

(GS04) Quaternary palynology and botany

Date: August 28, 29

Place: Rooms 5236, 5333 (oral), Room 6325 (poster)

Oral Presentation

Aug. 28 [AM1] Room: 5236

Chair: Ryoma Hayashi

9:20-9:40 **Palynological evidence for gradual changes in salinity for the Black Sea during early to mid- Holocene** [GS04-O01 \(313\)](#)

Fabienne Marret, Lee Bradley, Peta Mudie, Ali Aksu, Rick Hiscott, Kenneth Neil Mertens, Elena Ivanova, Ivar Murdmaa

9:40-10:00 **Vegetation dynamics of the Hyrcanian forests of northern Iran since the Last Glacial Maximum** [GS04-O02 \(427\)](#)

Elias Ramezani, Hans Joosten

10:00-10:20 **Flora and vegetation changes on the Russian Plain in response to the Lateglacial climatic oscillations** [GS04-O03 \(44\)](#)

Olga Borisova

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16:20-16:40 **Estimating crop yield of rice in Japan during Yayoi period by experimental cultivation** [GS04-O04 \(238\)](#)

Yukiko Kikuchi

16:40-17:00 **Recent fire events and sedimentary charcoal records from small basins in the Eda-jima Island, Hiroshima Bay, southwestern Japan** [GS04-O05 \(339\)](#)

Nao Miyake, Hayato Inao

17:00-17:20 **Applying an informational-statistical method to studying polygenetic burozems of the southern Far East of Russia (based on palynological data)** [GS04-O06 \(417\)](#)

Boris Pshenichnikov, Marina Lyashchevskaya, Nina Pshenichnikova

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GS04-O01 (313)

Palynological evidence for gradual changes in salinity for the Black Sea during early to mid-Holocene

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The timing and amplitude of the reconnection of the Black Sea (BS) with the global ocean (via the Mediterranean-Marmara Sea Corridor) at the beginning of the Holocene have been vividly debated over the last decades. Ryan and co-workers (catastrophic reconnection scenario) have been suggesting that the Black Sea was a freshwater body, with a sea level 100 meters below to its present-day one, prior to the reconnection with the Mediterranean Sea. The presence of a sediment dam in the Bosphorus Strait would have prevented the inflow of the BS, but under the pressure of sea-level rise, collapsed and rapidly filled the BS with salty water. Aksu/Hisccott and co-workers

have advocated for a one way-flow from a brackish Black Sea to the Marmara Sea early in the Holocene, followed by a gradual in-flow from the Marmara Sea (gradual reconnection scenario). A two-way flow was established around 8 cal ka BP, after an initial impulse of Mediterranean waters at around 9.14 cal ka BP. Because the BS has unique physico-chemical conditions with very low salinity surface waters, conventional macrofossils such as planktonic foraminifera do not occur; however, organic-walled specimens are very well preserved and in relatively high abundance. In the early 70s, Wall and co-workers have identified new species of dinoflagellate cysts, *Spiniferites cruciformis* and *Pyxidiniopsis psilata* that were dominant in the early part of the Holocene, followed by a dominance of *Lingulodinium machaerophorum* and *Cymatiosphaera* (Acritarch). Further studies in the west confirm this change, but most of the sequences were of poor temporal resolution. We present here detailed records from the SW and NE, with a millennial to centennial resolution, allowing to pinpoint the reconnection with the Mediterranean Sea, as well as the timing for the establishment of present-day conditions. Our records show relatively high diversity (~32 taxa), in contrast to previous studies (~4 to 6 taxa). Early Holocene sediments are dominated with *S. cruciformis*, *P. psilata* and *Quinquecuspis* sp. Occurrence of *L. machaerophorum*, *Operculodinium centrocarpum* and cysts of *Pentapharsodinium dalei* prior to 9.0 cal ka BP suggest an initial impulse of Mediterranean waters. A slow species turn-over occurred around 8.1 cal ka BP, with the arrival of euryhaline species. From 7.4 to 6.4 cal ka BP, *S. cruciformis* and *P. psilata* completely disappeared. Modern-day conditions were established around 4.1 cal ka BP. A semi-quantitative estimation of sea-surface salinity, based on the process length of *L. machaerophorum* suggests brackish conditions (~12) prior to the reconnection.

Keywords: dinoflagellate cyst, endemism, euryhaline species.

GS04-O02 (427)

Vegetation dynamics of the Hyrcanian forests of northern Iran since the Last Glacial Maximum

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A 12m core with 15 ¹⁴C dates from a peatland at 1,200 m elevation provides the history of the Hyrcanian forests of N Iran over the last 20,000 years. For the LGM (19,500-16,900 cal. BP), the pollen record indicates the presence of sparse stands of beech, oak, and birch associated with elm and hornbeam around the study site. High values of *Artemisia*, Chenopodiaceae and Amaranthaceae (C-A), and Umbelliferae, together with finds of *Hippophae* pollen suggest a dry or cold environment at higher elevations. Remarkable is a dip of AP and conspicuous peaks of C-A, *Artemisia*, and *Sinapis* type pollen around 17,300 cal. BP. The period 16,900-14,500 cal. BP shows a rise of oak and a strong decrease of beech. *Artemisia*, C-A, and Umbelliferae still dominate the pollen assemblage and reveal, with the continuous curve of *Eremurus*, the prevalence of steppe (i.e. drier and colder) conditions. The period 14,500-13,150 cal. BP shows a substantial rise of *Quercus*, *Carpinus*, and *Ulmus* and the virtual disappearance of *Artemisia*, C-A, and Umbelliferae, reflecting the Allerød interstadial phase. From 13,150-12,100 cal. BP, the radical decline of AP types and pronounced peaks of *Artemisia*, C-A, Umbelliferae, and *Ephedra* persuasively reflect the Younger Dryas cold episode. The early Holocene (12,100-8,100 cal. BP) shows increased values of *Quercus*, *Ulmus*, and *Carpinus*, abundant *Salix* and strongly diminished *Artemisia*, C-A, and Umbelliferae. Over the last 8,500-8,100 years *Quercus* has been replaced by *Fagus* and *Carpinus* indicating the establishment of

contemporary, i.e. temperate, climatic conditions. *Alnus* pollen whose values were moderate until around 3,200 cal. BP turns into one of the main AP types in the recent times. Similarly, *Pterocarya* starts to rise at 3,200 cal. BP followed by a dramatic decline at 1,200 cal. BP, a feature also observed in other palynological studies from northern Iran and Georgia. The occurrence of *Juglans* pollen since 1,350 cal. BP may point to the cultivation of walnut in the Caspian region of N Iran.

Keywords: palynology, late-Pleistocene, Holocene, Last Glacial Maximum, Hyrcanian forests, Iran.

GS04-O03 (44)

Flora and vegetation changes on the Russian Plain in response to the Lateglacial climatic oscillations

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At the end of the last glacial epoch a general trend towards warming was complicated by short-term climatic oscillations, the Allerød interstadial and the Younger Dryas cold stage being the most profound of them. In the Lateglacial, the middle Russian Plain was largely occupied by the periglacial forest-steppe. This complex vegetation included steppe, meadow, tundra, and boreal forest communities. The predominance of non-arboreal vegetation, especially during the cold stages, is evidenced by high contents of herbaceous pollen and by presence of typical heliophytes (*Helianthemum*, *Hippophae rhamnoides*). The diversity of the habitats was due to the cold and continental climatic conditions existing in the middle latitudes with relatively high summer insolation. In the open landscapes highly variable local ecological conditions – such as the depth of the annual ground freezing/thawing, snow depth, etc. – existed. The proportion of the main elements of the Allerød flora was different from that of the Pleniglacial due to the climate amelioration. However, the duration of the Allerød warming and its amplitude were not sufficient to cause disappearance of cryophytes and the immigration of the comparatively thermophile plants into the region. In the Allerød, open forest communities were formed mainly by spruce, birch and Scots pine. Tree species related to the continental climate (*Abies*, *Larix*, *Pinus sibirica*) were also present. The flora contained cold-resistant shrubs (*Alnaster*, *Betula nana*) and herbaceous cryophytes (*Thalictrum alpinum*, *Selaginella selaginoides*). Besides, the Allerød flora included many mesophilous meadow herbs (*Sanguisorba*, *Thalictrum*, *Valeriana*). Periglacial steppe elements (*Ephedra*, *Eurotia ceratoides*) were inherited from the glacial flora. The Younger Dryas cooling is indicated by an increase in herbaceous pollen content (especially in *Artemisia*) and a larger presence of cryophytes. Palynological data show a wide spread of periglacial steppe with sparse pine and birch communities. In spite of the relatively uniform vegetation in the mid-latitude Russian Plain, certain geographical tendencies can be traced in its composition. The farther to the East, the less tundra and mire plants and the more steppe plants occur. Species of light coniferous forest are more abundant in the west of the plain, those of dark coniferous forest – in the east. Meadow communities were characteristic of the Younger Dryas vegetation, which can be explained by high tolerance of meadow plants, their short life cycle and, therefore, their ability to respond rapidly to climatic changes.

GS04-O04 (238)

Estimating crop yield of rice in Japan during Yayoi period by experimental cultivation

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The crop yields of rice in Japan during Yayoi period (BC900-AD250) is so far estimated lower than 63.5kg/10a based on bibliographical sources of later ages (AD710-794). Because the lack of information, no further investigation have been attempted. The results obtained from around 10 years experimental cultivation provides information on relationship between each methods of cultivation which may existed in the past and crop yields. 2 kinds of old type local red rice are selected for cultivation in the restored paddy field where pesticides and fertilizers are not added. The paddy field is located in a small valley in the Sayama Hills, Saitama prefecture, Japan. The crop yields obtained from 4 different cultivation methods such as direct sowing, planting out in density of 18 stubbles per 1m², 30 stubbles per 1m², and 121 stubbles per 1m² were investigated. 121 stubbles per 1m² is a restored density based on the tracks of rice stubbles excavated at the later Yayoi period paddy field found in Hyakkengawa Haraojima site. Crop yields were calculated by the product of 4 elements such as the number of stubbles in 1m², the number of unhulled rice in 1 stubble, percentage of ripened grain, weight of 1000 grains of hulled rice. The crop yields obtained from each cultivation methods were as below. 20-80kg per 10a from direct sowing, 120-190kg/10a from 18 stubbles in 1m², 100-270kg/10a from 30 stubbles in 1m², 130-310kg/10a from 121 stubbles in 1m². We should not always think that the crop yields in old ages were low. Crop yields depends on the way of planting more than the ancientness, especially in areas like Japan where people might have accepted already technically matured rice cultivation method from other areas. The crop yields of rice during Yayoi period was perhaps much higher than it was expected before. Also, the density of 121 stubbles per 1m² was mostly denied before this experiment because it is too dense, or if harvested successfully the calculated crop yield will be too high for these ages. But the experiment shows that the crop yield obtained from the area which 121 stubbles were planted in 1m² is realistic (not too high nor too low), and furthermore, planting in high density is a possible way to obtain more crops per 1m². Planting in high density should be considered as one of the technical methods of planting to get more from limited area of paddy fields.

Keywords: experimental archaeology, red rice, paddy field, rice stubbles, Neolithic age.

GS04-O05 (339)

Recent fire events and sedimentary charcoal records from small basins in the Eda-jima Island, Hiroshima Bay, southwestern Japan

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Charcoal records are used to reconstruct long-term changes in fire activity. Recently, charcoal records showed greater-than-present fire activity during the late glacial and early post-glacial periods in Japan. Evaluating past fire activity and its impacts on terrestrial ecosystems will become increasingly important. There are, however, few theoretical and empirical studies to examine accumulation patterns of charcoal in Japan. Eda-jima is an island in Hiroshima Bay, southwestern Japan. The coastal region along the Seto Inland Sea, including this island, is the driest in Japan, and fires are frequent at this region. In this island, irrigation ponds and water source dams are abundant. Thus, this island is a suitable area for verifying how charcoal records are useful to reconstruct past fire events. In this study, sediment cores were collected at these basins with different sizes and proximities to the burned areas for charcoal analysis. The chronology of the cores was estimated based on Cs-137 and Pb-210 dating. Recent fire events were also explored using actual historical

materials. Since 1970s, there were fifteen fire events in this island. These were occurred mainly at the northern and southern hilly areas. The burned areas were mostly <50 ha, but the most catastrophic fire (1,005 ha) was occurred at the northern hilly area in 1978. The peak of macroscopic charcoal influx, dated to the late 1970s by Cs-137 and Pb-210 dating, was found at all core sampling sites. The peak should be correlated to this fire event, although several sites are ca. 8 km away from the area burned by the catastrophic fire in 1978. At the site burned by this fire event, macroscopic charcoal was much more abundant in the late 1970s. On the other hand, other fire events were not clearly recognized as peaks of macroscopic charcoal influx at sites lying outside the burned areas, probably due to small-scale watersheds at each site. Microscopic charcoal records showed a similar pattern at all sites, roughly reflecting the comprehensive history of fire events mainly in this island. These suggest that macroscopic charcoal provides information about local, extralocal fire events, as predicted by previous studies of charcoal transport and accumulation.

Keywords: actual historical material, Cs-137 and Pb-210 dating, microscopic and macroscopic charcoal, water source dam.

GS04-O06 (417)

Applying an informational-statistical method to studying polygenetic burozems of the southern Far East of Russia (based on palynological data)

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The study focuses on polygenetic burozems of the Muravyov-Amursky Peninsula (43°12'80" NL, 132°09'164" EL, the South of Primorsky Krai) which form under secondary oak forests on relic yellow residua. The soil profile comprises horizons A0 (0-3cm)-AY (3-17cm)-AYBM (17-29cm)-BM1 (29-63cm)-BM2 (63-93cm)-[C(93-110cm)], which differ widely in the amount of clay and chipping and stone content. The territory has a temperate monsoon climate with an average annual temperature (AAT) of 4°C, an annual precipitation rate (APR) of 800 mm, an average July temperature (AJLT) of 17°C, and an average January temperature (AJNT) of -13°C. To better understand polygenetic burozem genesis, we studied burozem granulometric composition and spore and pollen spectra and reconstructed paleoclimatic conditions by V.A. Klimanov's (1981) informational-statistical method. A skeletonless clayey horizon [C] formed under climates that were warmer and drier than present climates, with reconstructed values of AAT 6°C, APR 600 mm, AJLT 18°C and AJNT -8°C. Vegetation of that period included abundant thermophilic *Quercus* sp. and *Fraxinus* sp. (50.4% and 13.0% of tree pollen in the horizon). Spore and pollen spectra of heavily skeletal illuvial horizons BM1 and BM2 include single pollen grains of *Betula* sp., *Corylus* sp., *Quercus* sp., *Juglans mandshurica*, Cyperaceae, *Artemisia* sp., forbs, and single spores of ferns. We infer this horizon to have formed under severe climatic conditions, which is supported by high content of soil skeleton matter and its psephitic texture. A thinly skeletal light-clayey horizon AYBM was formed under much colder climatic conditions with an AAT 2°C, AJLT 16°C and AJNT -11°C, and APR 600 mm. Spore-pollen assemblages in this horizon are dominated by *Betula* sp. (54.9%) with *Quercus* sp. (23.9%), *Tilia* sp. (9.9%); *Corylus* sp. (7%) inferred to represent understory trees, and ferns in ground cover. A thinly skeletal heavily-loamy horizon AY formed under coniferous-broadleaved forests, as indicated by *Pinus koraiensis* (38.1%), *Abies* sp. (3.8%), *Quercus* sp. (19.1%), *Betula* sp. (20.9%), *Tilia* sp. (3.8%), *Alnus* sp. (2.9%), *Phellodendron amurense* (1.9%), *Kalopanax septemlobum* (1.9%) with fern-herb ground cover. Climatic conditions of that period resembled present-day climate. Spore and pollen spectrum of debris horizon A0 reflects modern anthropogenically transformed vegetation of the studied area, with broadleaved forest of *Quercus* sp.

(71.3%), *Betula* sp. (23.4%) with other species. Reconstruction of paleovegetation and climatic conditions for each genetic horizon by Klimanov's method offers evidence of horizon temporal dynamics and polygenetic burozem genesis.

Keywords: reconstruction of climatic condition and paleovegetation, soil formation, granulometric composition, spore and pollen spectrum.

GS04-O07 (348)

Modern vegetation and subrecent pollen spectra from the Lena River Delta, Russian Arctic

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The question about adequacy of reflection modern vegetation in spore-pollen spectra is always topical. It's actual especially for Arctic regions with vast open (non-forested) areas. Usually we found a lot of long-distance pollen (such as *Pinus*, *Picea*, *Betula*) in our samples from Arctic regions. So knowledge about particular qualities of formation spore-pollen spectra in Polar Regions is necessary to make qualitative paleoclimate reconstructions. Therefore 36 surface samples were collected from different parts of the Lena River Delta. The surface samples were taken from moss polsters and top soils. Vegetation at the surface sampling sites was described by 1×1m vegetation plots. Besides, geobotanical and geomorphological observations of surrounding area were carried out. As a result of our investigations we have that samples from low-level area (up to 11 m a.s.l.) contain a lot of long-distance pollen (up to 40%). Sample from the loftiest hill in the Lena River Delta (island Stolb is 114 m a.s.l.) also contain about 70% of trees and shrubs pollen. This is connected with transport of pollen by water in the first case and by airflow in the second case. The most adequate spectra we have obtained from samples which were collected on non-flooded areas. But in these samples many species of grasses didn't find reflection. Another important result is connecting with *Larix*. Presence its pollen five and more percentages in the spectra are point to the presence of *Larix* in vegetation. The study was supported by the Grant of the Government of Russian Federation No. 11.G34.31.0025.

Keywords: surface samples, pollen and plants.

GS04-P01 (4)

Applied palynodebris associations: Inferred systems tracts, palaeoenvironmental reconstructions and implications from the EA-DP-C Gravity Core, EA field, shallow offshore Niger Delta, Nigeria

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Applied quantitative and qualitative palynodebris assessments (palynofacies) have become a unique

tool for understanding and reconstructing palaeoenvironments due to restrictions associated with the offshore depobelt settings (sedimentation cycles). This research focuses on a case study based upon a 2.75 m Gravity Core collected from the EA field EA-DP-C location, sampled at every 2 cm intervals and believed to be Pliocene to Holocene age. The sequence is composed of mudstones, siltstones and pockets of sandstones. Initial results of the palynofacies analysis indicate that associated palynodebris consisting of brown wood phytoclasts, opaque wood and structured cellular together with degraded organic matter were deposited under different environmental conditions. Palynomorph distributions were highly diluted by the palynodebris as a result of oxidation and possible proximal, restricted environmental settings. Integrated palynodebris, palynomorph and lithofacies associations have led to the recognition of a series of palaeoenvironments ranging from deltaic lagoon – through to middle neritic. Mudstones and muddy heteroliths from low energy depositional environments are associated with abundant brown wood phytoclasts typical of lagoons/tidal flats, delta fringes, through to middle neritic settings. Siltstones and very fine sandy heteroliths from high energy depositional environments, in association with the abundance of opaque-black wood, structured cellular materials, degraded palynodebris and broken macro-fossil shells support distributary channel-fills, lagoons and similar oxic depositional environments. Palynodebris, integrated with foraminiferal trends allow further differentiation of systems tracts. Abundance/diversity trends of the benthonic and planktonic foraminiferal species increase through transgressive systems tracts to peak diversity at the maximum flooding surfaces which correlate with increased brown wood-phytoclasts, whereas the opaque-black wood debris increase is more often associated with the high stand systems tracts. Applied palynodebris associations together with other stratigraphic tools can be useful in the interpretation of depositional settings especially when abundance of faunal and floral species is diluted or restricted.

Keywords: palynodebris, palynofacies, systems tracts, palaeoenvironment, foraminifera.

GS04-P02 (257)

A new Mid-Quaternary interglacial record from Denmark: correlation, vegetation and fire dynamics

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Previously only three terrestrial interglacial periods were known from southern Scandinavia, all relatively easily correlatable within the Central-European framework. Here, we present the new Trelde Klint interglacial pollen and charcoal record from Denmark and document its biostratigraphy, discuss its correlation with other European records, interpret its vegetation and fire dynamics and present an effort to obtain its absolute dating. Except for a slight truncation of the early part the pollen stratigraphy exhibits a full interglacial succession including temperate trees (*Quercus*, *Ulmus* and *Tilia*) during its mesocratic stage. A short interstadial sequence is present above the interglacial deposit. Conifers (*Pinus*, *Picea*) dominate the pollen record of the interglacial sequence and especially diagnostic is the occurrence of pollen of *Larix* in the top part of the interglacial record as well as in the interstadial sediments. However, the overall diversity of tree genera remains rather low.

These biostratigraphical features suggest its uniqueness among records found in Denmark and propose its similarity with records in northern Germany. Forests during the temperate stage were dense and openness increased only towards the end of the interglacial strongly affected by fires. A warning is put forward that lack of due concern to differences in fire regimes may hamper understanding of between-site correlations of interglacial pollen records. OSL dating using novel techniques suggests that the interglacial sediments at Trelde Klint belong within either MIS 9a or 7c.

Keywords: lacustrine record, microcharcoal analysis, OSL, pollen analysis, Saalian complex.

GS04-P03 (401)

A comparison of vegetation and climate dynamics between MIS-1 and MIS-5 from Lake Suigetsu, central Japan, and its broader palaeoclimatic implications

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Comparison of interglacial climates globally has revealed diversity in terms of their duration, intensity and internal variability both temporally and spatially (e.g. EPICA Community Members, 2004; Jouzel et al., 2007; Tzedakis et al., 2009; Lang & Wolff, 2011). Accounting for this diversity remains a fundamental objective of the palaeoclimate community which necessitates examining multiple glacial-interglacial cycles globally. In the East Asian Monsoon region there are a number of high-resolution, continuous records spanning the Holocene (MIS-1), but this is not the case for the Last Interglacial (MIS-5e). Here we characterize and compare the vegetation and climate dynamics between MIS-1 and MIS-5 using the entirely continuous composite sediment sequence 'SG06', recovered from Lake Suigetsu, central Japan (Nakagawa et al., 2012). Results are reported of quantitative pollen-based vegetation (Gotanda et al., 2002) and palaeoclimate (Nakagawa et al., 2002) reconstruction methods; the latter uses a newly compiled dataset of modern pollen and climate data from 798 sites across Japan and the Russian Far East (Tarasov et al., 2011). The broader palaeoclimatic implications are discussed in reference to other records from Japan and elsewhere globally. Vegetation around Lake Suigetsu during MIS-1 is characterized by broad-leaved evergreen/warm mixed forest (WAMX biome) from ca. 8000 IntCal09 cal yrs BP, whereas temperate deciduous forest (TEDE biome) dominates throughout the majority of MIS-5, including the Last Interglacial, indicating cooler temperatures during this period. When considering the regional representation of interglacial climates, the results from Lake Suigetsu corroborate results reported from Lake Biwa which also indicate that in terms of interglacial intensity, MIS-1 was considerably warmer than MIS-5. This is contrary to Antarctic and marine records (Lang & Wolff, 2011) of interglacial intensity which show that MIS-5 was one of the warmest interglacials of the past 800,000 yrs. Overshoots in CO₂ concentrations which characterize shorter interglacials such as MIS-5e, which could inhibit the migration of warm temperate-plants from their glacial refugia, or non-linear response to the climate forcing are proposed to account for the observed differences between the interglacial signatures from Japan and elsewhere (Tarasov et al., 2011).

Keywords: Holocene, Last Interglacial, interglacial intensity, quantitative vegetation reconstruction, Modern Analogue Technique.

GS04-P04 (198)

The Last Glacial Transition at Lake St Clair, Tasmania

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The Last Glacial Transition (LGT) is a significant period of rapid climate change which has been the focus of much palaeoenvironmental research globally. There is ongoing contention surrounding the synchronicity of these changes in climate between the Northern Hemisphere and the Southern Hemisphere, in particular questioning the evidence for periods of post-glacial cooling such as the Younger Dryas (YD) and the Antarctic Cold Reversal (ACR) in the Southern Hemisphere. This paper presents a paleoenvironmental record from Lake St Clair, Tasmania, a mid latitude site spanning the LGT. To date, no evidence for periods of post-glacial cooling has yet been identified in Tasmania. This research aims to feed into the abovementioned debates and provide a well dated, high resolution pollen and charcoal record for this significant period of study in the Southern Hemisphere. Results to date indicate that at ~ 12.4 cal k yr BP a decrease in *Phyllocladus aspleniifolius* and increase in the rainforest taxa *Nothofagus cunninghamii* and *Dicksonia antarctica* could be an indication of an increased degree of warming. The timing of this change falls at the end of the ACR and is consistent with a stronger association with the ACR event at this site rather than the YD period. The conclusions from this research will be presented.

Keywords: Last Glacial Transition, Younger Dryas, Antarctic cold reversal, Tasmania, high resolution.

GS04-P05 (100)

Holocene vegetation dynamics and climate change in Kamchatka, Russian Far East

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Pollen records from Kamchatka peninsula are reviewed, and vegetation and climate changes are reconstructed for the past ca. 12000 years (all ages are given in ¹⁴C yrs BP), with new data presented from the interior and northeastern coast. Twenty pollen records from non-volcanic areas (to minimize local influence) are correlated within the main, longitudinally extensive physiographic units: (1) Western Lowland, open to the Sea of Okhotsk; (2) Central Kamchatka Depression, bordered by mountains; and (3) Eastern Coast, facing the Pacific Ocean; the results are then compared over the peninsula. The synthesized data suggest that the climate over Kamchatka ca. 12-6 ka was generally wet and mild due to strong and prolonged Pacific influence, which also suppressed the effect of Younger Dryas. At ca. 10 ka commenced a reduction in total shrubs and an advance of stone birch and downy alder forests in response to climate warming. The warmest period, defined by maximal forest extension, occurred in the Central Kamchatka Depression after ca. 8 ka, while in the Western Lowland and the Eastern Coast it was delayed until ca. 6.4 and 6.0 ka, respectively. Between 6 and 5 ka, general replacement of downy alder by birch in forests in the coastal areas, and first advance of larch in the interior, indicate that the Pacific influence became weaker. The cooling pulse, pronounced everywhere in Kamchatka after ca. 5.0-4.5 ka as drastic expansion of shrubs, could be attributed to the Neoglacial. The subsequent warming and enhanced continentality led to spatial heterogeneity of conditions and to larger differences in vegetation between the interior and coastal areas. In response to warmth, forests extended again since ca. 3.5-3.0 ka in the both Eastern Coast and Western Lowland. In the Central Kamchatka Depression, a remarkable coniferous

expansion began at ca. 3.1 ka, when larch, and then, after ca. 2.0 ka, spruce advanced and replaced deciduous forest so that the “Coniferous Island” appeared in Kamchatka. During the last ca. 300 years, spruce has expanded most rapidly in response to a wetter/cooler climate shift, which coincides with glacier advance in Kamchatka attributed to the Little Ice Age. Six key pollen records from volcanically affected areas on the peninsula show more complicated responses of vegetation to climate change, responses interpreted to have been caused by local volcanic activity.

GS04-P06 (99)

Holocene pollen record from Lake Sokoch, interior Kamchatka (Russia), and its palaeobotanical and paleoclimatic interpretation

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A pollen record obtained from Lake Sokoch in the mountain interior of Kamchatka covers the last ca. 9600 yrs (all ages are given in calibrated years BP). The studies of volcanic ashes from the lake sediments show their complex depositional histories and, therefore, the chronology of record is based on radiocarbon dating only. Variations in local components, including pollen, spores and non-pollen palynomorphs, and related changes in sedimentation document the lake development from initially seepage and shallow basin to deeper lake during the mid Holocene and then to hydrologically open system during the late Holocene. Lake Sokoch occupies a former proglacial basin between two terminal moraines of the LGM time. The undated basal part of record before ca. 9600 yrs BP, however, does not reflect properly cold conditions. At that time, although bushes and tundra dominated, stone birch and white birch forests have already settled in surroundings, and the presence of alder woodland indicates wet and maritime-like climate. The subsequent forest development in response to warming was interrupted by the ca. 8000-7600 yrs BP spell of cooler and drier/more continental climate. The following culmination of warmth related to the Holocene Thermal Maximum, led to first afforestation peak between ca. 7400 and 5100 yrs BP. During the HTM, dramatic retreat of alder forest suggests a reversal from maritime-like to generally continental conditions in response to weakness of Pacific influence. The cool and wet pulse after ca. 5100 yrs BP was pronounced as woodland retreat while bushes, meadows and bogs extended. An expansion of white birch forest since ca. 3500 yrs BP reflected the onset of drier climate and strengthening continentality. As a result, the second maximum of forests dominated by both birches occurred between ca. 2200 and 1700 yrs BP in response to warming in association with dry and greatly continental conditions. The following period was wetter and cooler, and the outbreak of alder forest indicates a short-term return of maritime-like conditions. Since ca. 1300 yrs BP forests retreated and replaced by bushes, tundra and bogs, suggesting cool and wet climate and likely increased back continentality. A re-advance of stone birch forest found atop the record, most probably reflect recent warming trend. The inferred paleoclimate changes are consistent with the pre-HTM, Neoglacial and Little Ice Age glacial advances in neighboring mountains as well as with the tree ring and ice core records from Central Kamchatka Depression, suggesting their regional significance.

GS04-P07 (509)

Vegetation reconstruction based on the plant fossils from the Fukuchi Peat Beds along the Fukuchi River in the south-eastern area of the Chugoku Mountains, western Japan

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Based on the investigation of fossil pollen, wood, and plant macrofossils from the Fukuchi Peat Beds exposed along the Fukuchi River in the southeastern Chugoku Mountains, western Japan, we reconstructed the early Holocene vegetation around there. The natural dam lake had formed during about 1,000 or more years in the early Holocene at Shirakuchi area in the upper reach of the Fukuchi River, and the plant fossils probably flowed in from the surrounding area and deposited on the lake bottom. The fossil wood proved that *Castanea* and *Prunus* grew around the paleo-lake at Shirakuchi area from 9,000 to 9,500 years ago. And then the deciduous broad-leaved forest consisting mainly of *Quercus* sect. *Prinus* may have developed from 8,000 to 8,500 years ago. On the other hand the upper stream area from the Shirakuchi site would be occupied by a cool-temperate deciduous broad-leaved forest consisting of *Fagus*, *Betula*, *Carpinus* sect. *Distegocarpus*, *Ostrya japonica* etc., suggesting the slightly cooler and wetter climate than the present. From the evidence of the plant macrofossils, it was suggested that dominant tree of those cool-temperate deciduous forest was *Fagus japonica* and fossil woods of *Fraxinus* should be identified as *Fraxinus spaethiana*. In addition, the existence of *Zelkova* and *Aphananthe* characteristic of the humid environment around a river possibly shows the shifting vegetation to an evergreen broad-leaved forest at that time, although no component of the evergreen broad-leaved forest was found from the plant fossils investigated.

Keywords: Chugoku Mountains, Early Holocene, Fukuchi Peat Bed, plant fossils, vegetation reconstruction.

GS04-P08 (298)

Modern pollen distributions in Qinghai-Tibetan Plateau and development of transfer functions for reconstructing Holocene environmental changes

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This study investigates the distribution of modern pollen assemblages in the Qinghai-Tibetan Plateau, China, based on surface soil samples collected at 1202 sites along an altitudinal gradient of 10 - 5500 m asl, where mean annual precipitation (MAP) ranges from 12 to 1840 mm and mean annual temperature (MAT) from -7 to 21.5°C. A total of 153 pollen taxa were found with relative abundances greater than 1% in at least two samples. Canonical correspondence analysis (CCA) was used to determine the main environmental variables influencing pollen distributions. The results reveal that MAP is the most significant dominant variable. However, MAT, altitude (ALT), July

temperature (MT7), and relative humidity (HHH) are also significant variables that clearly follow the gradients in the CCA ordination, suggesting that pollen assemblages probably not only reflect a single climatic parameter, but also a variety of other climatic inter-related parameters. Transfer functions, based on locally weighted weighted averaging (LWWA), were developed for MAP (R^2 -boot = 0.89, RMSEP = 109 mm), MAT (R^2 -boot = 0.78, RMSEP = 2.3°C), ALT (R^2 -boot = 0.73, RMSEP = 597 m), HHH (R^2 -boot = 0.82, RMSEP = 4.5%), and July mean precipitation (MP7) (R^2 -boot = 0.87, RMSEP = 23 mm). Overall, our results confirm that pollen can provide reliable estimates of the primary climatic parameters. The application of the LWWA model to the fossil records of Chen Co Lake allowed quantitative inferences to be made about Holocene climatic changes in the southern Tibetan Plateau, suggesting that LWWA is a robust calibration method for quantitative palaeo-environmental reconstruction based on pollen data in the regions.

Keywords: Qinghai-Tibetan plateau, pollen, transfer functions, Holocene, climatic changes.

GS04-P09 (597)

Study on modern pollen distribution in Heilongjiang-Amur cold-temperate regions of China and Russia

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The aim of this paper is to analyze the modern pollen in the region of Heilongjiang in China and Amur in Russia. A total of 40 surface soil samples have been collected, where the major vegetation types are deciduous coniferous forest, evergreen coniferous forest, coniferous and broad-leaved mixed forest, deciduous broad-leaf forest, wetlands and marsh. All of them has been conducted the description of vegetation types and the survey of coverage. The results showed that the main modern boreal pollen taxa was mainly composed of coniferous taxa of *Pinus*, *Larix*, *Picea*, and *Abies*, broad-leaved of *Betula*, *Quercus*, etc., and the herbs of Cyperaceae and *Artemisia*, all of which are comparable with the local vegetation types. The *R*-values of the main pollen type suggested that *Betula* and *Pinus* were over-represented, while *Larix* and *Abies* occurred with under-representation. The percentages of *Quercus* and *Acer* are roughly equivalent to the tree cover. The association index presented that the *A* values of Cupressaceae, *Salix*, Gramineae, *Larix* was higher, whereas *Pinus*, *Artemisia*, *Quercus*, *Betula* was moderate. Three groups can be distinguished by detrended correspondence analysis index: the first group includes *Pinus*, *Abies*, *Picea*, *Larix* and Cupressaceae; the second is *Carpinus*, *Alus*, *Betula*, *Quercus*, Compositae, Cyperaceae; and the third *Artemisia* and Gramineae, which represent respectively the vegetation communities of coniferous forest, deciduous broad-leaved forest and wetland. Therefore, the present result confirmed pollen composition can represent their associated vegetation types to a certain extent. Moreover, the canonical correspondence analysis was carried out to reveal the relation with climatic factors. The arboreal pollen is among the most sensitive taxa to the climate, mostly the monthly minimum temperature (January).

Keywords: Heilongjiang-Amur, modern, Surface pollen, vegetation, climate.

GS04-P10 (454)

Creation of photographic atlas of plants and pollen of the Lena River Delta, Russian Arctic

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The Photographic Atlas consists of the most widespread plants in modern vegetation cover of tundra zone within the Delta of the Lena River. These species are quite widely presented in quaternary deposits from the Arctic region. By the present time Atlases with photos of pollen and spores for the European part of Russia, Europe, the North Africa and etc. is composed and published. However, the similar Atlas for such extensive area as Arctic region of the Eurasian continent isn't present till now. It is necessary to notice that such spore-pollen catalog is a basis for correct identification of fossil pollen and spores in this area. Besides, the tundra zone has a rich variety of grassy plants which produce a large quantity of pollen. Now palynological studying of deposits from this region is based on determination of limited quantity of fossil pollen of grasses. It is connected with both different quantity of produced pollen, various stability of pollen exines to conditions of fossilization, etc., and absence of a considerable quantity of photos of modern pollen and spores. However, this last circumstance is very important for Arctic region where researches of palaeoclimatic changes are carried out applying the spore-pollen analysis. Detailed determinations of pollen and spores, revealing of sufficiently more numbers of fossil pollen and spore taxons will allow restoring more precisely and in detail the biodiversity of fossil flora. For this moment atlas contain about 80 species of plants. There are photos of plant, photos of pollen and short ecological description for each species of plant. The collection of pollen and plants from tundra zone of the Lena River Delta has been collected within the framework of the Russian-German expeditions "Lena-2009", "Lena-2010" and "Lena-2011". This work was supported by the Russian-German Otto Schmidt Laboratory for Polar and Marine Research (Grant OSL-11-18) and the Grant of the Government of Russian Federation No. 11.G34.31.0025.

GS04-P11 (242)

Estimated pollen production rates for several *Quercus* species in Japan

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Pollen grain production rates constitute the basis of pollen-analytical studies on paleovegetation. In Japan, the pollen production rates of several dominant arboreal tree species have been determined since the 1980s to assess production in the forest ecosystem. In addition to this, since the 1990s, pollen production rates have been determined as the basis of pollen-analytical studies. This study presents the pollen production rates for several *Quercus* (Fagaceae) species, which are important taxa in the Quaternary vegetational history of Japan. Pollen grain production rates (P) were determined by multiplying the production rates of male catkin (M) by production of pollen grains per male catkin (P_C). M were estimated by establishing quadrats in forest stands dominated by *Quercus* species, and measured using litter traps set for periods spanning a month or more over the flowering period, for several years. P_C was also measured using branches from conspecific individuals growing in or near the stands. P_C was determined counting and multiplying the number of pollen grains per anther, the number of anthers per male flower, and the number of male flowers per male catkin. In many cases, P was in the 10^{12} no.ha⁻¹yr⁻¹ range, varying from 10^{11} to 10^{13} no.ha⁻¹yr⁻¹. When considering the relation between P and tree size or forest age, P increased with the size, for example DBH, of dominant trees and stand age. This tendency was observed for all *Quercus* species analyzed. The P of mature *Quercus* forests is thus remarkably larger than that of younger secondary *Quercus*

forests which have been cut and coppice-regenerated every 10-20 years. These findings suggest that pollen production in extensive secondary *Quercus* forests may be similar to that in area-limited mature *Quercus* forests. Consequently, both of the forests may give roughly same percentages in the results of pollen analysis.

Keywords: pollen analysis, vegetation history, mature forest, young secondary forest.

GS04-P12 (557)

The history of human occupation at the Lake Lindu (Sulawesi, Indonesia) as inferred from pollen, diatoms and charcoal analyses

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Conservation programs for protected areas such as national parks often treat local communities or indigenous people as opponents rather than partners, and conflicts result when local people lose personal rights as conservation regulations are imposed without involving co-managing strategies. In order to manage the natural resources in the most sustainable way it is important to investigate the history of human-landscape interaction in those protected areas. Lake Lindu (Danau Lindu) is the largest lake in the Lore Lindu National Park in Central Sulawesi (Indonesia), a UNESCO “Man and Biosphere Reserve” since 1977. Present-day economy of the four villages near Lake Lindu (Anca, Tomado, Langko and Puroo) is based on the trading of rice cultivated in the plains surrounding the lake and fish caught in the lake itself. It is believed that before the Dutch arrived in the area in the 20th century, there was only little wetland rice growing and agriculture focused on upland dryland rice, corn, and tubers grown under a swidden system. Megaliths found in the area of the park indicate that well-organized human societies were present since at least 1.000 years BP. Closer investigations have so far only been conducted in the southern part of the park where pollen analysis revealed that deforestation occurred already 2.000 years ago. Little is known of the Lake Lindu area in the northern part of the park. We present the results of a multi-proxy analysis of a 130 cm sediment core from Lake Lindu (1°19'16”S, 120°04'36”E at 1.000 m a.s.l.) spanning the last 1.000 years. Pollen, charcoal and diatom analyses were used to reconstruct the vegetation and fire history as well as the history of eutrophication around the lake. Thanks to the high resolution of the record we were able to better understand the timing and intensity of human activities surrounding Lake Lindu. Our results will help to shed light on the history of human-landscape interaction in the northern part of the Lore Lindu National Park and also contribute to the understanding of the complex but poorly known history of central Sulawesi.

GS04-P13 (249)

Spatially bridging paleobotany and paleoanthropology: GIS-based data integration for the project “Replacement of Neanderthals by Modern Humans”

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This paper introduces our GIS-based interdisciplinary research to understand the impact of climatic change on the replacement of Neanderthals by Anatomically Modern Humans, as a model case of bridging paleobotany and paleoanthropology. In the research, GIS (Geographical Information Systems) serve as an information infrastructure to (1) integrate various data sources from different disciplines such as archaeology, geochronology, climatology, and geomorphology; and (2) visualize and analyze the data in geospatial context. The interdisciplinary workflow starts with qualifying radiometric dating records from paleoanthropological sites for specific human fossils or lithic industries using Bayesian statistics and a decision-tree model. Paleoenvironmental indicators such as temperature, precipitation, and vegetation are also simulated. These indicators and digital terrain models (DTMs) are employed for ecological niche simulators with the GARP and MaxEnt models to predict the density of paleoanthropological sites. The outputs will be published online and shared with collaborators through a WebGIS server *PaleoGeo* (<http://neangis.csis.u-tokyo.ac.jp/paleoGeo/>). The predecessor of *PaleoGeo* was developed in the early 2000s. It comprised a GIS-based mapping system and a relational database. *PaleoGeo* contains the same data and new data are added on an ongoing basis. As of April 7, 2012, the database contains more than 5,600 records of paleogeographical sites including hydrology, geomorphology, oceanology, biology, climatology, and geochronology, from approximately 1,900 scientific articles in 15 major international journals and some relevant books. It includes 149 records referring to palynology and 647 records associated with vegetation. These records are useful to query the paleobotanical data that correspond to specific paleoanthropological conditions such as human species and type of artifacts, and to discuss their causal relationships.

Keywords: archaeology, chronology, human evolution, WebGIS, exploratory data analysis.

GS04-P14 (78)

Pollen records of 20th-century tobacco production in southern Bulgaria

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Production of Oriental Tobacco (*Nicotiana tabacum*) was one of the most important economic activities in southern Bulgaria and neighbouring areas during the 20th century. Bulgarian tobacco production peaked in the 1970s, followed by a sharp decline in the 1980s as a result of government policies that prompted many tobacco growers to emigrate. Pollen records from two lakes in Southern Bulgaria – Lebed and Obel – track the rise and fall of tobacco production in Bulgaria, showing a discernable peak in *Nicotiana* pollen corresponding to the 1970s. The pollen data suggest that around Lake Lebed, in the Rhodope Mountains, grazing was an important activity in the mid-20th century, but gradually declined in favour of tobacco production. Following widespread emigration in the 1980s, palynological indicators of grazing and farming have declined and shrubby vegetation has increased. The occurrence of tobacco pollen in recent sediments provides a new perspective on the land-use history of the region and helps to resolve uncertainties in dating post-bomb sediments using radiocarbon methods.

Keywords: *Nicotiana tabacum*, Thrace, Balkan Peninsula, land-use changes, recent sediments.

GS04-P15 (211)

Continuity and change in the vegetation of a temperate oakwood: a multidisciplinary study from the Central Europe

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We studied the history of a large subcontinental oakwood (Důbrava) in the southeastern Czech Republic with interdisciplinary methods using palaeoecological and archival sources. The issue of continuity in deciduous oakwood vegetation has been in the forefront of woodland ecological studies for many decades. The two basic questions that emerge from existing research are whether or not oakwoods can be characterized by stability and what may be the driving forces of the observed stability or change. Two shallow profiles from small forest hollows were studied by means of pollen and macrocharcoal analyses, complemented with archival written sources from the area. Palaeoecology allowed us to reconstruct the vegetation composition and fire disturbances of Důbrava in the past 2000 years, while written sources provided information about tree composition and management from the 14th century onwards. The pollen profiles show that the present oakwood was established in the mid-14th century with an abrupt change from shrubby, hazel-dominated vegetation to oak forest. This change was most probably caused by a ban on oak felling in 1350 AD. From the 14th to the late 18th century Důbrava had multiple uses, of which wood-pasture and hay-cutting kept the forest considerably open. The second remarkable change was dated to the late 18th century, when multiple-use management was abandoned and Důbrava was divided into pasture-only and coppice-only parts. The last major shift occurred in the mid-19th century, when modern forestry and Scotch pine plantation became dominant. We conclude that the studied lowland woodland did not show stability on the long run. On the contrary, in the past two millennia its vegetation composition went through significant changes that were largely induced by management. Our objective is to contribute to a better understanding of the driving forces behind the history of oakwood vegetation, more specifically of subcontinental oakwoods.

Keywords: charcoal analysis, historical ecology, management history, palynology, written sources.

GS04-P16 (523)

Environmental change in the monsoon-westerlies transition area of Asia during the last 1200 years: lake sediment analyses from central Mongolia and supra-regional synthesis

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A high resolution multi-proxy (pollen, grain size distribution, total organic carbon) record from a small mountain lake (Lake Khuisiin; 46.6°N, 101.8°E; 2270 m a.s.l.) in the south-eastern Khangai Mountains of central Mongolia has been used to explore changes in vegetation and climate over the last 1200 years. The pollen data indicates that the vegetation changed from dry steppe dominated by Poaceae and *Artemisia* (ca. AD 830-920), to *Larix* forest steppe (ca. AD 920-1210), *Larix-Betula* forest steppe (ca. AD 1210-1600), meadow dominated by Cyperaceae and Poaceae (ca. AD 1600-1890), and *Larix-Betula* forest steppe (after ~AD 1890). There was no consistent evidence of warming during the Medieval Warm Period, but the cold wet period between AD 1600 and 1890 may relate to the Little Ice Age. Environmental changes were generally subtle and climate change seems to have been the major driver of variations in vegetation until at least the early part of the 20th century, suggesting that either the level of human activity was generally low, or the relationship between human activity and vegetation did not alter substantially between AD 830 and 1890. Low pollen concentrations, low total organic carbon contents, and high proportions of coarser particles over the last century indicate intensifying soil erosion due to a drier climate and increased human activity. A review of centennial-scale moisture records from central Asia revealed that most areas experienced major changes during the 14th and 19th centuries. However, the moisture availability from AD 1300 to 1850 varied between sites, with no clear regional pattern or relationship to present-day conditions. The moisture levels simulated by the millennium run performed in the MPI Earth System Model indicate that wetter conditions in central Asia between AD 1700 and 1730 were wetter than between AD 1400 and 1430, and also wetter than present-day conditions.

Keywords: pollen, grain size, TOC, late Holocene, vegetation change.

GS04-P17 (172)

Holocene palynology of south-central Missouri lakes: anthropogenic effects

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Cores from three shallow lakes in the Rolla Quadrangle, south-central Missouri, were sampled at high resolution to study the palynology of the upper 50 cm of sediment. Two of the lakes are located in residential areas, while the third lake is located in a conservation area. The aim of the study was to reconstruct the vegetation history of the study area. AMS ¹⁴C dating was used to constrain the age of the sediments. Comminuted phytoclasts and, to a lesser degree, structured phytoclasts, are the dominant organic matter components. Primary producers, such as algae and cyanobacteria, and amorphous organic matter make up a small but significant part of the organic matter. These components are important because they act as ecological indicators in the environment. The lake in the conservation area was found to have twice the amount of primary producers as those in the residential setting. Preliminary analysis of the pollen indicates a strong presence of Asteraceae, *Quercus*, *Populus*, Cupressaceae and a lesser presence of Poaceae, *Pinus*, and other non-aquatic plants. In addition, there is a strong presence of *Potamogeton/Typha*, freshwater dinoflagellates, and filamentous algae/cyanobacteria. Differences in palynomorph and palynofacies assemblages are being statistically evaluated with respect to the location of the lakes. The results of this study may

provide further insights into anthropogenic impacts on lacustrine palynology.

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From countryside to city: archaeobotanical analyses in Florence (Italy) since its origin to the Middle Ages

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During archaeological excavations in the urban area of Firenze (Florence, Italy), botanical investigations were carried out in several settlements most part of which dated back to the Neolithic and Bronze Age, before the foundation of the city in the Roman time. All the studies agree in presenting a prevalingly open and damp landscape, as commonly on alluvial soils, characterized by the occurrence of patches of woodland mostly formed by deciduous *Quercus*, *Ulmus*, *Salix*. Attempts of soil reclamation through draining channel construction are attested starting from the Neolithic and Eneolithic. Archaeological excavations carried out in Via de' Castellani, close to the Uffizi Gallery, and in Piazzale degli Uffizi offered the opportunity to collect new data regarding the late Roman and Medieval city of Firenze. The palynological study of the on-site stratigraphic sequences and the study of pollen and seed/fruits recovered in the fill of two wells allowed us to gather information at multiple levels: the ancient vegetation surrounding Firenze, the consequences of the increasing urbanization, human activity close to the ancient urban wall and the use of plants in the diet. In the late Roman time samples, pollen grains belonging to mountainous vegetation suggest the presence of *Abies* in the forests of the Apennine relieves, not very far from the town of Firenze. *Quercus* deciduous group and other elements of the mixed oak forest are present in the spectra, including *Fraxinus*, and *Ostrya carpinifolia*. Starting from the VII century, the mixed oak forest curve shows oscillations, suggesting different forest exploitations in the centuries. Pollen grains belonging to typical wetland plants are scarce, in accordance with the historically documented water management practices on the Arno river, starting from the Roman time. *Erica* is constantly recorded, but its amount increases during the XI-XII century reaching the highest percentages in the XIII century. The presence of great amounts of clumped pollen in the sediments suggests *Erica* branches as the main pollen source; traditionally used in Italy for broom making and roofing, heather was also popular for agricultural fencing and riverbank reinforcement. Pollen of cultivated plants (*Cerealia*, *Juglans*, *Olea* and *Vitis*) and weeds occur in the spectra from the Roman time. During the early Middle Ages, crops were cultivated close to the city wall, where the wells were also found, thus allowing us to gain a detailed list of plants used in the diet.

Keywords: archaeobotany, pollen, seeds/fruits, vegetation, plant use.