Evidence for late MIS3 abrupt climate change preserved in the Delmarva Peninsula stratigraphic record

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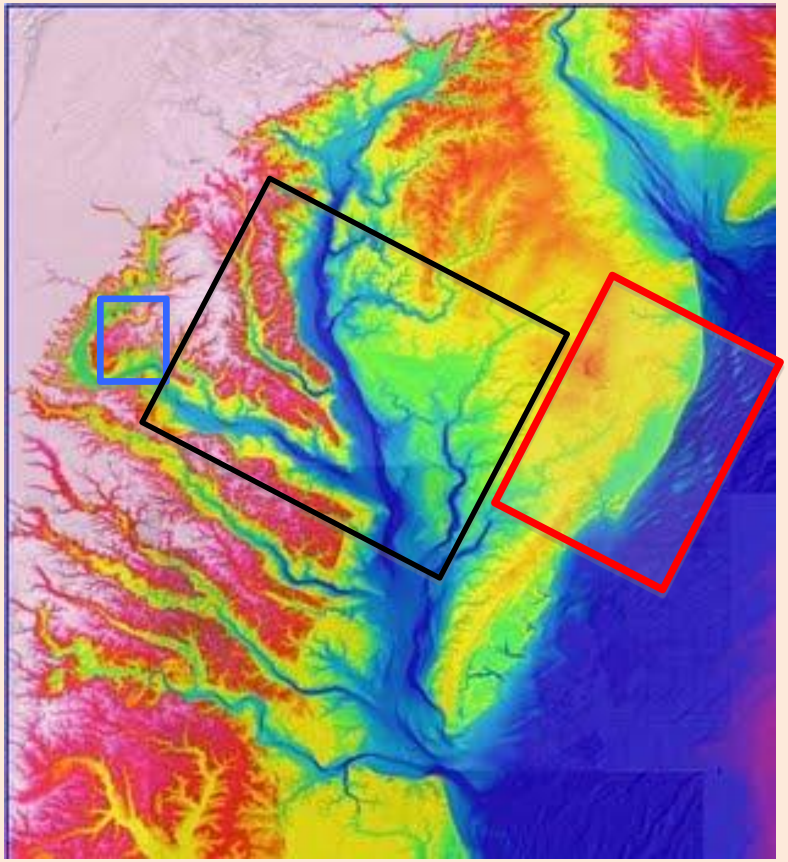
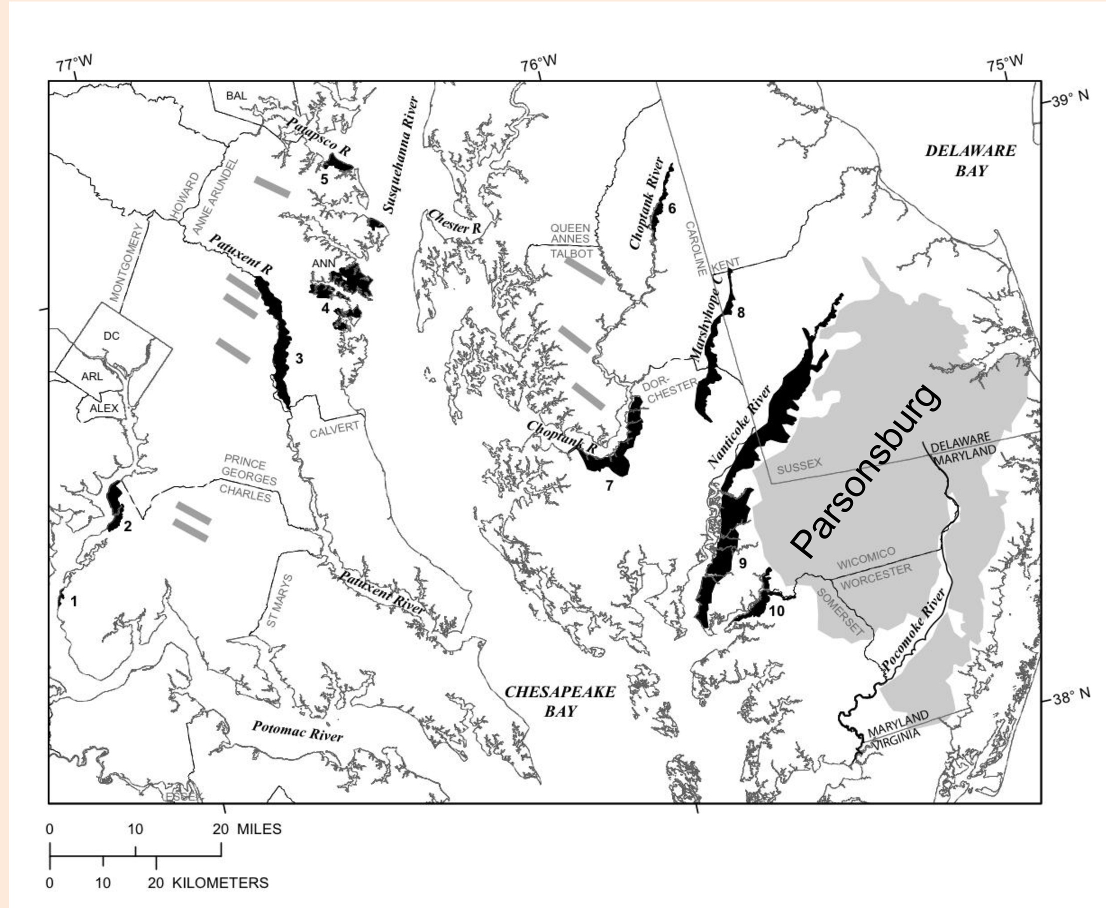
The history of landscape and vegetation response to climate change is important to developing regional and smaller scale climate models . We report here on an abrupt, periglcial landscape transition in late OIS3, at about 31ka.

We have multi-proxy records (relative sea level, pollen, and eolian landforms) that bracket this transition and provide comparisons and contrasts with other northern hemisphere records.

Climate change produced the Parsonsburg Sand (Denny and Owens, 1979). This eolian map unit, and associated periglacial features produced by permafrost and thermokarst, is a valuable record of local climate between ~31ka and ~13ka. It overlies late Quaternary marine and estuarine formations.





- The Parsonsburg Sand (1200 km^2) and source-bordering dunes (400km^2) overly Pliocene to late-Quaternary ***estuarine and marine*** deposits west of Chesapeake Bay and on Delmarva.
- We are developing Paleotemp & Paleoprecip reconstructions based on pollen, dunes and cryogenic deformation features.
- The blue box outlines Hybla Valley which contains a pollen record from estuarine and fluvial sediments deposited in the Potomac Valley.

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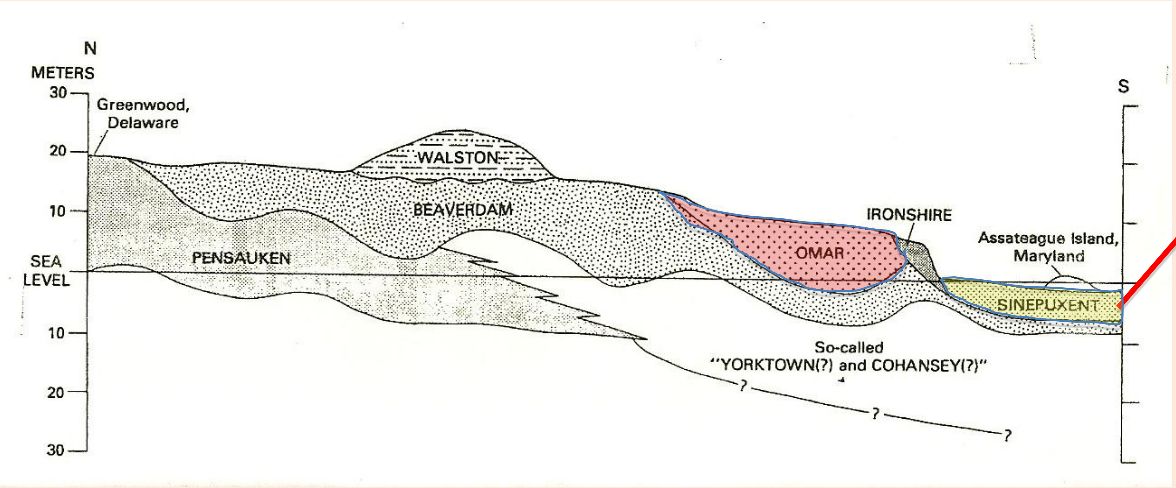
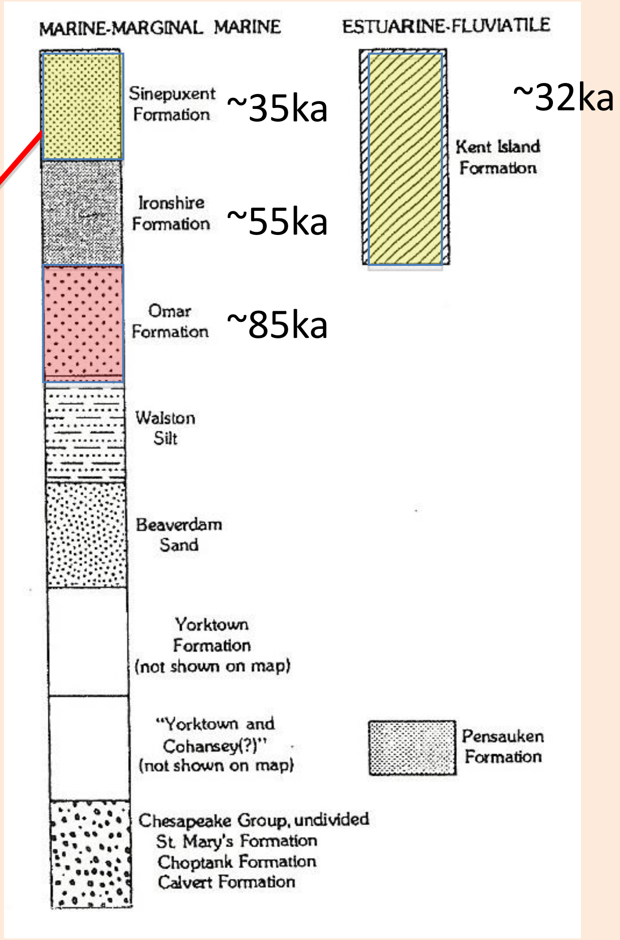
Delmarva Transgressive Marine & Estuarine Deposits





Owens and Denny (1979) mapped three late-Quaternary marine units: Omar Fm., Ironshire Fm., and Sinepuxent Fm.

OSL dates for the Omar and Ironshire are ~85ka and ~55ka respectively.

The Sinepuxent Fm. and estuarine Kent Island Fm. record the youngest relative sea level high prior to the LGM. ^{14}C dates from the Sinepuxent average ~35ka. The Kent Island Fm. is as young as ~32ka by OSL.

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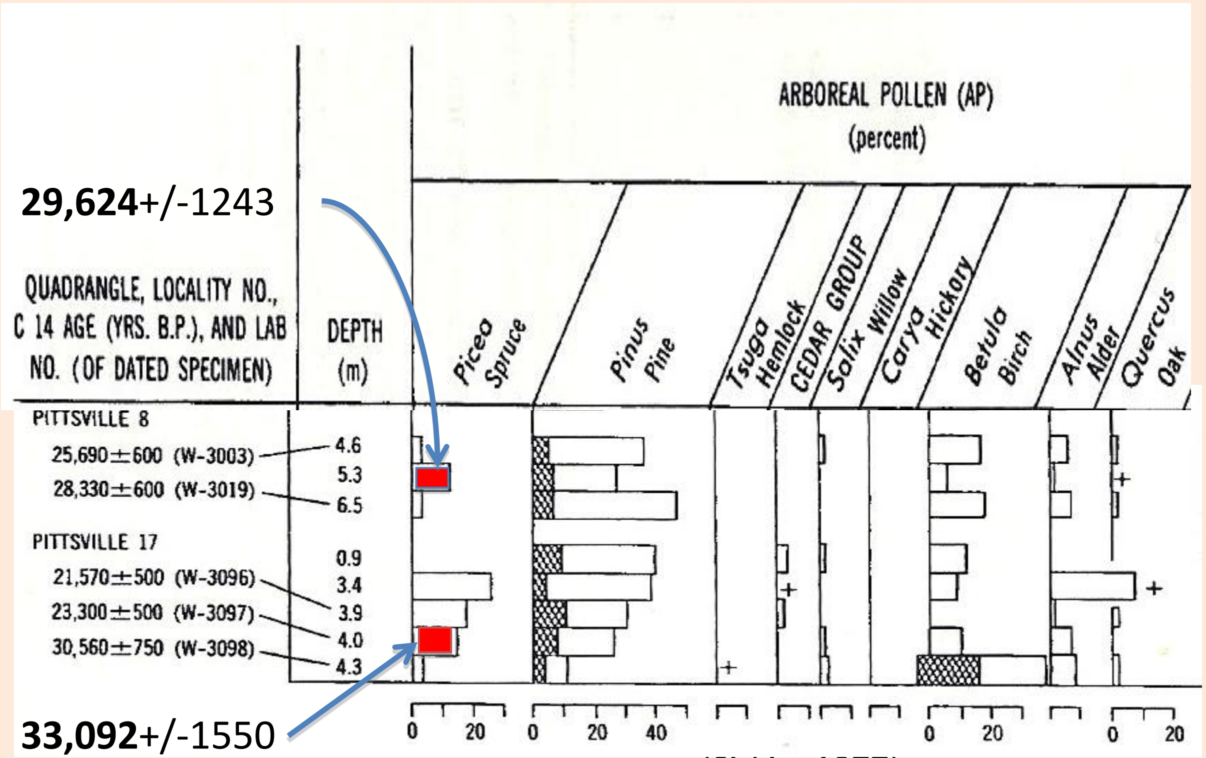
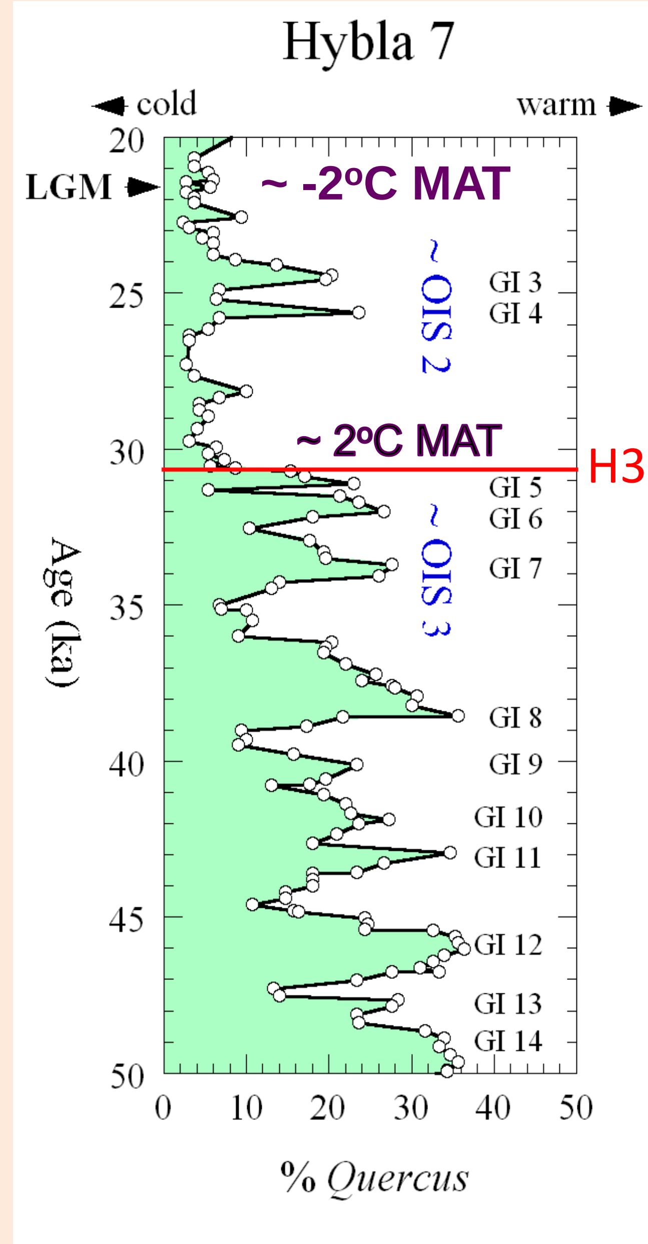
Pollen Records East and West of Chesapeake Bay

Parsonsburg Sand

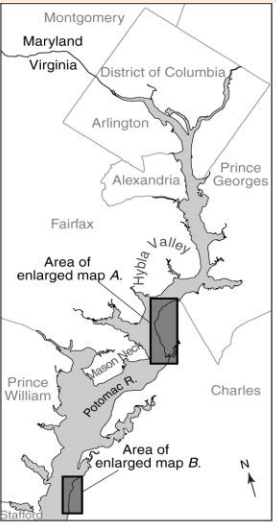


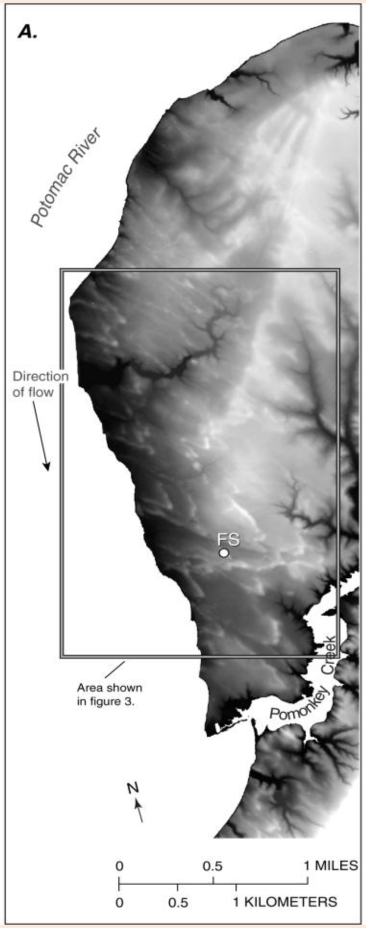
(Sirkin, 1977)

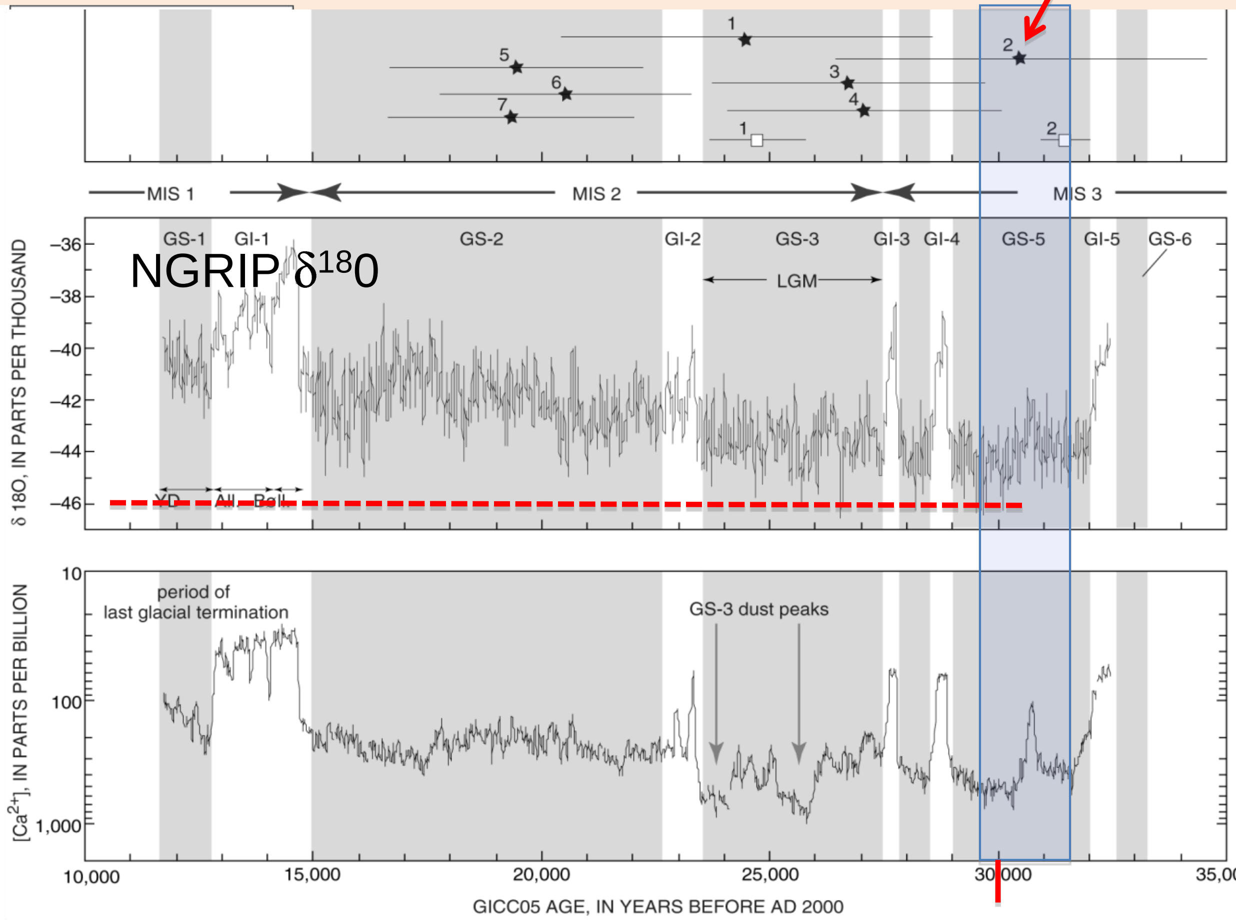


- Palynology shows that climate was highly variable and cooling during late OIS3, prior to the rapid rsl drop.
- A cold peak at Pittsville occurred between 33-30ka. That is a major transition in Hybla Valley coincident with H3.
- Both sites contain ~20% spruce after the transition indicating boreal forest.

Aridity: Potomac River Dunes at ~30ka







Oldest dunes

30ka

Parabolic dune formation began ~30ka on the Potomac River, correlative with the coldest interval of the NGRIP $\delta^{18}0$ record (GS-5) and H3 transition in the pollen record from Hybla Valley. Local MAT was ~2^{o}C.

Parsonsburg Sand ^{14}C Dates: Ponds & Peats

The basal Parsonsburg dates are from peats formed in interdune basins or bogs (Denny and Owens, 1979). The dates imply the onset of eolian sand transport as early as ~33ka east of Chesapeake Bay. This transition overlaps with the youngest of the Kent Island and Sinepuxent Formation OSL and ^{14}C ages.

These changes are consistent with a cold, seasonally dry climate at about the time of H3 (~31ka in Hemming, 2004). Pollen indicates that the initial cold interval in the Parsonsburg matches the age of the H3 cold transition in the Hybla record (MAT ~ 2^{0} C)

The **critical threshold** for pond and peat formation may have been the formation of either discontinuous (-1.5^{0}C MAT) or continuous permafrost on Delmarva as documented by French et al. (2009). They point out that well drained, windy upland sites are most likely to form frozen ground.

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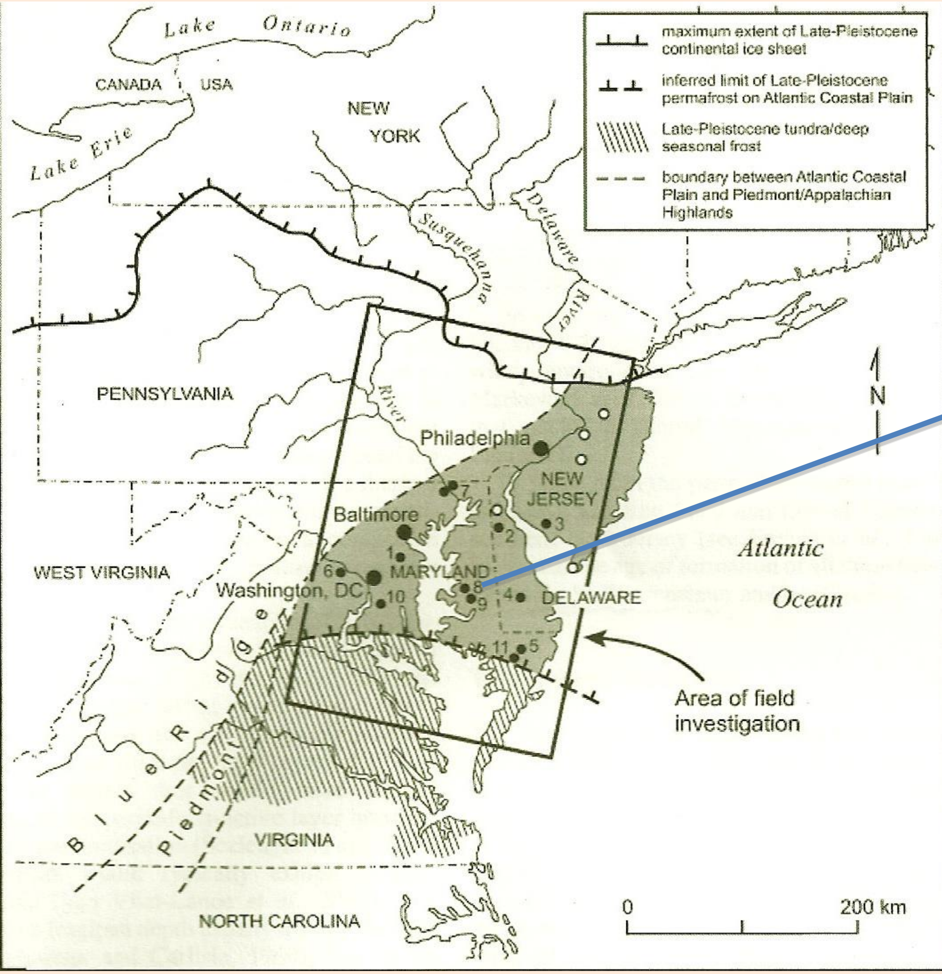
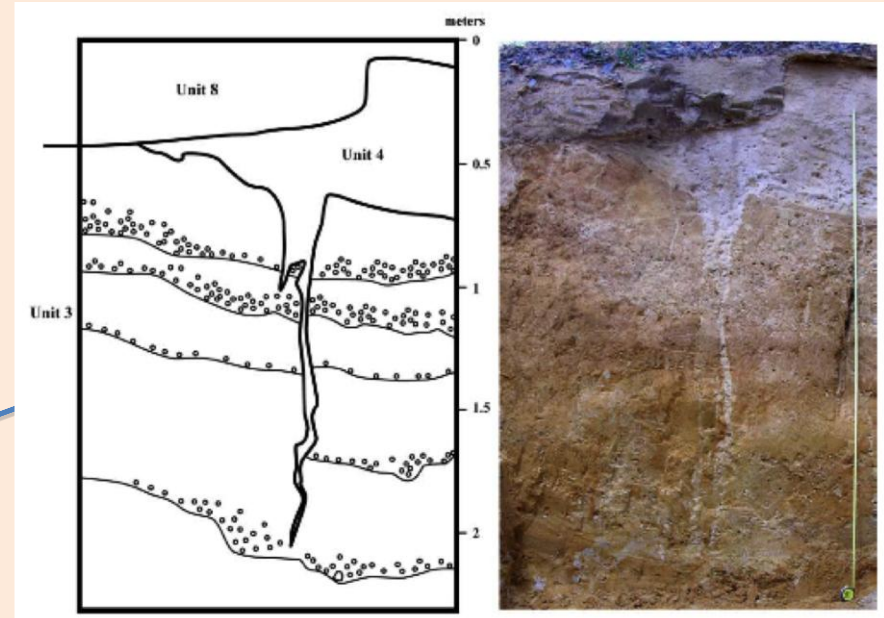
Mid-Altlantic Permafrost Distribution



French et al. (2009) documented the distribution of late Pleistocene permafrost features. Deformation features and stratigraphy indicate OIS6, OIS4 and OIS2 frozen ground.



Smoot et al. (2009) documented ice-wedge structures on central Delmarva uplands.

French et al. (2009) interpreted thermal contraction in gravel as evidence of continuous permafrost and MAT <-6^{0}C, but possibly pre-dating OIS2.

Hybla pollen indicates ~ **-2^0**C MAT at **~21 ka**, more consistent with discontinuous permafrost during the LGM.

Raised Rim Basins During and After the LGM

Fig. 1. Distribution of Carolina bays on the northern Delmarva Peninsula, and location of study sites 2, Gravel Bay; 13, Twin Bay; 15, Bear Pond; 29, Cemetary Rim; 31, Schribers Wallow; 50, Starr Pond; and 53, Kent County Bay. Inset map shows the location of the study area in Maryland and Delaware.

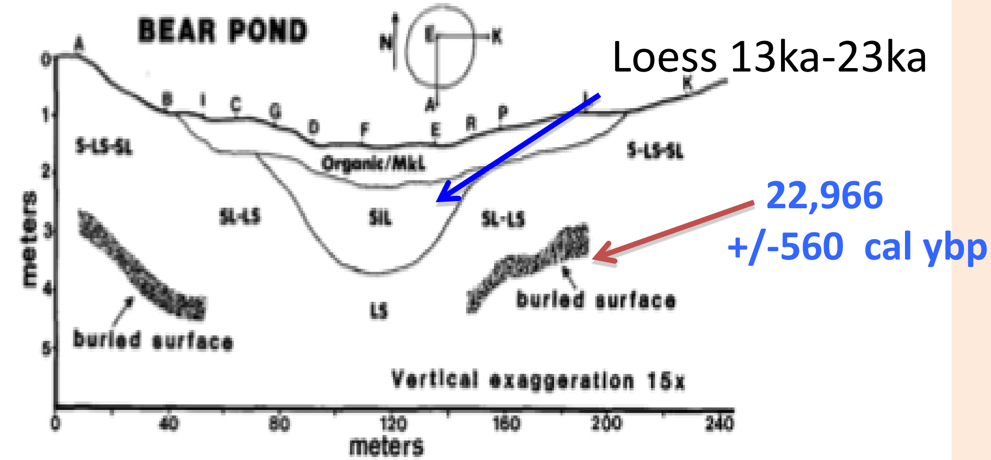
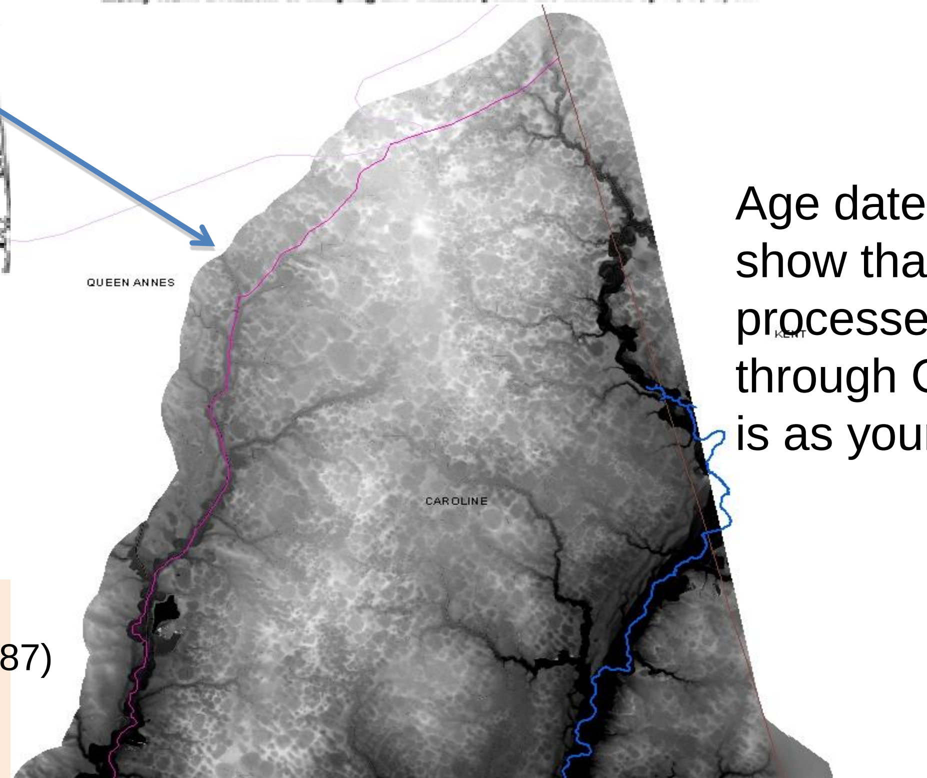


Fig. 2. Cross section of Bear Pond. Texture abbreviations are S = sand, LS = loamy sand, SL = sandy loam, SIL = silt loam, and MkL = mucky loam. Locations of sampling and transect points are indicated by A, B, C, etc.



Age dates from basins show that cold-climate processes persisted through OIS2. Loess is as young as 13ka.

Distribution of basins referred to as Carolina Bays (Stolt & Rabenhorst , 1987)

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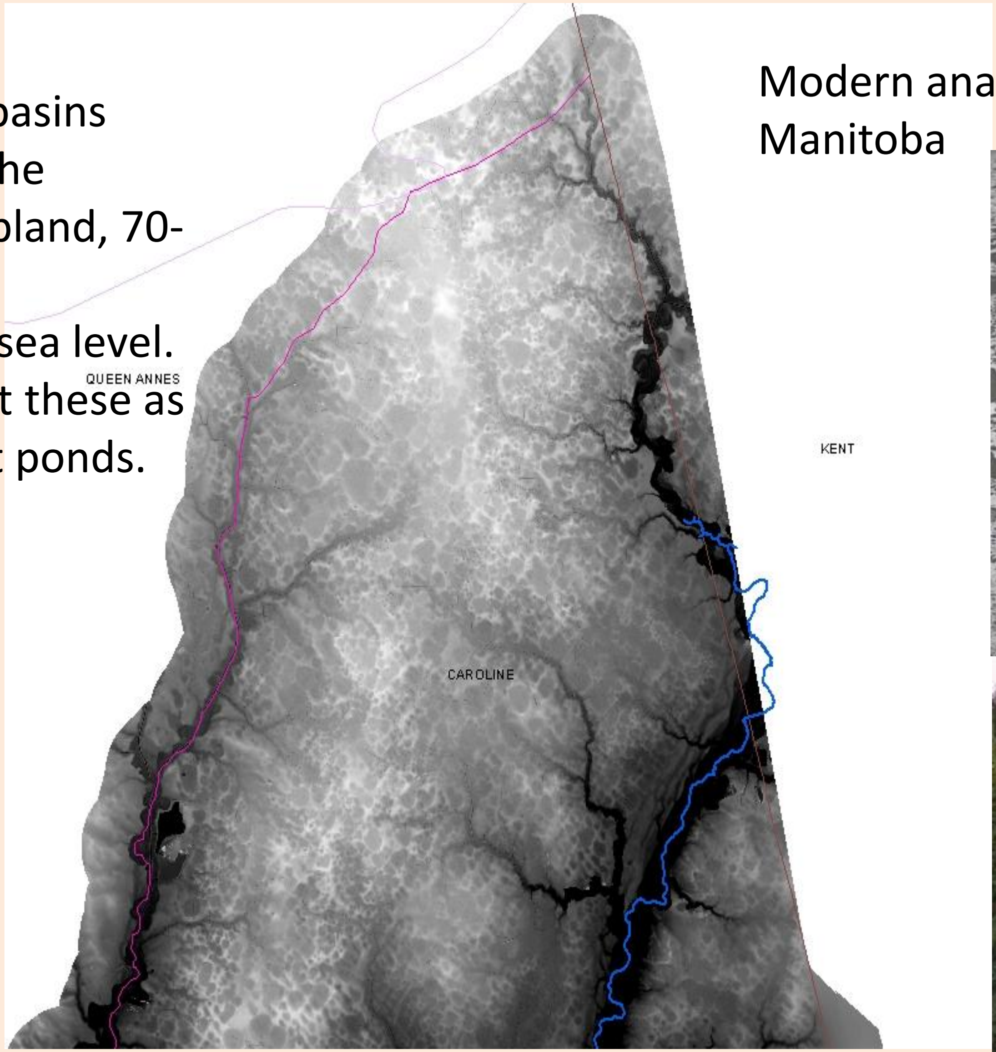
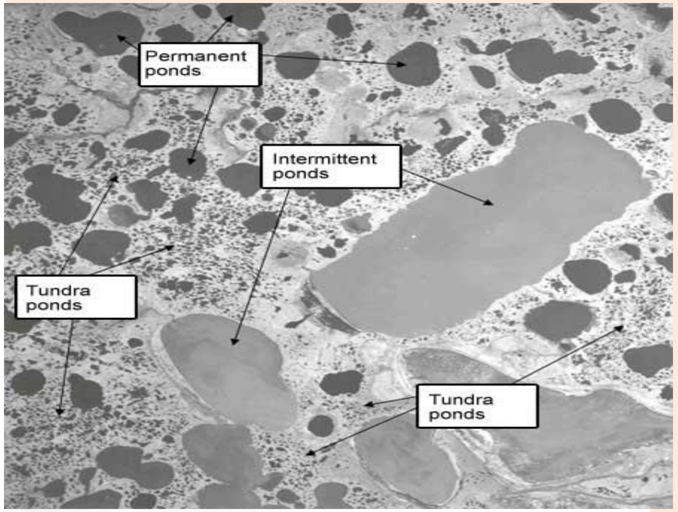
LGM Thermokarst Basins - Evidence for Seasonally Frozen Ground

1500-2500 basins formed on the Delmarva upland, 70-80m
above LGM sea level.
We interpret these as thermokarst ponds.



Modern analogs in Hudson lowlands, Manitoba



Sand rims on SE shores of basins and dunes indicate strong winds over a dry, vegetated landscape. Niveo-eolian bedding indicates winter winds and little snow cover (Koster, 1988).

Thermokarst basins on the landscape indicate seasonal or longer-term thaw during the LGM period.

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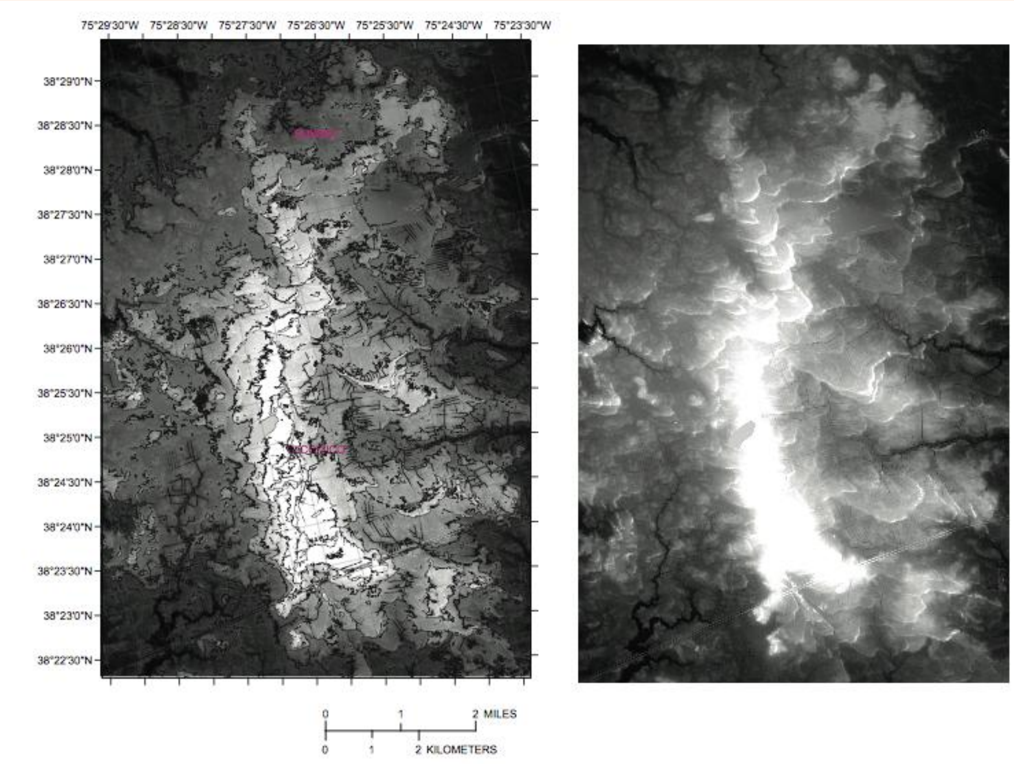
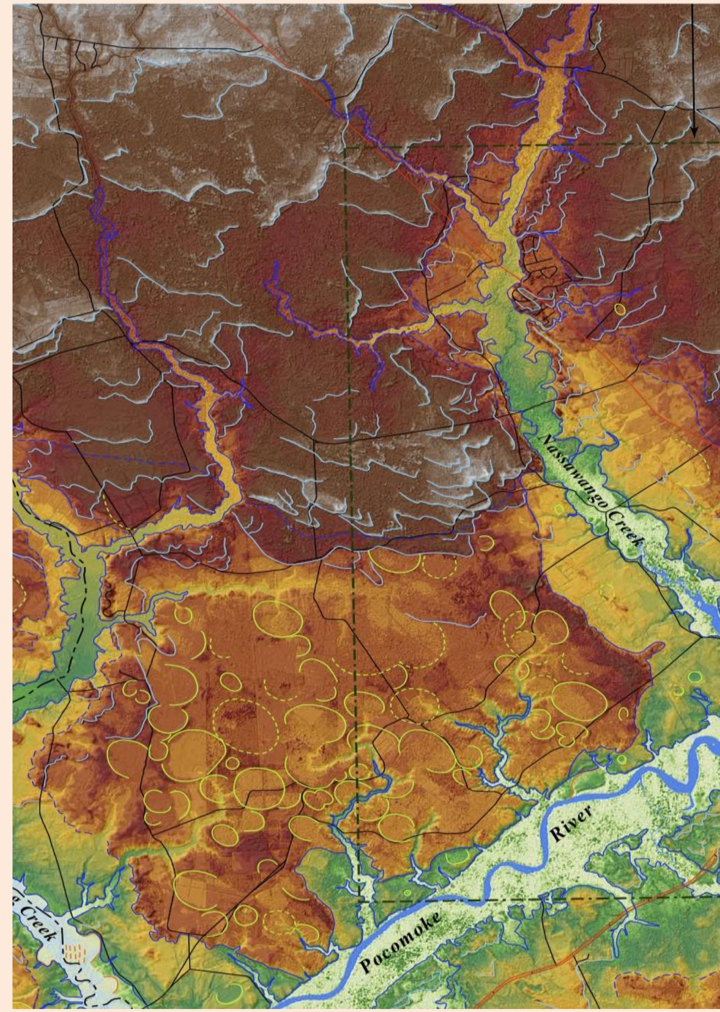
Complex Parsonsburg Dune Forms



In the Pittsville area, where the basal peat of the Parsonsburg is 33,092+/-1550 ^{14}C ybp, NW-SE parabolic dunes overlap and form sand sheets. The youngest dunes dates are ~13ka, as are the youngest loess deposits in basins (Stolt and Rabenhorst, 1987).



Worcester County: dunes over bays

Koster (1988) noted that for cold climate eolian deposits: *"The most widely distributed dune type is the parabolic dune…Linear or longitudinal dunes with almost straight or wavy crest lines…due to elongation of parabolic dunes."*

Conclusions

Formation of the Parsonsburg Sand began with H3 and the GS-5 Greenland stadial. Dunes and buried peats mark the onset of this cold/dry landscape.

Bays, thermokarst and dunes are all associated with a cold, windy upland. Such an association now exists on Arctic coastal plains (Walker and Harris, 1976). Periglacial processes persisted on Delmarva until ~13ka.

The Parsonsburg Sand evolved on an upland steppe as sea level fell to the LGM lowstand. The upland was one of the most thermally sensitive parts of the landscape.

Frozen ground facilitates abrupt landscape change. Periglacial landscapes such as central Delmarva provide potential age-control on abrupt change that can be compared to ice-core and marine-core data.