr>
<td>Schoch W.</td>
<td>76</td>
</tr>
<tr>
<td>Sibilia E.</td>
<td>109</td>
</tr>
<tr>
<td>Sileo G.</td>
<td>29</td>
</tr>
<tr>
<td>Simakova A.</td>
<td>131</td>
</tr>
<tr>
<td>Spagnolo M.</td>
<td>94</td>
</tr>
<tr>
<td>Soldati M.</td>
<td>26, 28</td>
</tr>
<tr>
<td>Soligo M.</td>
<td>71</td>
</tr>
<tr>
<td>Sostizzo I.</td>
<td>81</td>
</tr>
<tr>
<td>Spencer J.Q.G.</td>
<td>95</td>
</tr>
<tr>
<td>Spötli C.</td>
<td>44, 88, 93, 95</td>
</tr>
<tr>
<td>Stefanova I.</td>
<td>97</td>
</tr>
<tr>
<td>Tagliavini F.</td>
<td>27</td>
</tr>
<tr>
<td>Talamo S.</td>
<td>33, 34</td>
</tr>
<tr>
<td>Texier D.</td>
<td>63</td>
</tr>
<tr>
<td>Thouveny N.</td>
<td>63</td>
</tr>
<tr>
<td>Tonkov S.</td>
<td>133</td>
</tr>
<tr>
<td>Tretiach M.</td>
<td>103</td>
</tr>
<tr>
<td>Trifonov V.G.</td>
<td>51</td>
</tr>
<tr>
<td>Trignan A.</td>
<td>8, 80</td>
</tr>
<tr>
<td>Trombin L.</td>
<td>126</td>
</tr>
<tr>
<td>Tuccimei P.</td>
<td>71</td>
</tr>
<tr>
<td>Turner C.</td>
<td>87</td>
</tr>
<tr>
<td>Valentini G.</td>
<td>81</td>
</tr>
<tr>
<td>van der Borg K.</td>
<td>39</td>
</tr>
<tr>
<td>Van der Burgh J.</td>
<td>134</td>
</tr>
<tr>
<td>van Kolfschoten T.</td>
<td>74</td>
</tr>
<tr>
<td>Vassio E.</td>
<td>134</td>
</tr>
<tr>
<td>Vavassori E.</td>
<td>64</td>
</tr>
<tr>
<td>Velčev A.</td>
<td>133</td>
</tr>
<tr>
<td>Veres D.</td>
<td>63</td>
</tr>
<tr>
<td>Vescovi E.</td>
<td>39</td>
</tr>
<tr>
<td>Vezzoli L.</td>
<td>100</td>
</tr>
<tr>
<td>Vignola P.</td>
<td>109</td>
</tr>
<tr>
<td>Villa I.M.</td>
<td>44</td>
</tr>
<tr>
<td>Vittori E.</td>
<td>29</td>
</tr>
<tr>
<td>Von Grafenstein U.</td>
<td>63</td>
</tr>
<tr>
<td>Weerts H.</td>
<td>18</td>
</tr>
<tr>
<td>Westerhoff W.</td>
<td>18</td>
</tr>
<tr>
<td>Wohlfarth B.</td>
<td>63</td>
</tr>
</tbody>
</table>
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