GC23A-19 1330h POSTER

Climate, Water and Renewable Energy in the Nordic Countries

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Climate and Energy (CE) is a new Nordic research project with funding from Nordic Energy Research (NEFP) and the Nordic energy sector. The project has the objective of a comprehensive assessment of the impact of climate variability and change on Nordic renewable energy resources including hydropower, wind power, bio-fuels and solar energy. This will include assessment of the power production of the hydropower dominated Nordic energy system and its sensitivity and vulnerability to climate change on both temporal and spatial scales; assessment of the impacts of extremes including floods, droughts, storms, seasonal patterns and variability. Within the CE project several thematic groups work on specific issues of climatic change and their impacts on renewable energy. A primary aim of the CE climate group is to supply a standard set of common scenarios of climate change in northern Europe and Greenland, based on recent global and regional climate change experiments. The snow and ice group has chosen glaciers from Greenland, Iceland, Norway and Sweden for an analysis of the response of glaciers to climate changes. Mass balance and dynamical changes, corresponding to the common scenario for climate changes, will be modelled and effects on glacier hydrology will be estimated. Preliminary work with dynamic modelling and climate scenarios shows a dramatic response of glacial runoff to increased temperature and precipitation. The statistical analysis group has reported on the status of time series analysis in the Nordic countries. The group has selected and quality controlled time series of stream flow to be included in the Nordic component of the database FRIEND. Also the group will collect information on time series for other variables and these series will be systematically analysed with respect to trend and other long-term changes. Preliminary work using multivariate analysis on stream flow and climate variables shows strong linkages with the long term atmospheric circulation in the North Atlantic. The hydrological modelling group has already reported on “Climate change impacts on water resources in the Nordic countries - State of the art and discussion of principles”. The group will compare different approaches of transferring the climate change signal into hydrological models and discuss uncertainties in models and climate scenarios. Furthermore, comprehensive assessment and mapping of impact of climate change will be produced for the whole Nordic region based on the scenarios from the CE-climate group.

GC23A-20 1330h POSTER

Quantitative Paleoclimate Reconstruction From Pollen Assemblages Preserved in Arctic Lake Sediments

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Surface sediment pollen assemblages from 390 lakes in northwestern Canada, northern Québec, the Canadian Arctic Archipelago and Greenland have been analyzed in order to provide modern analogs for quantitative paleoclimatic reconstruction. This represents a modern environmental gradient spanning 2400 mm of mean annual precipitation, 14.7° C of July temperature, and 32.7° C of January temperature. The modern pollen data includes relative frequencies of the 35 most common taxa. Correspondance analysis (CA) was used to explore spatial distribution of pollen assemblages and relationships with climatic parameters. The CA demonstrates a clear latitudinal pattern, with Axis 1 (27.1% of variance) positively and disgnificantly correlated (r=0.85) with July air temperature. The use of closest modern analogues for quantitative paleoclimatic reconstruction was evaluated by estimating modern climate from surface pollen spectra. The best results were obtained using a chord distance dissimilarity metric and the 5 closest analogues. Observed versus estimated modern variables produced root-mean-squared errors of prediction (RMSEP) of ±1.98° C and ±0.71° C for the January and July temperatures, respectively, and ±175.32 mm for annual precipitation. Detailed pollen analyses and paleoclimate reconstructions have been undertaken on Holocene sediments from two well dated lake cores on Cumberland Peninsula, Baffin Island. Squared chord distances between successive pollen spectra were first used to identify times of rapid vegetation change. Notable transitions occurred at 8000, 3000 and 500 cal BP. Although climate reconstructions from both sites indicate some local differences, there are generally consistent features on a regional scale, including a progressive 1.5° C decrease in July temperature since 8000 cal BP, a progressive 5° C increase in January temperature since 7000 cal BP and an increase in annual precipitation. These reconstructions are therefore consistent with a progressive reduction in the seasonal amplitude of Holocene paleotemperatures, which is tentatively attributed to enhanced oceanic influences at the regional scale.

GC23A-21 1330h POSTER

Inter-Annual Variability of Water Vapor and its Relation with the Onset of Monsoon

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The seasonal and inter-annual variability of total precipitable water (TPW) deduced from Special Sensor Microwave Imager (SSM/I) satellite over oceanic regions around the Indian sub-continent during 1991 - 2000 show characteristic behavior. The TPW over the Arabian Sea is found to be closely related to climate dynamics and the onset of the monsoon which first manifests over the Kerala coast around May and June. The TPW anomaly during the monsoon period over the Bay of Bengal is found to be lower than that of the Arabian Sea for the same latitudinal zone. Low water vapor anomaly over the Bay of Bengal is likely to be related to the existence of finer aerosol particles compared to the Arabian Sea. The spatial and temporal variation of aerosol over the Bay of Bengal and over the Arabian Sea will be presented. The sea surface temperature (SST) anomaly during the year 1991-2000 is found to be very dynamic and shows consistent relation with the water vapor anomaly for the same latitude. The maximum peak of TPW appear 5 to 10 days lag with that of the SST. The water vapor deduced from SSM/I is compared with the water vapor retrieved from the IRS-P4 MSMR and NOAA-NCEP data. The use of water vapor data will be discussed for forecasting the onset of Indian monsoon.

GC23A-22 1330h POSTER

”Smoky” Days in the Canadian Rockies, 1907-1925

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The incidence of forest fires may be a proxy for climate, but consistent records are scarce before the widespread use of aerial photography in the mid-20th century. During his tenure as fourth Secretary of the Smithsonian Institution (1907-1927), Charles D. Walcott spent 19 summers as a paleontologist in the Rocky Mountains, all but two of them in the Canadian Rockies west and northwest of Calgary. Prior to becoming Secretary, Walcott had been the second Director of the U.S. Geological Survey, with responsibility for the Forest Reserves established by Presidents Cleveland and McKinley. Walcott was frequently quoted in the newspapers on the subject of forest fire. During the 17 Canadian summers, Walcott camped an average of 86 days per summer, measured from the date he made his first camp to the date he broke his last camp of the summer. He wrote brief daily comments in diaries that did not change in size or style. The small diary page began with a pre-printed prompt to describe the weather, and there were summers when Walcott frequently wrote ”Smoky” at the start of diary entries. Here is a summary of eight Canadian summers (two 4-yr sets), with inclusive dates of his camping: 1908(26Jun-19Sep)was wet or clear until 1, 2, 3 Aug when he reports ”forest fire”, a rumor that Fernie, B.C., had been ”destroyed by fire”, and ”RR station at Fernie burned”. 9, 10 Aug had ”Smoky atmosphere”. On 6 Sep, ”Mr Clark left us to go & fight a forest fire.” 1909(18Jul-8Sep) has only one mention of ”forest fire” (13 Aug). This was the summer when Walcott discovered the Burgess shale fossils. 1910(28Jun-13Sep) contains no diary record suggesting forest fire. This was a summer when Walcott exploited the Burgess shale fossils. 1911(6Aug-21Sep) was the shortest of Walcott’s field seasons, most of it on the Burgess shale quarry, with no record relating to forest fire. 1922(23Jun-1Oct) reports ”Smoky” on 30 Jun, 1, 2, 3, 18, 19, 20, 21, 28, 29, 30, 31 Jul, and 1, 2, 3, 4, 5, 6, 9, 28, 29 Aug. 1923(5Jun-24Sep)lacks any indication of forest fire. 1924(3Jul-25Sep) was a cold wet summer, but with ”Fine day Smoky” and Half cldy &smoky” on 16, 17 Sep. 1925(5Jul-21Sep) mentions ”Smoky” on 16, 17, 19, 20, 212, 22 Jul, and on 5, 12 Aug, ”dense smoke” on 18 Jul, ”a blaze” on 1 Aug, ”smoke dense” on 3 Aug, and ”forest fire smoke” on 4 Aug. The diary entries suggest that forest fires occurred with a bimodal distribution: either none at all, or multiple incidents in a given summer. Per day camped, the entries suggest that July and August were smokier than September, and hint that fires in August were closer to Walcott than fires in July. Weather and recent fire history determine likelihood of forest fire, but Walcott’s desire for photographs, the elevation of his camp, his health, and competition for the small diary space from other events worth recording must have affected the degree to which Walcott noted evidence of forest fire. However, these consistent and continuous records by one competent observer, in one locality, during the same season, using the the same diary format have unusual value in providing evidence of smokey atmosphere in the first quarter of the 20th century. This study grew out of a close reading of E.L.Yochelson’s two-volume biography (1998-2001) of Walcott, and it depends on my reading the original diaries at the Smithsonian Archives.

GC41A CC: 220 C-E Thursday 0830h

Continental Energy Balance, Land-Surface Processes, and Surface Temperature I Posters

Presiding: **R N Harris,** University of Utah**; H Beltrami,** St. Francis Xavier University

GC41A-01 0830h POSTER

A Multidisciplinary Approach to Assessing the Causal Components of Climate Change

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Separation of climate forcing by anthropogenic greenhouse gases from natural radiative climate forcing is difficult because the composite temperature signal in the meteorological and multi-proxy temperature records cannot be resolved directly into radiative forcing components. To address this problem, we have initiated a large-scale, multidisciplinary project to test coherence between ground surface temperatures (GST) reconstructed from borehole T-z profiles, surface air temperatures (SAT), soil temperatures, and solar radiation. Our hypothesis is that radiative heating and heat exchange between the ground and the air directly control the ground surface temperature. Consequently, borehole T-z measurements at multi-year intervals spanning time periods when solar radiation, soil and air temperatures have been recorded should enable comparison of the thermal energy stored in the ground to these quantities. If coherence between energy storage, solar radiation, GST, SAT and multi-proxy temperature data can be discerned for a one or two decade scale, synthesis of GST and multi-proxy data over the past several centuries may enable us to separately determine the anthropogenic and natural forcings of climate change. The data we are acquiring include: (1) New T-z measurements in boreholes previously used in paleoclimate and heat flow research in Canada and the United States from the 1970’s to the present. (2) Meteorological data from the US Historical Climatology Network and the Automated Weather Data Network of

the High Plains Regional Climate Center, and Environment Canada. (3) Direct and remotely sensed data on land use, environment, and soil properties at selected borehole and meteorological sites for the periods between borehole observations. The project addresses three related questions: What is the coherence between the GST, SAT, soil temperatures and solar radiation? Have microclimate changes at borehole sites and climate stations affected temperature trends? If good coherence is obtained, can the coherence between thermal energy stored in the ground and radiative forcing during the time between T-z measurements be extended several centuries into the past?

GC41A-02 0830h POSTER

A Test of the Reliability of Borehole Paleoclimate Reconstruction

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Paleoclimate reconstructions using borehole T-z profiles require the assumption that the surface air temperature correlates 1:1 with the ground temperature. We are testing this assumption in several ways. First, we compare climate driven T-z models with T-z data collected at several intervals during the past two decades. Three boreholes in North Dakota, four in South Dakota, three in Nebraska, and three in Saskatchewan were logged at multiple times between 1978 and 2003. These boreholes are located within several tens of kilometers of NCDC or Environment Canada weather stations, thus they offer an excellent opportunity for comparative study. We compared individual climate station data and ensembles of climate station data to the borehole records, all of which show ground surface warming between logging intervals. In this aspect of our study, monthly mean-air-temperatures obtained from NCDC weather stations within 100 km of the boreholes were used as model-forcing signals at each borehole site. Two ensemble signals, one for weather stations within a 50 km radius of the borehole and one within a 100 km radius of the borehole were used in the test and found to agree closely with the borehole data. We also are using the differences between temperature profiles in the boreholes to estimate surface energy flux and comparing the results with both meteorological and solar radiation data. We suggest that achieving a direct comparison of GST, SAT and solar radiation will allow us to address the larger question of distinguishing between anthropogenic forcing and natural climate variability. Radiative heating and heat exchange between the ground and the air directly control the ground surface temperature, and a time-series of borehole T-z measurements spanning time periods when solar radiation, soil and air temperatures have been recorded will enable comparison of the thermal energy stored in the ground to these quantities. If coherence between energy storage, solar radiation, GST, SAT and multi-proxy temperature data can be discerned for a one or two decade scale, synthesis of these data over the past several centuries may enable us to separately determine anthropogenic and natural forcing of climate change.

GC41A-03 0830h POSTER

Long-Term Air-Soil Temperature Coupling at Fargo, North Dakota: Assessment of Borehole Climate Reconstruction Assumptions.

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A critical question in borehole paleoclimate reconstruction concerns the nature of the coupling between the air and ground temperatures. Although the shelter-height air temperature and ground temperature profiles are both a direct thermophysical consequence of the surface energy balance, several factors complicate the nature of that linkage. First, borehole paleoclimate studies assume that conduction is the only significant form of heat transfer in the ground. In warm regions this assumption appears to be met, and time-averaged air and ground temperatures closely track one another with appropriate phase lags. Second, seasonal snow cover affects the thermal coupling of air and ground temperatures, producing a thermal offset in the respective mean annual temperatures. If the magnitude of the thermal offset remains constant over time, the ground surface temperature record will continue to track the surface air temperature record. Third, seasonal frost complicates the coupling issue by introducing a significant non-conductive heat source along the freezing front. Finally, advection of heat associated with rainfall and snowmelt infiltration provides another non-conductive heat source that affects all borehole studies. This project investigates the nature of air and ground temperature coupling at Fargo, North Dakota over a 20-year period. Several specific questions are examined: (1) What do the phase-space figures (Beltrami, 1996) demonstrate about air-ground coupling and non-conductive heat transfer at this site? (2) Do winter phase-space figure distortions show a systematic relationship to snow depth and fall soil moisture content? (3) Is there evidence of interannual and intraseasonal variation in the thermoinsulation effect of snow cover on soil and air temperatures? (4) Are there long-term trends in the first/last date of snowfall, first/last date of snow cover, and snow cover duration at the site? Based on this long-term temporal analysis of air-ground coupling at a single station, we will investigate spatial patterns of air-ground coupling in the Great Plains.

GC41A-04 0830h POSTER

Impact of Drought on Land Surface Albedo

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Albedo controls radiation partitioning of a surface and affects its physical, biological, and biogeochemical processes. Recent studies have indicated that climate change induced by the land surface albedo change due to land cover and land use changes can have similar or even greater magnitude than that induced by doubling atmospheric CO2 concentration. Land surface albedo can be changed by anthropogenic as well as natural factors. While anthropogenic changes involving changes in land use tend to be persistent, albedo changes caused by natural factors can be dynamic and difficult to quantify. For example, it is well known that albedo of water-stressed leaves tends to be higher than well-tugored leaves. However, how water-stressed ecosystem can affect land surface albedo at large scale has rarely been studied. This knowledge gap may cause great uncertainties in the climate model projections. We investigated the impact of drought on land surface albedo for four typical ecosystems in Canada: temperate grassland, cropland, boreal deciduous and conifer forests. The study region includes the whole Canada prairies and part of the boreal forest close to its north border. In 2001, precipitation was below historical average for most of the area. As a result, extensive drought occurred across the region. In 2003, precipitation was close to its normal for most of the region. The 1km resolution land surface albedo product from MODIS onboard terra was used. It was found that in 2001, visible band (VIS) albedo in some of the grassland and cropland areas reached as high as 15%, indicating low biomass and vegetation cover caused by drought. In 2003, however, most of the prairie area VIS albedo remained below 10% due to the better crop growing conditions. Water stress in 2001 also led to the higher near infrared (NIR) albedo for most of the prairie regions. For the forest areas, there were no significant differences found in both VIS and NIR albedos between the two years. In conclusion, albedo changes for the grassland and cropland caused by drought could exceed well above 5%. Although this difference seems small, it may be large enough to influence the surface energy balance, and ultimately climate. Therefore, albedo changes caused by drought could significantly feed back to climate on the local, and possibly global, scale.

GC41A-05 0830h POSTER

Five centuries of global records of climate change from geothermal data

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Energy at the Earth's surface propagates into the subsurface by conduction, thus ground surface temperature histories (GSTH) can be retrieved from temperature versus depth profiles measured in boreholes. Here we report on the analysis of 776 borehole temperature profiles from all continents except Antartica in order to examine the spatial patterns of GST variation over the last five centuries. The reconstruction is based on a 1D heat conduction model and was carried out using a singular value decomposition inversion algorithm. In order to preserve the same number of principal components at each site, the same eigenvalue cutoff was used in the analysis. Individual GST histories show high spatial variability. Results show that a 1 $^{\circ}$K ground temperature increase has taken place during the last 500 years, but local colder or warmer short-term excursions interrupted this global trend. We observed that the warming occurs sooner in the southern hemisphere and that a general cooling, more intense in North America and Europe occurred around the end of the 19^{th} century which is in agreement with the local meteorological record. The global bimodal latitudinal distribution of temperature (above and below 40 $^{\circ}$N) seems to be less striking since the beginning of the last century during which the largest warming occurs. The latitude-weighted average northern high latitude GSTH shows a cold period from the mid-18^{th} to the end of the 19^{th} century that may be evidence of the "Little Ice Age" cold period (LIA). The LIA is not clearly observed elsewhere.

GC41A-06 0830h POSTER

Paleoclimate from Inversion of Subsurface Temperatures, Kola Peninsula (Russia)

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Using an extensive data set of temperature logs and thermal properties from 20 shallow boreholes (up to 1.6 km) in the immediate vicinity of the Kola super-deep borehole, we present results from inversions for ground surface temperature histories. We apply a versatile 1-D inversion technique based on a finite-difference approach in order to take into account the heterogeneity of thermal properties and their nonlinear dependence on temperature. Regularization of this generally ill-posed problem is achieved by Tikhonov regularization of variable order. The scheme is easily generalized for use with multiple boreholes. We implemented in our inversion code an enthalpy scheme dealing with latent heat effects due to freezing and thawing. However, because of the very low porosity (less than 1 %) of the crystalline bedrock in the Kola region, our calculations show that the influence of permafrost can be neglected here. We could determine GST histories back to 50 ky BP. The temperature change from the last glaciation period to the Holocene is smaller (4-5 K) than in lower latitudes, suggesting the existence of an insulating ice cover. The good database with respect to thermal conductivity (over 3400 measurements) makes it possible to extend the 1-D inversions to three dimensions by setting up a detailed 3-D model of the Kola region. This will enable us take into account effects of lateral heterogeneity and groundwater flow.

GC41A-07 0830h POSTER

No Evidence for Recent Climatic Warming From Borehole Temperatures in the Canadian Cordillera

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Inversions of temperature data from 60 boreholes at 20 sites spanning 13 degrees of latitude in the Canadian Cordillera show that there was no significant unexplained change in the GST (ground surface temperature) over the last two centuries. There were no changes in the GST at undisturbed sites, and at sites where a known event altered the terrain surrounding them, the modelled changes in GST were in agreement with the site histories. These boreholes were chosen for analysis from over 500 in this region in the GSC data base. The others were excluded because of unknown terrain histories, obvious effects of water flow in crystalline rocks, low water tables, or penetration of sedimentary rocks that might have bulk permeability. From a consideration of the heat budget at the surface of the earth, the change in the average surface temperature expected due to permanent deforestation and/or drainage of surface waters is approximately 2 K. This is due to the greater run off of water and the smaller amount of heat required, principally in the

summer time, for evaporation and transpiration. This is equivalent to the average amount detected at such sites. The GST tracks the SAT (surface air temperature) in this region, except when it is below 0° C. Climatic warming in the winter time would not be detected by this method, except in the very southern, coastal part of this region. Proxy data indicate that winter temperatures have not changed significantly in the north. Therefore I suggest changing amounts of precipitation and their distribution in time are causing glacial recession.

GC41A-08 0830h POSTER

Synchronicity of Holocene climate changes in Europe and North America

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We estimated transitions in pollen diagrams from Europe using two sets of data. The first is radiocarbon dates from the European Pollen Database that are assumed to preferentially date transitions in vegetation. A second is the Pollen Assemblage Zones defined by palynologists in a series of regional summaries (Berglund, B., et al., eds. 1996. Palaeoecological events during the last 15 000 years. J Wiley). Major transitions in Holocene and late-glacial vegetation, as recorded in pollen diagrams, were widespread throughout Europe and synchronous with vegetation transitions identified in North America as well as major environmental changes recorded in North Atlantic marine records and Greenland ice cores. This synchronicity suggests that the major vegetation transitions in Europe during the Holocene and late glacial were primarily caused by large-scale climate changes.

URL: http://www.uottawa.ca/academic/arts/geographie/lpcweb/

GC41B CC: 516 A Thursday 0830h

Environmental Records With Anthropogenic Impacts I

Presiding: **J C Varekamp,** Wesleyan University**; T C Ku,** Wesleyan University

GC41B-01 0830h

The Eutrophication of Long Island Sound

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Long Island Sound (LIS) is an urban estuary that receives waste fluids from millions of coastal inhabitants. This influx of nutrients has led to high organic productivity with resulting hypoxia in the western and central sections of LIS during the summer months. We collected a set of short cores to determine the history of eutrophication and determined organic Carbon, Biogenic Silica, and stable isotope ratios on carbonates from core samples. Dating was accomplished with 137Cs, 210Pb and 14C determinations and the onset of Hg contamination, which was dated in land sections. Time constraints are not very precise because of variations in 14C reservoir effect and minor bioturbation effects. The tests of Elphidium excavatum were analyzed to determine paleo water temperature (from Mg/Ca), paleo salinity (from T and d18O) and dissolved O2 levels (from T, S and d13C). The various parameters were calibrated in modern LIS through measurements on live foraminifera' from surface sediment and water column analyses. The strong seasonal temperature fluctuations and variable life span of live collected foraminifera introduce a certain amount of noise into these calibrations. A simple mixing model was created for the Sound using river waters and pure seawater as endmembers. The paleo temperature record seems to indicate a warm period around 1000 BP , followed by the Little Ice Age. The dissolved O2 record for the last 1000 years shows mean annual values of about 70 percent saturation prior to 1800 AD, when mean values dropped to about 30 percent saturation. Eutrophication thus started as early as 1800 AD as indicated by the increased accumulation rates of organic carbon, biogenic silica and low d13C values in carbonate. The Sound has shown a trend of increasing productivity from east to west for many hundreds of years. Earlier warm periods lack evidence for hypoxia and we therefore surmise that the increase in organic productivity is the main driver for the modern hypoxia. The western LIS cores show possibly some evidence that the Sound has become less saline over the last few 100 years, possibly the result of changes in land use that has increased run off. Reductions in sewage and/or nutrient inputs most likely will reduce the occurrence and overall intensity of hypoxia, although climate will always modulate the strength of the hypoxia.

GC41B-02 0845h INVITED

Nitrogen Isotopic Ratio Records The Eutrophication History of Long Island Sound

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Increasing coastal population and industrialization has led to the steady degradation of the Long Island Sound (LIS) environment. Increased nutrient loading from sewage inputs has resulted in eutrophication and decreased summertime subsurface oxygen concentration particularly at its western end. It is critical to develop a detailed history of these environmental changes, both to understand causative processes and for design of optimal and cost effective remediation plans. We are developing a detailed time line of environmental changes in LIS over the last few centuries based on the study of geochemical and paleo-ecological proxies in geographically distributed sediment cores. Sediment nitrogen isotopic ratio (d15N) in particular is being used as an indicator of perturbations of the nitrogen biogeochemistry. Higher d15N is expected from sewage inputs as well as from the initiation of subsurface denitrification during low O2 conditions. Contemporary correlation between eutrophication intensity and d15N is seen in sediment core top data which show a substantial 4 per mil increase in d15N going from eastern to western LIS. This observation is consistent with greater nutrient loading toward New York City with its greater coastal population density. Downcore data from a site in western LIS show 4 per mil lower d15N prior to 200 years ago, documenting the point at which significant anthropogenic impact began. Increasing d15N over the last 200 years correlate with productivity proxies and other proxies for anthropogenic influence.

GC41B-03 0900h INVITED

Paleoredox Reconstructions on the Century Time Scale; Place of Molybdenum in the Toolbox

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The need to set realistic goals for restoration of coastal environments calls for knowledge of conditions prior to anthropogenic impacts. Environmental monitoring data mostly span less than 3 decades, whereas human impacts have accrued for several centuries. Therefore, the pristine state of coastal environments usually is not determinable from archived data. Where restoration of eutrophic or hypoxic-anoxic ecosystems is contemplated, paleoredox indicators in dated sediments can be used to fill the knowledge gap. The requirement that sediments be datable limits application of this approach to deep, anaerobic sediments that are minimally turbated physically or biologically. Examples of indicators that have been found useful in Chesapeake Bay are trace elements (Mo, U), isotopes (15-N), organic biomarkers (fatty acids, sterols), bulk components (TOC, TON, biogenic silica, degree of pyritization) and microfossils (ostracods, diatoms, foraminifera). Most of these, especially those depending on viability of indicator organisms, respond to multiple environmental forcing factors. They therefore do not provide information solely about paleoredox conditions. Molybdenum concentrations in sediments appear to be an exception. Although Mo is biologically an essential trace element, its concentration in coastal and estuarine waters is large relative to needs of organisms, so biological mechanisms affect its distribution in a minor and often undetectable way. Even though Mo is enriched in coal vs. continental crust and is an important component of stainless steels, anthropogenic sources of Mo rarely control Mo concentrations in coastal sediments. Seawater is a strong and uniform source of Mo, dampening temporal variations in other sources to estuarine and coastal waters. Molybdenum is deposited in sediments primarily in Mn oxydyroxides, in Fe mono- and disulfides and in organic materials. The first of these is unstable and redissolves in the anoxic sediments that are most suitable for dating. Fe monosulfides are also ephemeral, but may be important in the initial capture of Mo. Fe disulfides have been reported to be the chief host phases of sedimentary Mo, but there is also good evidence for a competing role for organic matter. Depending upon circumstances, the degree of Mo enrichment in sediments can be controlled by chemical reactions or by diffusion. The key chemical reaction is transformation of molybdate to thiomolybdates, which occurs when molecular hydrogen sulfide in pore waters is near or above 10 micromolar. Thiomolybdates can react with zero-valent sulfur donors, such as polysulfides, to produce dissolved species which are readily sorbed to pyrite surfaces and which are probably reactive to organic materials.

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Geochemical Screening of Contaminated Marine and Estuarine Sediments

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Waterways near urban centers have been subject to pollution by human activities for centuries. This process greatly intensified with the advent of the Industrial Revolution and the attendant exponential population increase in coastal areas. The co-occurrence of port facilities for ocean-going vessels, large factories, major power generating stations, dense automotive transportation networks, and massive wastewater outfalls, all in compact geographical areas, has produced severe environmental stress. In recent decades, the growing awareness of the seriousness of coastal urban environmental degradation has inspired intensive efforts at pollution prevention and remediation. To better understand pollution dynamics over time in an aquatic urban setting, a program of intensive sampling and analysis leading to the creation of geographic information systems (GIS) would be desirable. Chemical evaluation of sediments for pollution remains a costly and time-consuming procedure, particularly for organic analysis. Pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) offers a practical alternative for rapid, inexpensive molecular organic analysis, simply employing milligram quantities of dry, whole sediment. The compounds detected comprise an information-rich mixture of thermally extractable components and the products of the thermal decomposition of (bio)polymers present in the sample. These include PAHs, petroleum-derived hopanes, organonitrogen compounds, and linear alkylbenzenes, as illustrated with examples from Long Island Sound and the Passaic River (USA) and Barcelona harbor (Spain).

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Record of Environmental Change in San Francisco Bay, California

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Benthic foraminifera in a 3.52 m core recovered from San Francisco Bay, CA yield a 3,800-year sediment record of climate and environmental change. The microfaunal assemblage of the core contains abundant subtidal estuarine benthic foraminifers found today at shallow water depths (<10 m) in the bay. A Q-mode cluster analysis of the samples grouped them into two clusters and one outlier. Cluster A is dominated by the herbivorous species Elphidium excavatum; its abundance often comprises 70-90% of the foraminiferal assemblage. Today, the species typically resides in cold, estuarine waters. Its dominance in the core from 352-150 cm (1920 B.C. to A.D. 652) and 88-18 cm (from A.D. 1224 to A.D. 1980) suggests that this area of the bay has remained relatively cold and shallow for about 3400 years out of the last four millennia. Cluster B, the Ammonia beccarii-Elphidium gunteri association, occurs from 150-88 cm in the core and is interpreted as representing warmer and possibly lower oxygenated conditions from A.D. 652 to A.D. 1224. The outlier,