During the first half of the Holocene, much of SW Alaska experienced two profound environmental changes, the first driven by postglacial global warming and the second by the expansion of alder (*Alnus crispa*) over shrub tundra. To determine the timing and rate of these changes, we analyzed the abundances of organic matter (OM), biogenic silica (BSi), chlorophyll-*a*, carbon, and nitrogen, and the isotope ratios of C and N, grain-size distribution, and pollen assemblages in a sediment core from Lone Spruce Pond (60.007°N, 159.143°W, 22 m depth). The chronology is constrained by 22 AMS ^{14}C ages and is corroborated by the regional tephrochronology. Here we focus on the interval following the YD and prior to Neoglacial cooling, from 11.5 to 4.0 cal ka, represented by 1.5 m of sediment accumulation. The first environmental shift is recorded by a dramatic increase in OM content (LOI 550°C), from 10 to 30%, during the 1000 yr following the YD. C and N abundance, and the C:N ratio increased, while δ^{13}C decreased, signaling an input of organic C from the watershed. The ^{14}C ages are too old during this interval, consistent with a flush of old DOC to the lake. These changes are inferred to represent an increase in lake and watershed production associated with early Holocene warming. The second major shift occurred 8.2 cal ka when BSi and chlorophyll-*a* nearly tripled in less than 200 yr, concurrent with the expansion of alder. δ^{15}N began a steady rise, reflecting the build up of N and an increase in denitrification in soils. BSi reached peak values between 6.8 and 6.4 cal ka, whereas OM peaked more than 1000 yr later, between 5.2 and 4.2 cal ka. The offset in timing between the Holocene maxima in BSi and OM probably reflects the difference in the response of the two proxies to changes in temperature versus nutrients, or to their response to groundwater-derived versus overland inputs.

A 432-YEAR-LONG PALEOCEANOGRAPHIC RECORD IN PORITES CORAL IN KIKAI ISLAND, SOUTHERN JAPAN

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In June 2009, we obtained a long modern core from a coral reef in Kikai Island, Japan. The island is located on the eastern boundary of the East China Sea in the northwestern Pacific. The coral core is approximately 440 cm long and dates back to 432 years (1578-2009 A.D.) including the Little Ice Age (LIA). The LIA was a time when Europe and other regions neighboring the North Atlantic experienced colder conditions between the 16th to mid-19th centuries. It is reported that this was characterized by the most extensive period of mountain glacier expansion in the recent past. However, owing to the sparseness of the available proxy data during the LIA, there is still no consensus concerning its spatial pattern, timing and cause. In particular, there is a lack of records in the Pacific during the LIA. Thus our 432-year-long coral record from Kikai Island is a useful tool to understand the global-scale picture of climate change during the LIA.
Here we show a continuous 432-year record of sea surface temperature and other parameters based on coral paleo-climate proxies including trace elements, such as Sr, U, and Ba. We analyzed the skeletal elements using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). This is a very powerful tool to handle long-term records since it requires a relatively brief experimental time compared with analysis using isotope dilution or thermal ionization ICP-MS. Based on these results, we discuss the paleoceanographic conditions in the northwestern Pacific during the LIA.

TIMING AND DURATION OF THE LAST FOUR INTERGLACIAL PERIODS IN THE NORTHERN HEMISPHERE CONSTRAINED BY THE DOME FUJI ICE CORE, ANTARCTICA

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Investigation of the roles of different forcings (e.g. orbital variations and greenhouse gases) on climate requires a paleoclimate chronology with high accuracy (~1/10 of precession cycle). Recently, we established such a chronology for the past 360 ky through orbital tuning of O2/N2 ratio of trapped air in the Dome Fuji and Vostok ice cores with local summer insolation. We extend the O2/N2 data back to ~500 kyr by analyzing the second Dome Fuji ice core, Antarctica. We find the duration of 11 ka, 5 ka, 9 ka, and 20 ka for MIS 5e, 7e, 9e and 11c interglacial periods in Antarctica. The termination onsets lag behind the Northern Hemisphere summer solstice insolation minima by 2-7 ka. Marine sediment cores from northern North Atlantic contain millennial-scale signatures in various proxy records (e.g. SST, IRD), including abrupt climatic shifts and bipolar seesaw. Based on the bipolar correlation of millennial-scale events, it is possible to transfer our accurate chronology to marine cores from the North Atlantic. As a first attempt, the planktonic δ18O and IRD records from the marine core ODP 980 are correlated with Dome Fuji δ18O and CH4 at the end of termination V and the first two millennial-scale events after MIS 11c. We find that the durations of plateaus of planktonic and benthic d18O for MIS 11c are 20 and 15 ka, respectively, which are significantly shorter than originally suggested. These durations are similar to that of interglacial warmth in Antarctica. However, the onsets of interglacial levels in ODP980 for MIS 11 are significantly later than those in Antarctic δ18O and atmospheric CO2 (by as much as ~10 ka), suggesting very long duration of ice sheet melting and northern high-latitude warming for termination V. The investigations on other interglacial periods and other marine cores are ongoing, and the results will also be reported.

SUBGLACIAL DRAINAGE OF THE SAGINAW LOBE, MICHIGAN, USA

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The Saginaw Lobe of the Laurentide Ice Sheet contains multiple networks of partially buried to open tunnel valleys that may have formed at the Late Glacial Maximum (LGM) as well as during re-advances and/or retreats after the LGM. Valleys in the most recent network are 1-3 km wide and 10-30 m deep and display the criteria typically used to identify subglacially eroded valleys: 1) radial orientation around the lobe indicating control by the subglacial hydraulic gradient, (2) undulatory long profiles, (3) irregular sides and bottoms, and (4) discontinuous eskers on the valley floors. Over the past several years, 5 rotasonic borings to or near bedrock (60-80 m) have recovered nearly continuous core from 4 different valley segments. These borings show that the depths of incision and the valley fill sediments are highly variable. The presence of eskers inset into tunnel valleys, along with the nature of the sediment fills, suggests a sequence of: (1) tunnel-valley erosion, (2) partial closure by ice creep into the valley, and (3) deposition of eskers by drainage through smaller ice-walled conduits on the valley floor, probably during ice stagnation. Generalized models for the origin of tunnel valleys include: (1) steady-state drainage through stable, persistent tunnels incised into the glacier bed near an ice margin, (2) discrete catastrophic outbursts limited to one or at most several tunnel valleys, and (3) broad, catastrophic subglacial sheet floods that collapse to channelized flows after producing drumlins and other landforms. Model (3) would produce an entire network of channels in one event. The evidence collected to date fits certain elements of both models (1) and (2), but does not support (3).

NATURE AND AGE OF MIDDLE TO UPPER QUATERNARY BASIN DEPOSITS IN THE ZAFARRAYA POLJE (SOUTHERN SPAIN)

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The Zafarraya Polje is an endorheic tectonic basin located in the external zone of the Betic Cordillera. While geophysical information is available on recent tectonics and the general structure of the basin, the nature and age of basin deposits is poorly known. To elucidate the processes and the timing of sedimentary infill and geomorphogenesis within the polje (about 20 km2), a series of vibracorings were conducted down to 15 m below surface (b.s.). Sediments were sampled and analysed for magnetic susceptibility (Bartington MS field spectrometer), geochemical composition (portable XRF, Thermo Scientific; CN-elemental analysis, Elementar) and grain size distribution (conventional wet sieving and pipette method). Physical dating included age estimates by Optically Stimulated Luminescence (OSL) on samples taken from liner cores and AMS radiocarbon datings on humic acids. In addition, electrical resistivity measurements were carried out at the coring locations. In the eastern part of the polje, the uppermost basin fill consists of fluvial brown sand, silty loam and loamy

clay with gravel layers accumulated by the Arroyo de la Madre, an ephemeral river draining the basin. At 7.5 m b.s., a palaeosol testifies a period of reduced sediment accumulation and geomorphodynamic stability. Near the ponor of Arroyo de la Madre in the western part of the polje, reddish brown clayey loam and clay occur near the surface of alluvial fans and pediments. These sediments represent reworked residual loams of carbonate weathering subsequently eroded from the hill sides. Shortly above the boundary between brown and red sediment layers, a palaeosol again documents a period of reduced geomorphodynamics. The uppermost basin fill thus provides detailed insight into the landscape evolution during the Middle to Upper Quaternary.

RECONSTRUCTION OF PAST ISOTOPE GRADIENTS USING MODERN AND FOSSIL EUROPEAN LAND-SNAIL SHELL $\delta^{18}O$

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Oxygen isotopes from land-snail shells provide both an age and detailed isotopic data over a wide geographic area. Here, we present the use of land-snail whole shell samples as a paleoclimatic indicator that provides insight into the source region and trajectory of precipitation. Last Glacial Maximum (LGM) gastropods were sampled from low-elevation (< 400 m) previously-dated European loess profiles from Belgium to Serbia. Wherever possible, modern snails of the same genus as the LGM samples were collected to provide a comparison with fossil $\delta^{18}O$ shell values. Both modern and fossil land-snail shells record $\delta^{18}O$ values between 0‰ and -5‰. This study comprises the first continental-scale study of $\delta^{18}O$ in LGM land snails, and with results comparable to $\delta^{18}O$ measured in other low-elevation European modern and fossil gastropod studies. There are significant differences in mean fossil shell $\delta^{18}O$ between sites but not among genera at a single location. Therefore, we group $\delta^{18}O$ values from different genera together to map the spatial distribution of $\delta^{18}O$ in shell carbonate. Shell $\delta^{18}O$ ratios reflect the spatial variation in the isotopic composition of precipitation in humid regions. Temperature and precipitation amount to not appear to significantly affect land-snail shell $\delta^{18}O$ in humid regions, but the seasonality of snail activity plays a large role in the gastropod shell $\delta^{18}O$. Fossil and modern shell $\delta^{18}O$ ratios incorporate the preferential sampling of precipitation during the warm season. Modern shell $\delta^{18}O$ decreases in Europe along a N-S gradient from the North Atlantic inland toward the Alps. Modern observed data of isotopes in precipitation (GNIP) demonstrate a similar trend for low-altitude sites. LGM shell $\delta^{18}O$ data show a different gradient with $\delta^{18}O$ declining towards the ENE, implying a mid-Atlantic source due to increased sea ice and a possible southern displacement of the westerly jet stream.

DECADAL-SCALE CHANGES IN EAST AFRICAN FIRE ACTIVITY FOR THE PAST 4000 YEARS

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Ice cores record essential components of the human-climate ecosystem by providing multi-proxy data for atmospheric circulation and chemistry including past fire variability. A novel technique now allows for the direct determination of past biomass burning in polar and tropical ice cores. Tropical savanna fires are the dominant source of carbon from fire emissions and provide more than sixty percent of the global total. The Kilimanjaro ice fields (3o04'S; 37o21'E, 5893 meters above sea level) are located near the largest savanna system in the world, and ice cores from the summit provide a Holocene history of East African climate.
Glaciers on Kilimanjaro trap and preserve atmospheric aerosols produced by tropical savanna fires. Although fire regimes dramatically alter interactions between the land surface, biosphere and atmosphere, the impact of these fires on the climate system is not clear. In addition, humans impact fire regimes by changing fire ignition rates, fuels, and land cover. Levoglucosan (1,6-anhydro-α-D-glucopyranose) is a major component of and a globally present molecular tracer for atmospheric biomass burning. Levoglucosan can only be produced by burning woody tissue at temperatures of 300°C or greater, and is transported in smoke plumes. While a percentage of levogluosan degrades in the presence of hydroxyl radicals, the volume of levoglucosan produced in fires allows for the use of levoglucosan as a tracer of past biomass burning. Here, we present the decadal-scale levoglucosan flux determined in the Kilimanjaro Northern Ice Field 2 (NIF2) ice core for the past 4000 years. We compare the past fire activity to stable isotopes and major ions measured across the same sections of the Kilimanjaro NIF2 ice core as well as vegetation changes recorded in regional sediment cores.

THE SCHMIDT-HAMMER AS A RELATIVE AGE DATING TOOL FOR ROCK GLACIER SURFACES

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Rock glaciers originate from thick debris accumulations (talus/till) in high-relief environments that are under cryogenic conditions for a substantial period of time. Surface morphology, extent, and shape are the cumulative result of their entire genesis and hence climatic past. Temporal dates regarding their initiation and evolution period are the key to valuable palaeoclimatic information. Precise dating of rock glacier is not trivial but can be best achieved by applying an integrated approach, using relative (fieldwork-based, photogrammetry-based) and absolute dating methods. In this study the use of the Schmidt-hammer, as a fieldwork-based relative method, was evaluated by analysing previously published results of 30 rock glaciers of Lateglacial to Holocene age. A Schmidt-hammer is a light and portable instrument traditionally used for concrete stability testing by recording a rebound value (R-value) of a spring-loaded bolt impacting a surface. Beginning in the 1980s, this method has been increasingly applied in glacial and periglacial studies. The obtained R-value gives a relative measure of the surface hardness and thus provides information on the time since surface exposure and degree of weathering. Low values are indicative of a higher age and vice-versa. The 30 rock glaciers are located in the Swiss (n=10), Austrian (n=8) and Japanese Alps (n=5), in Northern Iceland (n=4), on the Faroe Islands (n=2) and in Northern Norway (n=1). These rock glaciers consist predominantly of metamorphic (gneiss, mica-schist) and igneous (andesite, basalt, granite) rocks. The results show that the Schmidt-hammer method is a powerful, cheap tool in rock glacier dating, particularly for large rock glaciers where multiple measurement sites along a longitudinal profile are sampled. R-value data from such profiles enable the establishment of relative chronologies with high temporal resolution. However, a major drawback is the coarseness of the established chronologies.

GLACIER AND PALAEOCLIMATIC HISTORY BETWEEN CAL. BC 3530 AND 1400 IN CENTRAL AUSTRIA: NEW INSIGHT BASED ON RECENT PEAT FINDINGS AT PASTERZE GLACIER

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Precise knowledge of glacier extent and its variation over time during the Holocene in the Austrian Alps is still far from being complete. Ongoing global warming and its melting effects on the cryosphere reveal previously glaciated terrain and its minerogenic and biogenic sediments. In this study we present results of the analysis of five large peat pieces melted out from the glacier ice at the tongue of Pasterze Glacier (47°05'N, 12°44'E), largest glacier of the Eastern Alps (17.5km^2). The peat pieces showed clear signs of glacier compression and were found in non in-situ positions. The compressed peat pieces had a weight of 43kg and a total profile thickness of 47.5cm. The material was radiocarbon dated and analysed regarding pollen content and macro remains. Our results show that the peat covers the period cal. BC 3530-2200 and 1950-1440. Pasterze Glacier was therefore substantially smaller and allowed peat growth during a c.2000 year long period not considering the time for plant colonisation. Peat was growing at a presumably basin position that is still ice-covered at present. Pasterze Glacier reacts very slowly to changes in the mass balance due to its large size. Therefore, it lags behind present accumulation and ablation conditions. This effect has also implications for past glacier extents. The main glacier tongue follows a broad, long and gently sloping valley with