22nd Annual

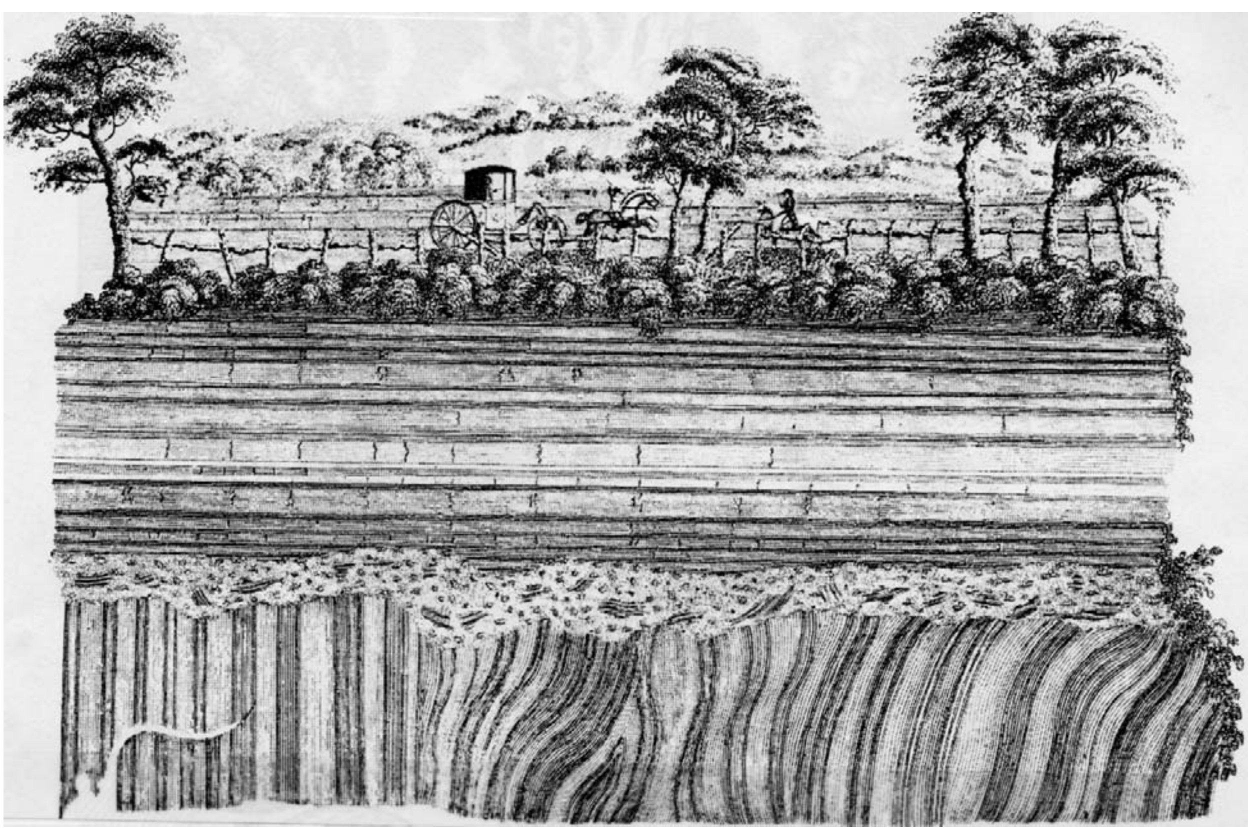
(23rd according to Richard Yuretich)

Five College Geology Faculty Symposium

Hampshire College,   Amherst, Massachusetts

September 28, 2001, 3:30pm

West Lecture Hall, Franklin Patterson Hall



PROGRAM

3:30	Welcome/Introductions
3:35	**Darby Dyar, Mount Holyoke College** Going InXANE over Iron in Feldspar
3:55	**Ed Belt, Amherst College** Marine Flooding Intervals within Fresh Water Tongue River Member (Fort Union Fm-Paleocene), Western Williston Basin
4:15	**Stephen Burns, University of Massachusetts** Rain, rain, go away, Come again another day: Using Speleothems as a Paleoclimate Indicator in Southern Arabia
4:35	**John Reid, Hampshire College** $^{87}Sr/^{86}Sr$ in Icelandic Sheep, Mexican Tortillas and the Teeth of African Slaves Buried in New York City; What's the Connection?
4:55	**Julie Brigham-Grette, University of Massachusetts** Tors, Eustatic Shorelines, and Mammoths: Evidence Against Ice Sheets on Wrangel Island, East Siberian & Chukchi Seas
5:15	Pizza and Refreshments in FPH Rooms 105-106

Going InXANE over Iron in Feldspar

Darby Dyar
Mount Holyoke College

Feldspar is the most commonly-occurring mineral group in the Earth's crust, and probably in the crusts of other terrestrial planets as well. Feldspar has a relatively simple formula (XZ_4O_8, where X can be Na, Ca, B, or K and Z can be Al or Si). However, the most interesting elements are the ones that it contains as trace components, because they may be used to understand how, where, and under what conditions the feldspar crystallized. I am particularly interested in the iron contents of feldspar, because they can tell us a lot about how much oxygen was present when the crystals formed.

However, iron is an extremely difficult element to analyze. In this talk, I review some of the bodies in our solar system where feldspar is probably present. I will then discuss the analytical technique of synchrotron micro-XANES (X-ray Absorption Near-Edge Structure) spectroscopy, which my students and I are using to study iron in feldspars from various places in the solar system. I'll show some preliminary results, and talk about the pitfalls of developing a new method! The talk will conclude with some optimistic thoughts of future directions for this technique, and for our work on terrestrial and extraterrestrial feldspars.

MARINE FLOODING INTERVALS WITHIN FRESH WATER TONGUE RIVER MEMBER (FORT UNION FM-PALEOCENE), WESTERN WILLISTON BASIN

Belt, E. S., Dept. Geology, Amherst College, Amherst, MA 01002; **Curran**, H. A., Dept. Geology, Smith College, Northampton, MA 01063; **Diemer**, J. A., Dept. Geography & Earth Sciences, UNC-Charlotte, Charlotte, NC 28223; and **Tibert**, N. E., Dept. Geology, Smith College, Northampton, MA 01063.

The Tongue River Member is extensively exposed from eastern Montana to western North Dakota. It was deposited on an alluvial plain, and was the result of many brief episodes of crevasse splay and interdistributary bay deposition. Trunk (i.e. thick) channel deposits are rare. This facies resulted from a complex interplay of fluvial and marine facies with the source of marine water being the Cannonball Sea.

Until recently only fresh water body fossils (Unionid bivalves, Viviparid gastropods) were reported the Tongue River, whose facies were thought to be entirely of fresh water origin. We recently reported marine trace fossils at discrete horizons from four districts (Miles City, Locate, Terry (all in MT), and Little Missouri River, (in ND)) all within the lower 85 m of Tongue River strata. The most up-to-date list of ichnofossils includes (in order of abundance): *Skolithos linearis*, "*Skolithos*", *Teichichnus*, *Thallassinoides*, *Diplocraterion*, *Arenicolites*, *Monocraterion*, *Rhizocorallium*, *Ophiomorpha* and *Planolites*.

Coscinodiscus sp, a marine diatom, has been reported (David Harwood) from a basal burrow bed in the Tongue River Member at Terry, Montana. Those beds also included the greatest number of diverse trace fossils of all horizons examined. Work by Tibert continues to extract ostracodes (all to date have been fresh water); in the future, hopefully, foraminifera will be found.

The Cannonball Sea, to the east in central North and South Dakota and adjacent Canada, was responsible for the brackish-water horizons in the lower Tongue River Member. These beds are not likely the result from a Williston Basin-wide tectonic or eustatic event, but from avusion, delta-lobe switching, and compactional processes because no single ichnotaxa horizon can be correlated with another. The Cannonball Sea was a remnant of the late Cretaceous interior sea; it lasted until the early Tiffanian-2 (NALMA date) in the Williston Basin (Little Missouri River district).

The boundary between the Tongue River Member and the underlying Lebo or Ludlow members was traditionally considered a time-line that was correlated throughout the western Williston Basin (see Belt, *et al.*, 1992, fig. 2). Recent pollen work by the late Don Engelhardt (unpubl., 1999, ESRI, Univ. So. Carolina), and on-going work by Tim Kroeger (Bemidji State Univ., Bemidji, MN) shows that this boundary transgresses most of the P-3 pollen zone, younging from Miles City eastwards to the Little Missouri River. Because the P-3 interval is 3 Ma in length, the diachroneity from west to east probably exceeds 1 Ma. The Tongue River - Lebo/Ludlow contact, therefore, is an unconformity, and is found in the field to be marked by incised paleovalley fills that vary from 12 m to 23 m in depth.

Rain, rain go away, Come again another day: Using Speleothems as a Paleoclimate Indicator in Southern Arabia

Stephen J. Burns
Dept. of Geosciences, University of Massachusetts

The goal of this research is to investigate the nature and causes of climate variation in southern Arabia using speleothems, deposits of calcium carbonate that are precipitated from groundwaters in caves. The approach taken combines studies of modern caves and cave waters, H isotope analyses of water from fluid inclusions in modern and ancient speleothems, high resolution O and C stable isotopic analyses of recent and well-dated ancient speleothems and spectral analyses of the isotopic time series. We have worked on samples from two areas: Hoti Cave in northern Oman, and several caves in the Salalah region of southern Oman.

On timescales of 10s to 100s of ky, growth periods and oxygen isotope chemistry of samples from Hoti Cave are related to large scale fluctuations in the position of the monsoon rainfall belt. A composite record of the ages and oxygen isotope values of 11 large speleothems shows that they grew during discrete periods: the early to mid-Holocene (6.2 to 10.5 ka), 78-82 ky BP, 117-130 ky BP, 180-210 ky BP, and 300-325 ky BP. Each growth phase is marked by very negative $\delta^{18}O$ values, a characteristic of monsoon rainfall. The growth phases also all coincide with interglacial periods in the marine oxygen isotopic record, suggesting that during peak interglacials the monsoon belt moves far northward of its present position and brings heavy rainfall to much of southern Arabia.

Speleothems can also provide very high-resolution records of monsoon variation. For the Holocene pluvial period (6.2 to 10.5 ka) speleothem $\delta^{18}O$ values yield a record of variation in monsoon intensity with an average resolution of 4 years. Comparison of speleothem $\delta^{18}O$ values with atmospheric ^{14}C measured in tree-rings provides solid evidence that both signals are responding to the same forcing. Because variations of ^{14}C are attributed to changes in global solar radiation, the similarity of the two records indicates a strong solar influence on the monsoon. Active stalagmites from southern Oman can be used to investigate more recent monsoon variability at up to annual resolution. Stalagmite S3 holds three essentially independent climate records: annual layer thickness and oxygen and carbon stable isotope ratios of speleothem carbonate. All three of these factors vary primarily in response to changes in the amount of precipitation. A strong coherence is observed between S3 $\delta^{18}O$ values and Indian Ocean SST (Seychelles coral $\delta^{18}O$). The further demonstrated coherency between the latter and Pacific climate records suggests that on the decadal scale, monsoon rainfall variability originate in the tropical Pacific and can be related to decadal ENSO variability.

$^{87}Sr/^{86}Sr$ IN ICELANDIC SHEEP, MEXICAN TORTILLAS AND THE TEETH OF AFRICAN SLAVES BURIED IN NEW YORK CITY; WHAT'S THE CONNECTION?

John Reid
School of Natural Science, Hampshire College

In 1991, 408 burials of 18th century enslaved Africans were discovered in lower Manhattan. We have analyzed $^{87}Sr/^{86}Sr$ in tooth enamel and dentine in 31 of these individuals as well as in two burials and the local well water from near Elmina, Ghana, a major slave shipment port from which many NYC slaves were sent. Since $^{87}Sr/^{86}Sr$ is particularly high in the ancient high Rb/Sr cratons of west Africa, we felt that Sr isotopes might distinguish New York-born from African-born individuals. About 1/3 of all burials display decoratively filed teeth, an African custom generally repressed in the New World. Twelve of the 31 analyzed individuals (young people ages 4-25) lack decorative modification and show tightly clustered $^{87}Sr/^{86}Sr$ in dentine and enamel (~0.71159 +/-0.00072). This value seems to be the indigenous NYC $^{87}Sr/^{86}Sr$ composition, and thus the group are probably native New Yorkers. The remaining nineteen with filed teeth show enamel $^{87}Sr/^{86}Sr$ ranging widely (0.7085 to 0.7275). Most of the modified group show dentine $^{87}Sr/^{86}Sr$ generally quite unlike that in their enamel, and closer than the enamel to 0.71159 whether their enamel fell above or below the "NYC" value (avg dentine: 0.71240+/-0.00185). Two modified individuals have the NYC value, and one (#165) shows enamel ~0.718 and dentine ~0.719. The enamel-dentine differences may be due to physiological reworking of dentine Sr during later life, or to diagenetic alteration after death. If, as suggested by #165's result, reworking during life is the more important, a rough estimate of residence time in NYC may be derived from the proximity of the dentine $^{87}Sr/^{86}Sr$ to 0.71159 relative to the enamel value. At 0.7355, the Ghanian well water is our highest measured ratio. The dentines of the Ghanian teeth show $^{87}Sr/^{86}Sr$ closer to 0.7355 than the corresponding enamel, also suggesting that these individuals were not native to their place of burial.

As part of a nutritional study aimed at understanding the possible connection between landscape, diet and pervasive moderate malnutrition in a group of Mexican villages ~150 km NW of Mexico City, we have analyzed $^{87}Sr/^{86}Sr$ in soils, well waters, deciduous teeth and a variety of dietary items. The major food (up to 80% of calories for some individuals) is tortillas. The study serves as something of a control for the NYC study, though the results are unanticipated. In tortilla preparation, corn is boiled in Ca(OH)2 derived from slaked limestone (whose $^{87}Sr/^{86}Sr$ differs strongly from the local landscape), and the long and short of it is that [Sr], $^{87}Sr/^{86}Sr$, (and [Ca]) in human teeth and bones are dominated by this additive. In Icelandic sheep bones, $^{87}Sr/^{86}Sr$ also do not match the local landscape. There it appears that 50% of Sr and up to 80% of Ca in the sheep bones are reprocessed sea water falling in rain and snow. These considerations must be addressed in any Sr isotope-based dietary/archaeological reconstruction, but it appears that the NYC story may lack this complication.

Tors, Eustatic Shorelines, and Mammoths: Evidence Against Ice Sheets on Wrangel Island, East Siberian & Chukchi Seas

Lyn Gualiteri[1], Julie Brigham-Grette[2], Sergey Vartanyan[3] and Pat Anderson[1]

[1]Quaternary Research Center, University of Washington, Seattle, WA 98195
[2]Department of Geosciences, University of Massachusetts, Amherst, MA 01003
[3]Wrangel State Reserve, Ushakovskoye, Chukotka Region, Russia 687870

Assumed glacial flutings on the Chukchi Rise in the Arctic Ocean have reinvigorated hypotheses concerning the past presence of some type of ice sheet or ice shelf on the Chukchi and/or East Siberian sea shelf. Field work on Wrangel Island has been aimed at determining the glacial and sea level history of this geographically strategic island to address these various hypotheses. Cosmogenic isotope ages (Be and Al) on bedrock are all older than 35 ka years dating, at a minimum, the rates of pervasive periglacial processes. Tors, commonly forming columns 10 m high, are ubiquitous throughout the mountains of Wrangel Island. Eustatic shorelines (and not glacioisostatic shorelines) across the northern tundra plain marked by remanent marine sediments and ancient barrier beaches up to 40 m above sea level are all older than the range of radiocarbon dating (>50 ka) and yield amino acid age estimates (D/L aspartic as well as aIle/Ile) in excess of 400-500 ka, similar to sediments found on the Alaskan North Slope. Radiocarbon dates on mammoth bones, teeth, and tusks and other animals (Rhinos, bison) yield ages that range continuously through time from >38 ka to 3700 years indicating the local presence of large mammals during the Last Glacial Maximum (LGM) and most of the Holocene (Vartanyan et al, 1993, Nature). These data preclude the presence of an ice sheet during the LGM and probably over the past half million years. Glacial ice extent on the island during the LGM was limited to a few small north-facing cirque glaciers. An ice sheet over or near Wrangel Island could not have formed the flutings on the Chukchi Rise in at least the last four or five major glacial/interglacial cycles.