PP32A MCC: Level 1 Wednesday 1330h

The Last Interglacial II Posters *(joint with A, OS, C, GC)*

Presiding: **M Zhao,** Dartmouth College

PP32A-0275 1330h POSTER

Aquaculture-Based Calibration of *Mytilus edulis* as an Isotope Paleothermometer

Alan D Wanamaker[1,2] (207 581-2028; alan.wanamaker@umit.maine.edu)

Karl J Kreutz[1,2] (207 581-3011; Karl.Kreutz@maine.edu)

Harold W Borns[1,2] (207 581-2196; Borns@maine.edu)

Bruce Barber[3] (207 581-1476; bjbarber@maine.edu)

Douglas Introne[2] (207 581-2192; Introne@maine.edu)

[1]Department of Earth Sciences, University of Maine, 5790 Edward T. Bryand Global Sciences Center, Orono, ME 04469-5790, United States

[2]Climate Change Institute, University of Maine, 303 Edward T. Bryand Global Sciences Center, Orono, ME 04469-5790, United States

[3]School of Marine Sciences, University of Maine, 214 Libby Hall, Orono, ME 04469-5741, United States

Oxygen isotopic analysis of marine carbonate shells (δ^{18}Oc) is a standard paleoceanographic method used to record the chronology of seawater temperature change. Shell δ^{18}Oc is a function of seawater temperature, isotopic composition of the seawater (δ^{18}Ow - related to salinity), and any species-specific fractionation that occurs during biomineralization. Previous empirical calibrations of marine bivalves used estimates of time-series variability for the key parameters in the paleotemperature equation. These estimates limited the ability to quantitatively estimate paleotemperatures and salinities from any particular species of interest or environment. The relative abundance and broad geographical distribution of the intertidal bivalve *Mytilus edulis* makes it an ideal species for aquaculture-based isotope paleothermometry. To calibrate *M. edulis*, a four by three factorial design is being used to evaluate the effects of water temperature and salinity on isotopic uptake in mussel carbonate. This experimental design consists of four circulating temperature baths (8, 12, 16, and 20 $^\circ$ C), each containing three salinities (23, 28, and 33 ppt), with replicate environments for each temperature and salinity configuration. In mid-July of 2003, 4,800 juvenile mussels were collected in Salt Bay, Damariscotta, Maine, and 200 were placed in each configuration. The size (shell length) distribution of mussels, based on 100 randomly selected specimens, ranged from 9.8 mm to 20.2 mm with a mean size of 15.3 mm. This variation in shell length allows for quantification of vital effects based on age. Water samples for each configuration are being collected weekly, measured for salinity and analyzed for δ^{18}Ow. Mussels are being collected monthly, prepared, and microsampled in regions of new growth for δ^{18}Oc analysis. Initial results to be presented will include the time-series of δ^{18}Ow, δ^{18}Oc, temperature, and salinity. The calibrated paleotemperature equation developed from this study will be applied to fossil *M. edulis* shells collected in coastal Maine, and provide quantitative estimates of deglacial oceanographic conditions to test hypotheses that link the North Atlantic Oscillation, glacier dynamics, and climate variability ca. 15,000 - 13,000 ^{14}C years BP.

PP32A-0276 1330h POSTER

New gas Measurements in the GRIP ice Core: Rapid Interglacial Climate Variability Ruled out and Proposal for a Reconstruction of the Last Interglacial in Greenland.

Nicolas Caillon[1] (caillon@lsce.saclay.cea.fr); amaelle landais[1] (landais@lsce.saclay.cea.fr); jerome chappellaz[2] (jerome@lgge.obs.ujf-grenoble.fr); Jorge Peder Steffensen[3] (jps@gfy.ku.dk); marc delmotte[1] (delmotte@ipgp.jussieu.fr); jean jouzel[1] (jouzel@lsce.saclay.cea.fr); Valerie Masson-Delmotte[1] (masson@lsce.saclay.cea.fr); dominique raynaud[2] (raynaud@lgge.obs.ujf-grenoble.fr)

[1]IPSL/LSCE, Orme des merisiers, Gif s Yvette 91191, France

[2]LGGE, 54 rue moliere, st martin d'heres 83402, France

[3]Dpt of Geophysics, Julianes Maries Vej 30, Copenhagen 2100, Denmark

The disturbed stratigraphy of the ice in the lowest part (before 110 kyr BP) of the Greenland GRIP ice core has been demonstrated using gas measurements on a large depth scale. This is especially regretful since this period covers the previous interglacial corresponding to MIS 5e (130-120 kyr BP). Rapid isotopic variations on the scale of 20 cm are however experienced in the bottom of the GRIP ice-core with complicated chemical signatures that make them difficult to reconcile with disturbed stratigraphy of the ice. The d15N measurements associated with a simple modelling study lead to the solid conclusion that the most problematic of those rapid events (5e1) is not a climatic event. d18O of O2 is in agreement with a disturbed ice stratigraphy but recalls surprising features observed also on chemical data. Processes of diffusions after the mixing or even post-coring have to be involved to explain this profile; consequently we must place limits to the interpretation of some classical paleoclimatic proxies in small scale mixed ice. Despite these stratigraphy problems, we managed to propose a reconstruction of the disturbed GRIP chronology based on the succession of globally well mixed gas parameters. The GRIP d18Oice chronological sequence is obtained by comparing a new set of d18O of O2 and CH4 measurements from the bottom section of the GRIP core with their counterpart in the Vostok Antarctic profiles. This comparison clearly identifies ice from the penultimate glacial maximum (MIS 6: 190-130 kyr BP) in the GRIP core. Further it allows rough reconstruction of the last interglacial period and of the last glacial inception in Greenland.

PP32A-0277 1330h POSTER

Temperature changes in tropical oceans over the last 140.000 years based on δ ^{44}Ca, Mg/Ca and δ ^{18}O: Warming predates melting at glacial-interglacial transitions

Dorothee Hippler[1] (hippler@geo.unibe.ch)

Anne Mueller[2] (amueller@gm.ufz.de)

Anton Eisenhauer[3] (aeisenhauer@geomar.de)

Thomas F. Naegler[1] (naegler@geo.unibe.ch)

[1]Institute of Geological Sciences, University of Bern Erlachstrasse 9a, Bern 3012, Switzerland

[2]UFZ Environmental Research Centre Halle-Leipzig Ltd, Brueckstr. 3a, Magdeburg 39114, Germany

[3]Marine Environmental Sciences, GEOMAR Wischhofstrasse 1-3, Kiel 24148, Germany

Here we present a refinement of the current δ ^{44}Ca-temperature calibration (Naegler et al. 2000) based on modern and fossil planktonic foraminifera *Globigerinoides sacculifer* demonstrating the high potential of Ca isotopes as an SST-proxy. Ca isotope measurements performed on modern specimen of *G. sacculifer* result in a quantitatively resolvable δ ^{44}Ca change per degree Celcius defined by a linear regression. The SST(Mg/Ca)-cross-calibrated thermometer based on fossil *G. sacculifer* from sediment core GeoB1112 (tropical East Atlantic) supports the refined calibration in slope and absolute temperatures. The slope of the observed temperature dependence is also identical to the published calibration based on cultured specimen. However, there is an offset of approximately 3.5°C. The refined δ ^{44}Ca-thermometer tend to predict lower sea surface temperatures than the published δ ^{44}Ca-thermometer. The most probable reason is that cultured samples are biased. Extending a multi-proxy approach, application of this independent method to fossil *G. sacculifer* covering the past 140.000 years of sediment core GeoB 1112 from tropical East Atlantic confirms known changes in SST reflecting glacial-interglacial cycles. Pronounced changes of δ ^{44}Ca are found at Terminations I (Holocene-LGM) and Termination II (MIS 5e-6). According to the refined temperature calibration the glacial-interglacial amplitude of the record is $3.0 - 3.5^\circ$C for Termination I and slightly higher for Termination II with $4.0 - 4.5^\circ$C, respectively. Interglacial MIS 5e is characterised by a double peak in SST. Both independent proxies (δ ^{44}Ca, Mg/Ca) indicate that for both terminations the increase in SST predates ice melting as reflected by the oxygen isotope record by several thousend years. This is in line with previously published data for the Pacific. Additionally we will present first results of tropical temperature changes in the south-western Indo-Pacific Warm Pool. References: Naegler, T. F. et al. (2000) G3, 1, 2000GC000091.

PP32A-0278 1330h POSTER

Marine Isotopic Stage 5e in the Southwest Pacific: Similarities with Antarctica and ENSO Inferences

Carles Pelejero[1,2] (61-2-61259967; Carles.Pelejero@anu.edu.au)

Eva Calvo[1,2] (61-2-61253348; Eva.Calvo@anu.edu.au)

Graham A Logan[2] (61-2-62499460; graham.logan@ga.gov.au)

Patrick De Deckker[3] (61-2-61252057; patrick.dedeckker@anu.edu.au)

[1]Earth Environment, Research School of Earth Sciences, The Australian National University, Mills Rd., Canberra, ACT 0200, Australia

[2]Petroleum and Marine Division, Geoscience Australia, GPO Box 378, Canberra, ACT 2601, Australia

[3]Department of Geology, The Australian National University, The Australian National University, Canberra, ACT 0200, Australia

Here we present a detailed record of alkenone-derived sea surface temperature (SST) offshore western New Zealand (Core SO136-GC3; 42°18'S, 169°53'E, 958m water depth), covering the penultimate deglaciation and last interglacial. We focus on Marine Isotopic Stage 5e, which is characterized by three main singular features: first, maxima SSTs (18.5 to 19.5°C) are 3.5 to 4.5°C higher than today for the studied site. Second, surface warming peaked about 4.5 kyr ahead of the ice volume interglacial minimum recorded by planktonic foraminifera oxygen isotopes. And third, the decline of temperatures towards Stage 5d started earlier than ice volume minimum, leaving a mean duration for the whole warm stage of only about 5 kyr. These features of Stage 5e off New Zealand exhibit striking similarities to the record of air temperatures at Vostok, Antarctica. In addition, changes in latitudinal SST gradients for the Southwest Pacific have also been assessed by SST comparison between our core and published SST data from a key equatorial core (ODP 806B; 0°19.1'N, 159°21.7'E, 2520m water depth). This comparison shows that a significantly lower thermal gradient characterized the austral western Pacific Ocean during the whole deglaciation and Stage 5e. In this region, low modern SST gradients usually parallel positive values of the Southern Oscillation Index and thus La Niña conditions. By inference, we suggest that our assessed low gradients might be indicative of a prevalence of La Niña conditions, particularly during early Stage 5e.

PP32A-0279 1330h POSTER

High Resolution Characterization of the Asian Monsoon Climate During MIS 5 and 6, Dongge Cave, China

Megan J. Kelly[1] (1-612-626-7663; kell0738@umn.edu); R. Lawrence Edwards[1] (edwar001@umn.edu); Hai Cheng[1] (cheng021@umn.edu); Daoxian Yuan[2] (dxyuan@karst.edu.cn); Yanjun Cai[3] (ycai@loess.llqg.ac.cn); Meiliang Zhang[2] (mlzh@karst.edu.cn); Yushi Lin[2] (ysln@karst.edu.cn); Zhisheng An[3] (anzs@loess.llqg.cn)

[1]Department of Geology and Geophysics, University of Minnesota, 310 Pillsbury Drive SE, Minneapolis, MN 55455, United States

[2]Karst Dynamics Laboratory, The Ministry of Land and Resources, 40 Qixing Road, Guilin 541004, China

[3]State Key Lab of Loess and Quaternary Geology, Institute of Earth Environment, Chinese Academy of Sciences, Xi'an 710075, China

Speleothem samples from Hulu (eastern China, 32°30'N, 119°10'E) and Dongge (southern China, 25°17'N 108°5'E) caves provide a nearly continuous record of the Asian monsoon over the last 160 ka. Based on the δ^{18}O records of two stalagmites from Dongge Cave (D3 and D4), we have shown that Termination II was an abrupt climatic transition occurring at 129.3 $\pm$ 0.9 ka marking the onset of the Last Interglacial Asian Monsoon (Yuan et al., in review). This earlier work had relatively coarse resolution with Termination II bracketed by a single pair of δ^{18}O measurements $\sim$200 years apart in age, providing an upper limit for the rapidity of the climate transition. The Last Interglacial Asian Monsoon lasted 9.7 $\pm$ 1.1 ky, also ending abruptly ($<$300 y, limited by sample resolution) at 119.6 $\pm$ 0.6 ka. The full glacial-interglacial amplitude is $\sim$5$^o/_{oo}$, with the abrupt transitions into and out of the Last Interglacial having a range of approximately 3$^o/_{oo}$. Higher resolution isotope sampling (averaging $\sim$30 y, with $\sim$10 y resolution over Termination II) from stalagmites D3 and D4 has provided a more detailed account

of δ^{18}O variations over much of MIS 5 and 6. Precise ^{230}Th dating has replicated the chronology of the samples within error. The higher resolution data set confirms the timing of Termination II, placing it at 128.9 $\pm$ 0.9 ka, BP. The bulk of this transition ($\sim$1.7$^{o}/_{oo}$) took place within 60 years, with the total range of the transition being $\sim$3$^{o}/_{oo}$. A major issue is climate stability during interglacial periods. There were some early indications of major instability of the Last Interglacial climate (GRIP members, 1993, Nature 364, 203-207). Whereas our record shows no evidence for instability with glacial-interglacial δ^{18}O amplitudes, there is clear evidence for abrupt $\sim$1$^{o}/_{oo}$ shifts with periods on the order of several hundred years during the Last Interglacial (supporting some earlier work, An and Porter, 1997, Geology 25, 603-606). Similar to the features found by Dykoski et al. (this meeting) during the Holocene in the Hulu/Dongge record (see also Bond et al., 2001, Science 294, 2130-2136), these shifts cover approximately of the amplitude of millennial-scale events during the Last Glacial Period in China (Wang et al., 2001, Science 294, 2345-2348). Thus, it appears that abrupt centennial or millennial-scale changes are a general feature of interglacial periods, albeit with significantly smaller amplitudes than events during glacial periods.

PP32A-0280 1330h POSTER

Paleoceanographic Change off Central Japan Since the Last 150 ka Recorded in an IMAGES Core.

Tadamichi Oba (81117062233; oba-tad@ees.hokudai.ac.jp)

A long core (45.82 m length) was recovered from 2,224 m water depths off the central Japan during the IMAGES cruise in 2001. A multi-disciplinary study was carried out on this core by analyzing the following: color, grain size, mineral composition, paleomagnetism, d18O, d13C Opal, CaCO3, species of diatoms, coccolithophorids, radiolaria, planktonic foraminifera and benthic foraminifera, CaCO3 preservation, Uk37O, TOC, C/N, d13CTOC, d15NTOC, biomakers and pollen. The following main results were obtained. The d18O curve of benthic foraminifera is very similar to the standard oxygen isotope curve, suggesting continuous deposition over the last 150 ka. All warm water indices yielded by the four microfossil assemblages (diatoms, coccolith, radiolaria, planktonic foraminifera) show temperature decreases during the MIS 2 and 6, and increases during the MIS 5, although their correlation coefficients with each other are not always high (between 0.5 and 0,6). The Alkenon and oxygen isotope-derived temperature s (19?C) at the core top agree with the modern SST in this region. The isotope SST at the MIS 2 and 6 were 12-13?C, which are seen today about 4.5 degree latitude north than the core site. Similar migrations in SST are inferred from the coiling ratio of Neogloboquadrina pachyderma. The C/N ratio, d13CTOC and d15NTOC indicate that the TOC is mainly of marine origin, although terrestrial origin slightly increases during the MIS 6. The curve of the warm pollen index is similar to the d18O curve of G. bulloides, except for the MIS 6 and 5e when the land temperature changes inferred from the pollen curve precede the d18O curve. Variabilites in detritus transport and onland vegetation suggest higher precipitation on the central Japan during MIS 1 and the later half of MIS 5. Highest precipitation occurring during MIS 5 is attributed to be increased temperature contrast between air and sea surface due to significant drop of air temperature along the Pacific margin of the central Japan.

PP32A-0281 1330h POSTER

Sensitivity of Paleoreconstructions to Measurement Accuracy of the Glacier Borehole Temperature and Ice Core Geochemical Data

Oleg V. Nagornov[1] (7 095 324 0425; nagornov@dpt39.mephi.ru)

Yurij Konovalov[1] (7 095 324 0425; konovalov@dpt39.mephi.ru)

[1]Moscow Engineering Physics Institute (State University) Department of Environmental Modeling, Kashirskoe Shosse 31, Moscow 115409, Russian Federation

This study is aimed to analyze sensitivity of various approaches to the past surface temperature reconstructions based on the glacier borehole temperature-depth profiles and the ice-core geochemical data. Except test study we compare results of inversions for Antarctica sites: South Pole, Vostok, and Siple Dome. The reconstructions are based on the solutions of the well and ill-posed inverse problems.

PP32B MCC: Level 1 Wednesday 1330h

Terrestrial and Lacustrine Records of Past Climate Posters *(joint with A, C, GC)*

Presiding: **B Brandsd́ottir,** Science Institute, University of Iceland

PP32B-0282 1330h POSTER

Obsidian hydration profiles and dating

Youxue Zhang[1] (1-734-763-0947; youxue@umich.edu)

Xiaomei Xu[2] (1-949-824-9027; xxu@uci.edu)

[1]The University of Michigan, Dept of Geological Sciences, Ann Arbor, MI 48109-1063, United States

[2]University of California, Dept of Earth System Science, Irvine, CA 92697-3100, United States

Obsidian hydration dating (or more generally, glass hydration dating) has been investigated as a method to determine the age of archeological samples (e.g., Lee et al., 1974; Freidman and Long, 1976; Anovitz et al., 1999; Liritzis and Diakostamatiou, 2002; Riciputi et al., 2002). This presentation attempts to lay the theoretical foundation for understanding glass hydration. Treating hydration as diffusion into a semi-infinite medium, a theoretical foundation requires an understanding of the following: (1) water concentration at the surface (water solubility in glass and whether equilibrium is reached); (2) water diffusion in glass; (3) diffusion behavior for periodically changing temperature and periodic boundary condition; (4) possible dissolution of obsidian in water, and (5) the effect of long-term trends in temperature (global warming) and humidity (such as drying or uplift of the region, etc.). Previous experimental data and models are extrapolated to room temperature on water speciation, solubility and diffusivity. Such information is compared with that extracted from measured obsidian hydration profiles. The effect of periodic T and surface conditions on diffusion is analytically examined. We conclude: (i) molecular H2O is the dominant species at room T; (ii) the surface water concentration in obsidian hydration is roughly consistent with extrapolated water solubility at room T and a humidity of 1; (iii) high-T water diffusion data cannot be extrapolated to room T (Leschik et al., 2003); and (iv) the most reliable part of a hydration profile is at depth greater than 0.6 micrometers. Because the total hydration depth is proportional to the square root of the integration of diffusivity with respect to time, it is sensitive to not only age (for dating), but also to the variation of diffusivity, which depends on mean annual T and humidity. Only when the annual mean diffusivity is constant, and when there was no dissolution of obsidian, would it be reliable to determine the age. On the other hand, the sensitivity of the diffusivity and hence the hydration depth to climate conditions (especially humidity) means that obsidian hydration profiles may be a good climate indicator if age of obsidian can be independently determined by, e.g., C-14 dating (Riciputi et al., 2002).

PP32B-0283 1330h POSTER

Behaviour of Structural Carbonate Stable Carbon and Oxygen Isotope Compositions in Bioapatite During Burning of Bone

L E Munro[1] ((519) 661-3881; lmunro3@uwo.ca)

F J Longstaffe[1] ((519) 661-3041; flongsta@uwo.ca)

C D White[2] ((519) 661-2111 ext. 85091; white2@uwo.ca)

[1]The University of Western Ontario, Dept. of Earth Sciences, London, ON N6A 5B7, Canada

[2]The University of Western Ontario, Dept. of Anthropology, London, ON N6A 5C2, Canada

Bioapatite, the principal inorganic phase comprising bone, commonly contains a small fraction of carbonate, which has been substituted into the phosphate structure during bone formation. The isotopic compositions of both the phosphate oxygen and the structural carbonate oxygen are now commonly used in palaeoclimatological and bioarchaeological investigations. The potential for post-mortem alteration of these isotopic compositions, therefore, is of interest, with the behaviour of structural carbonate being of most concern. In bioarchaeological studies, alteration of bone isotopic compositions has the potential to occur not only during low-temperature processes associated with burial but also during food preparation involving heating (burning, boiling). Here, we examine the stable isotopic behaviour of structural carbonate oxygen and carbon, and coexisting phosphate oxygen during the burning of bone. Freshly deceased (6<8 months) white-tailed deer leg bones (*Odocoileus virginianus*) were collected from Pinery Provincial Park, Ontario, Canada. Each long bone was sectioned and incrementally heated from 25 to 900°C, in 25° intervals. The samples were then ground to a standardized grain-size (45<63μm), and changes in bioapatite crystallinity (CI) were determined using powder X-ray diffraction (pXRD), and Fourier transform infra-red spectroscopy (FTIR). Combined differential thermal and thermogravimetric analyses (DTA/TG) were used to evaluate weight loss and associated reactions during heating. Stable carbon isotope compositions of the bioapatite remain relatively constant ($\pm$1$^{o}/_{oo}$) during heating to 650°C. A 4$^{o}/_{oo}$ increase in stable carbon isotopic composition then occurs between 650-750°C, accompanied by an increase in CI, followed by a 10$^{o}/_{oo}$ decline at temperatures above 800°C, as carbonate carbon is lost. Carbonate and phosphate oxygen isotopic compositions are correlated over the entire heating range, with carbonate being enriched relative to phosphate by about 8-10$^{o}/_{oo}$ below 500°C, 5-6$^{o}/_{oo}$ between 500-700°C, and 8-10$^{o}/_{oo}$ above 700°C. CI and oxygen isotopic compositions of carbonate and phosphate are not well correlated. Only modest CI changes are recorded from 25-675°C, compared with much larger changes in oxygen isotopic composition, especially above 300°C. On average, original isotopic compositions are largely preserved for both phosphate ($\pm$1$^{o}/_{oo}$) and carbonate ($\pm$2$^{o}/_{oo}$) oxygen at <300°C. At higher temperatures, however, both phosphate and carbonate oxygen in the bioapatite are systematically depleted of oxygen-18 relative to original values.

PP32B-0284 1330h POSTER

Pleistocene Glaciations on the Northwestern Tibet

Ping Kong[1] (86-10-62007823; pingkong@mail.igcas.ac.cn)

Chunguang Na[1] (n-c-g@163.net)

Feixin Huang[1] (huangfeixin@sina.com)

David Fink[2] (fink@ansto.gov.au)

[1]Institute of Geology and Geophysics, Chinese Academy of Sciences, P.O. Box 9825, Beijing 100029, China

[2]Physics Division, Australian Nuclear Science and Technology Organisation, ANSTO, Menai, NSW 2234, Australia

As a result of its immense size and high elevation, the Tibetan plateau plays a major role in affecting global climatic changes, and in particular the Asian monsoon system. Consequently knowledge of its glacial evolution during the Quaternary is an essential parameter. However, the chronology and extent of Quaternary glaciations on the Tibetan plateau is still in debate. Based on ice cores and other geological settings from the Tibetan plateau, it is inferred that temperatures during LGM were depressed by 6-9 $^{\circ}$C. Kuhle (1998) proposed an extensive ice sheet on the Tibetan plateau during LGM, whereas others believe that, because of extreme aridity, the ELA depression in the western and interior sections is less than 300m. Thus, given that a large fraction of the Tibetan plateau surface would be below the ELA during LGM times, the extent of the proposed ice sheet would presumably be limited. We determined in situ cosmogenic nuclides Be-10 and Al-26 in young volcano samples located in Ashikule basin, western Kunlun Shan. The eruption ages of the samples are 130$\pm$40ka, 340$\pm$10ka and 780$\pm$140ka, dated by the K-Ar method. The exposure ages of the samples are, however, 70$\pm$7ka, 150$\pm$7ka, 160$\pm$8ka, respectively. All samples analyzed possess lava flowing textures, which suggests no erosion since eruption. Field observations indicate no sediment nor vegetation on the samples. Thus, the age differences most likely reflect ice and snow cover on the samples. The current ELA in western Kunlun Shan is about 6000m, whereas the samples are located at an elevation of 4800m. This implies that ELA depression in the western part of the Tibetan plateau was most likely larger than 1200m during LGM. If the interior of Tibetan plateau has a similar ELA depression, a large part of Tibetan plateau surface would be above the ELA during LGM. Therefore, Pleistocene ice coverage on the Tibetan plateau may be more extensive than previously recognized. Kuhle (1998) Quaternary International 45/46,71-108.

PP32B-0285 1330h POSTER

Cosmogenic Dating of Moraines of the Local Last Glacial Maximum in the Tropical Andes

Jacqueline A. Smith[1] (315-443-2672; jasmit10@syr.edu)

Geoffrey O. Seltzer[1] (315-443-4980; goseltze@syr.edu)