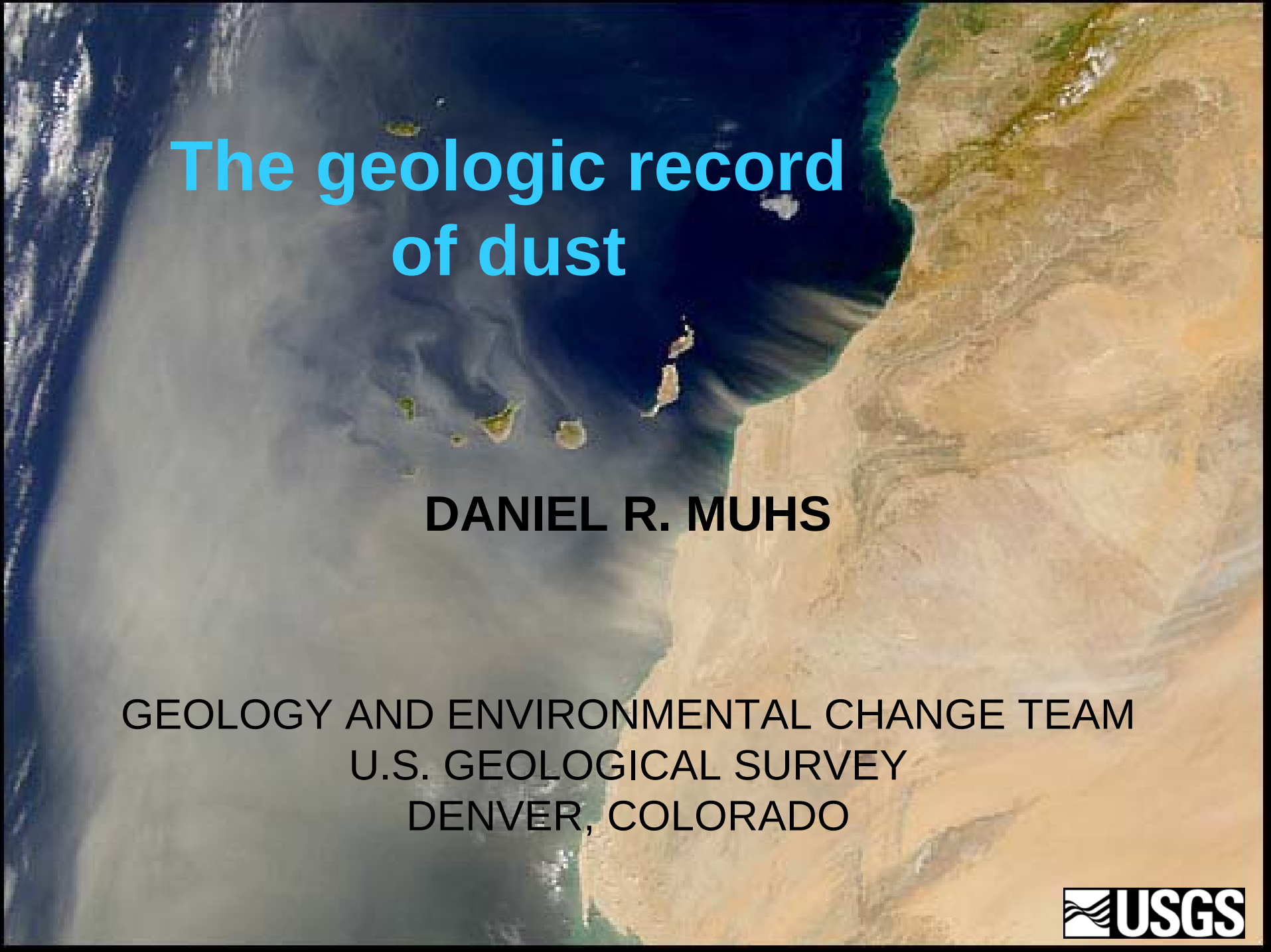


The geologic record of dust

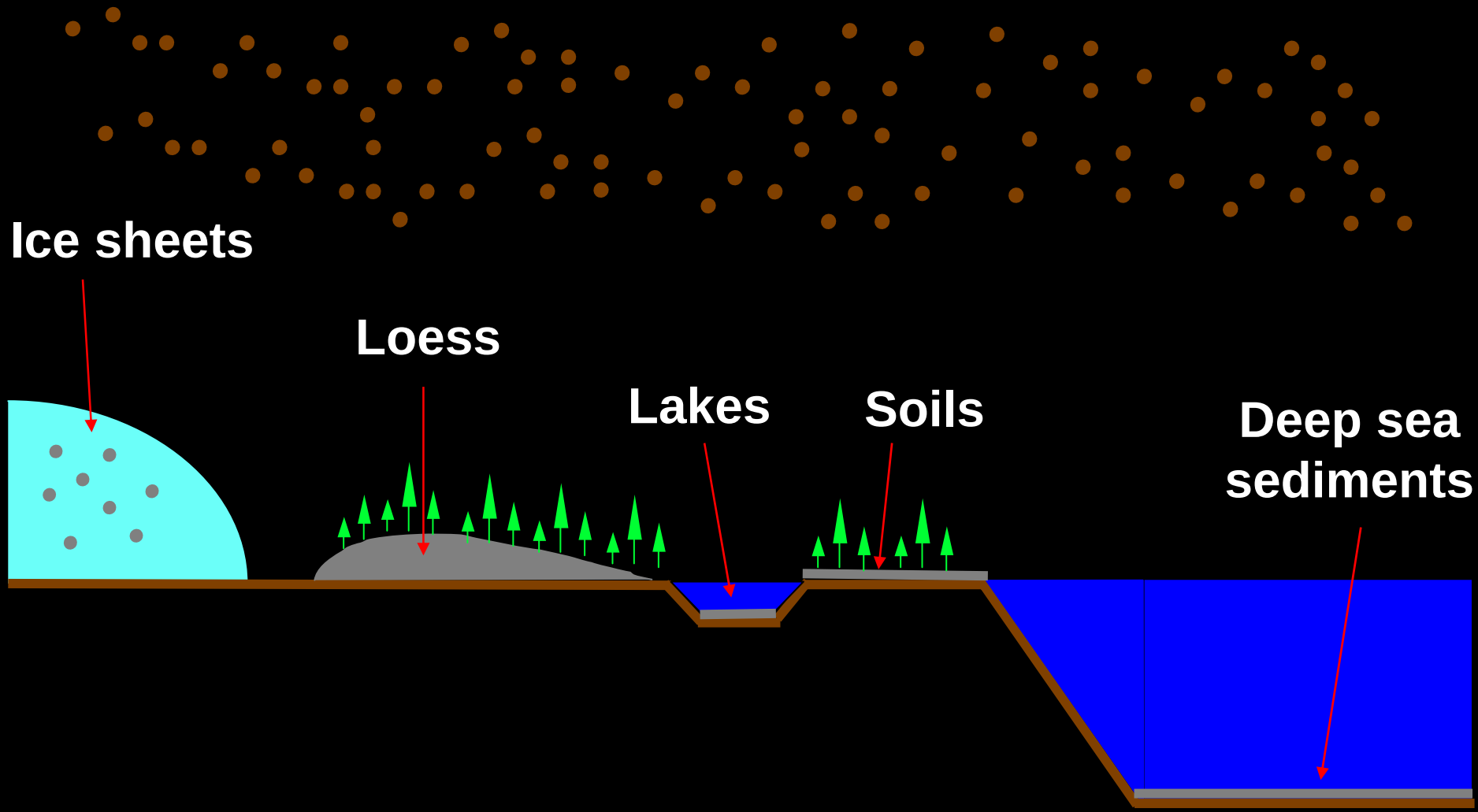
DANIEL R. MUHS

GEOLOGY AND ENVIRONMENTAL CHANGE TEAM
U.S. GEOLOGICAL SURVEY
DENVER, COLORADO

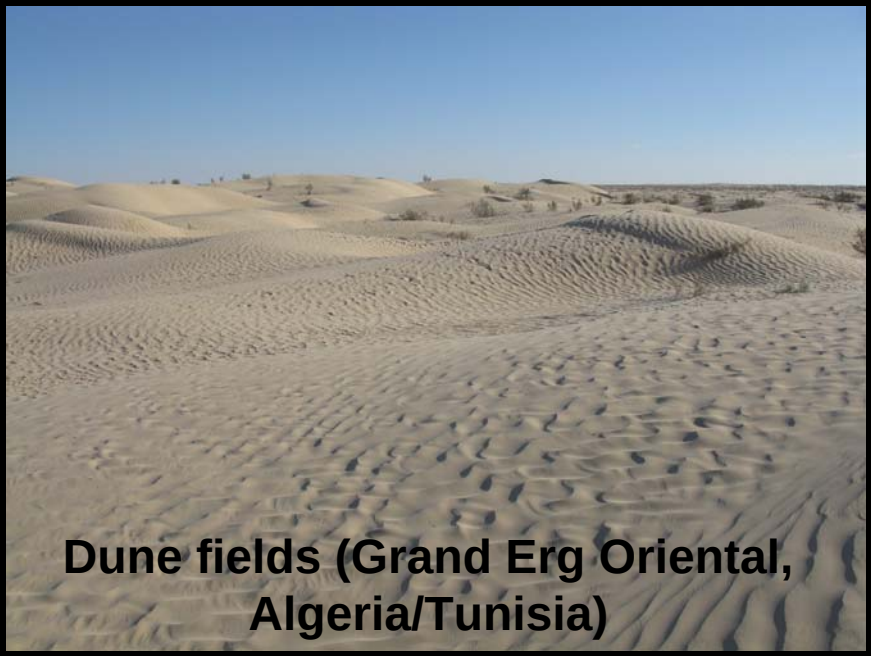
USGS

Thanks to Art Bettis for organizing this session and with whom I've studied North America's loess deposits from the Arctic Ocean to the Gulf of Mexico

Geologic records of dust are found over much of the Earth's surface:



What are the sources of dust in the geologic record?



Dune fields (Grand Erg Oriental, Algeria/Tunisia)

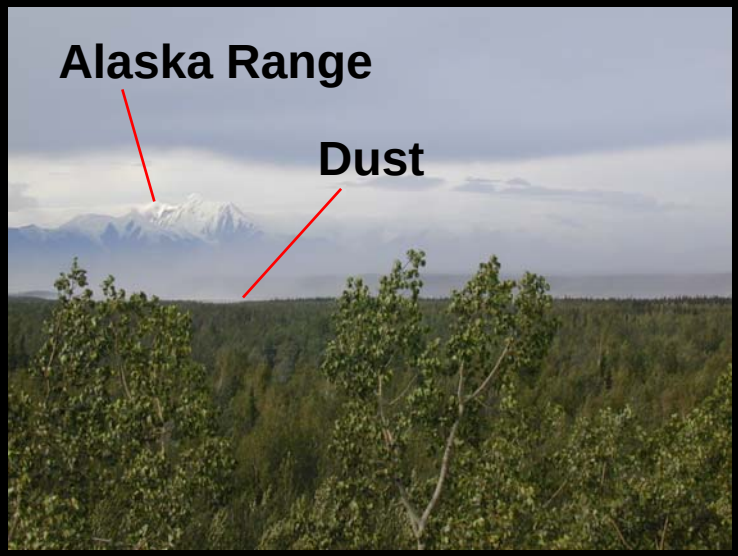
Non-glacial sources of dust are most common in desert regions

Playas (Chott el Jered, Tunisia)

Dry washes (Algeria/Tunisia)

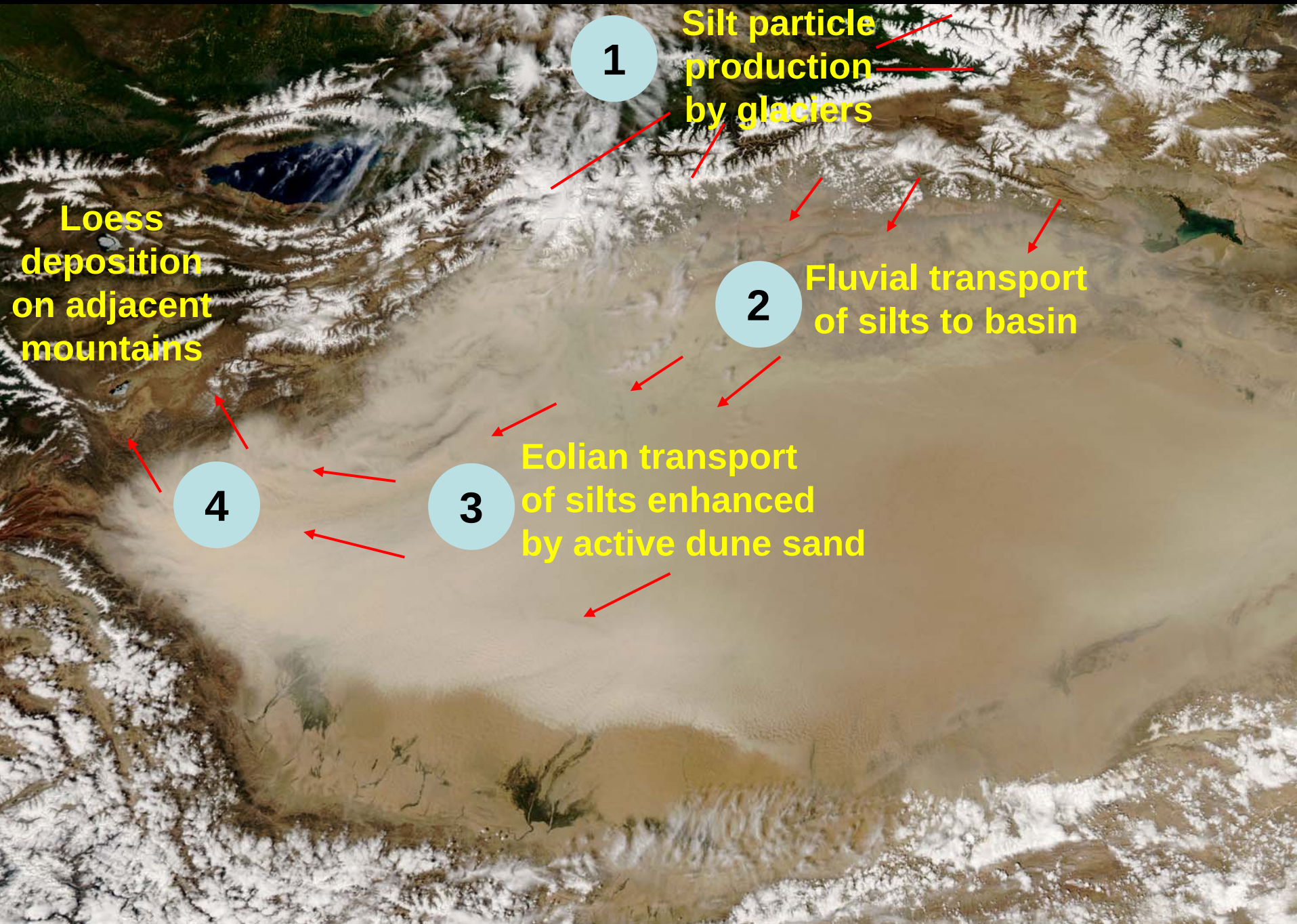
What are the sources of dust in the geologic record?

Glaciers, such as those in the Alaska Range, are efficient rock grinders and produce abundant dust-sized particles



Dust storm in the Delta River Valley, Alaska, July, 2004

There can be both glacial and non-glacial dust: Taklimakan Desert, China

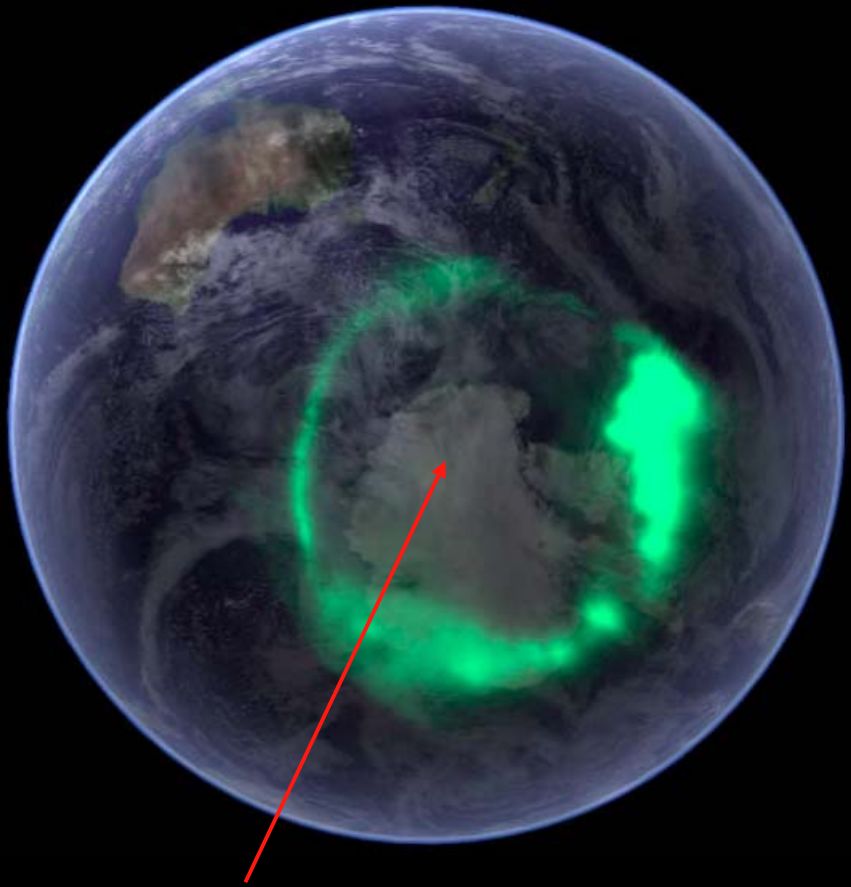


Because glaciers are efficient producers of silt, there was much more "rock flour" dust produced in the last glacial period

The last glacial period, 25-10 ka

Present interglacial period,10-0 ka

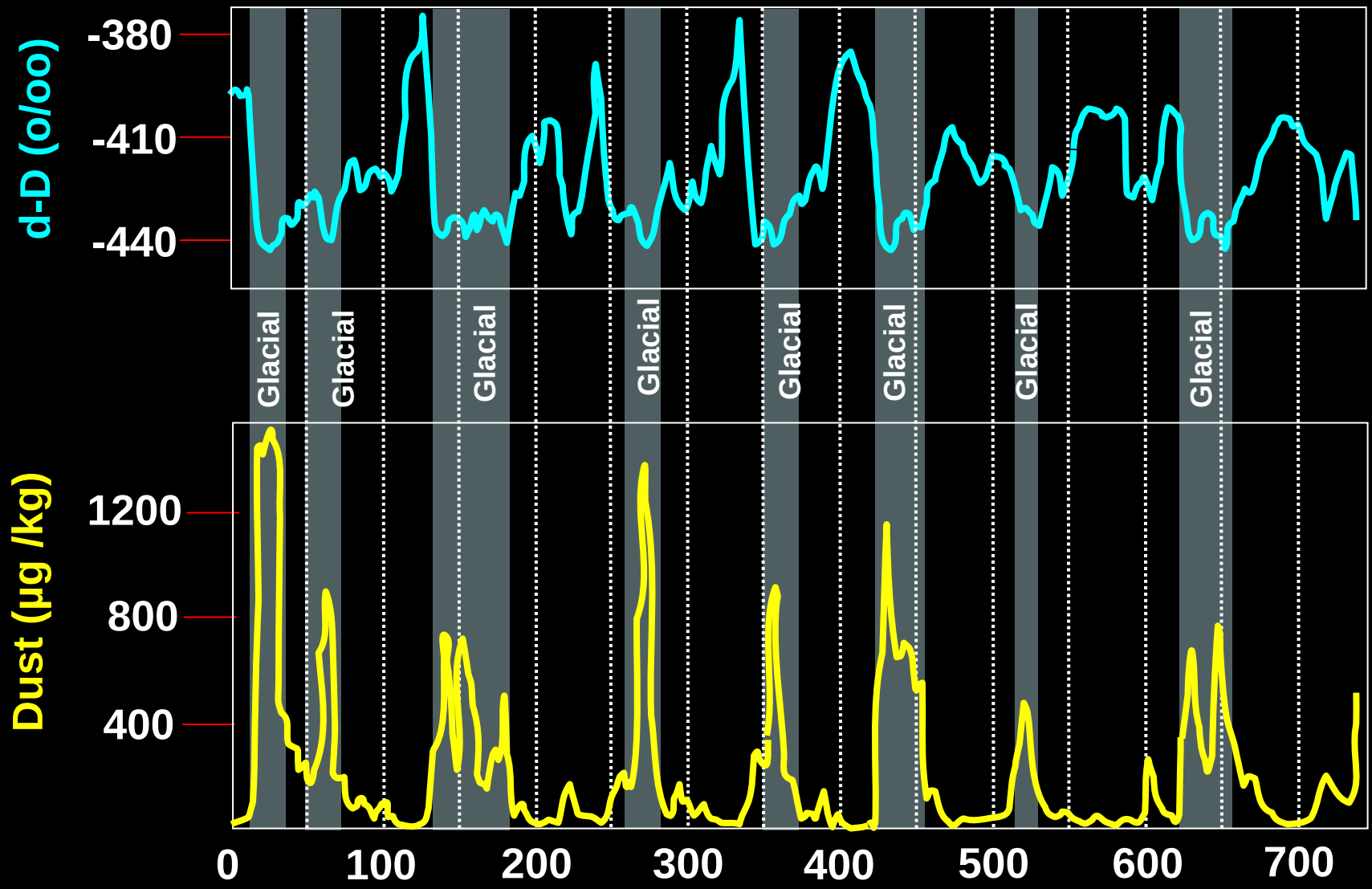
Ironically, some of the best archives of dust accumulation are in the remaining ice sheets:



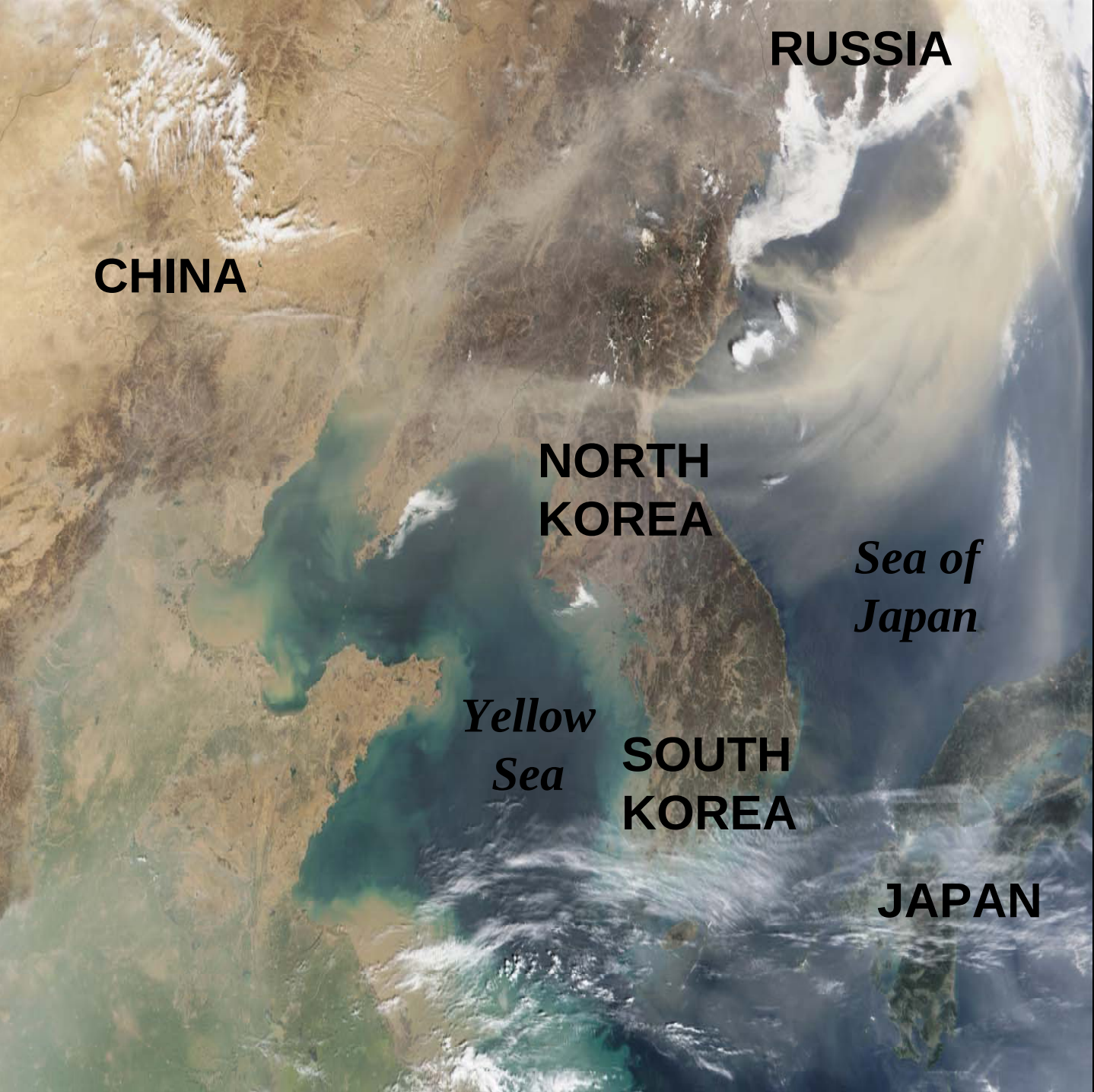
Antarctica
(Vostok, Dome C)

Greenland
(Dye 3,
Camp Century
GRIP, NGRIP)

The Dome C, Antarctica record shows that dust deposition is cyclic, with much greater rates in glacial periods:



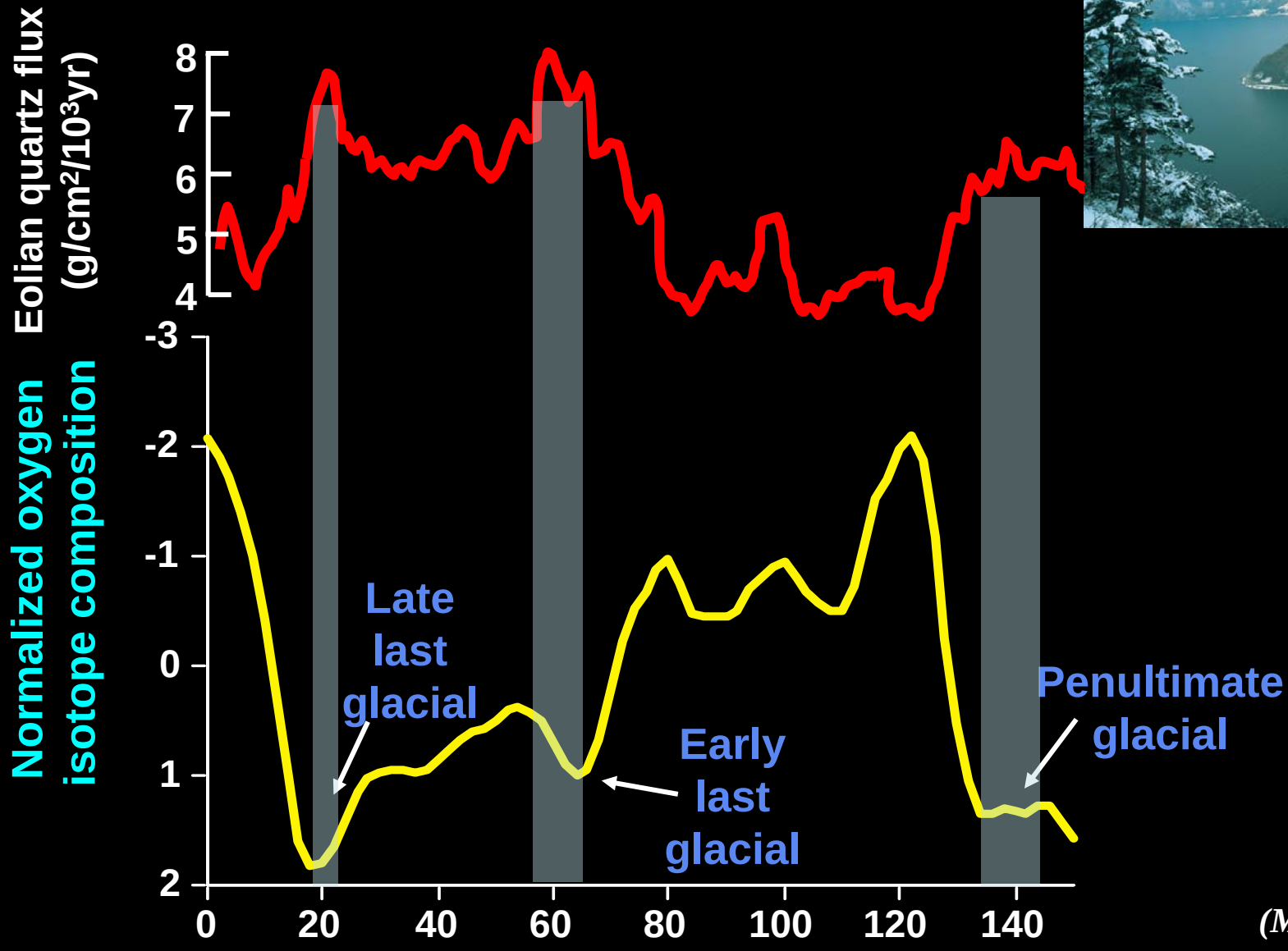
EPICA project members, 2004



Dust from China is transported regularly to Korea and Japan; a record of this dust is found in lake sediments

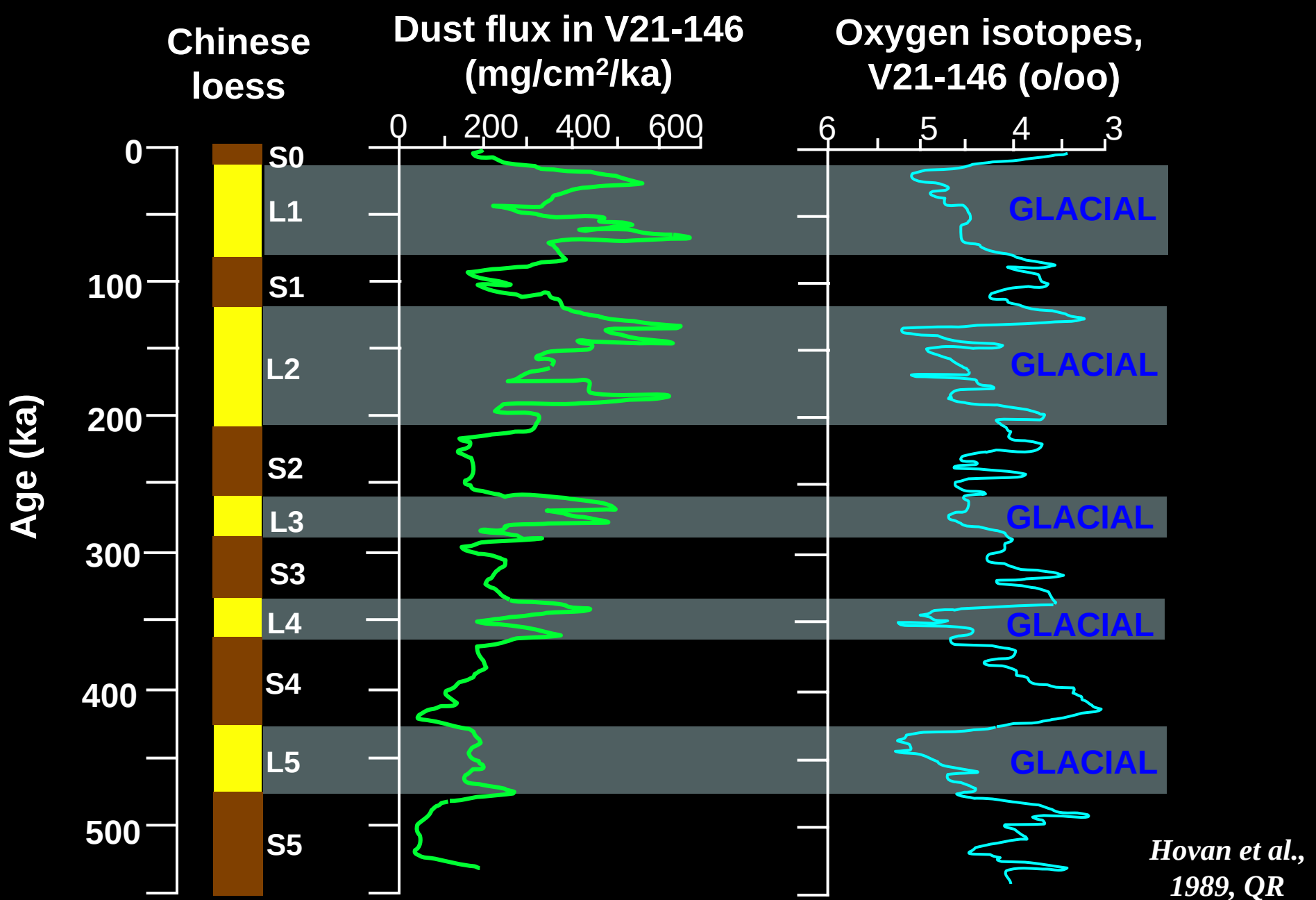
NASA-MODIS, 2 April 2002

Flux of Chinese dust to Lake Biwa, Japan: also greater during glacial periods:



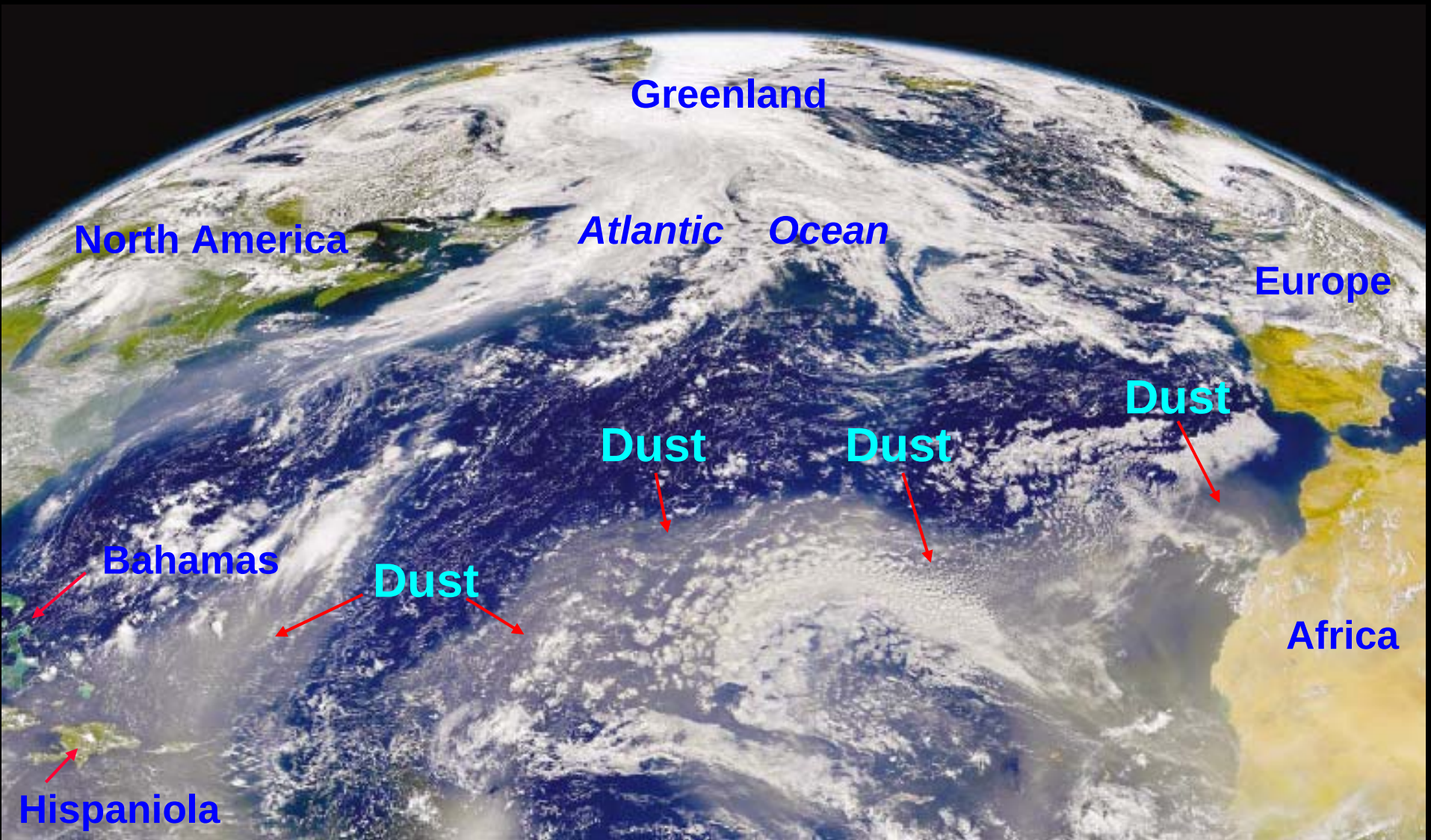
(Martinson et al., 1987, QR; Xiao et al, 1997, QR)

East of Japan ~2000 km, the deep sea records similar cycles of dust:



Hovan et al., 1989, QR

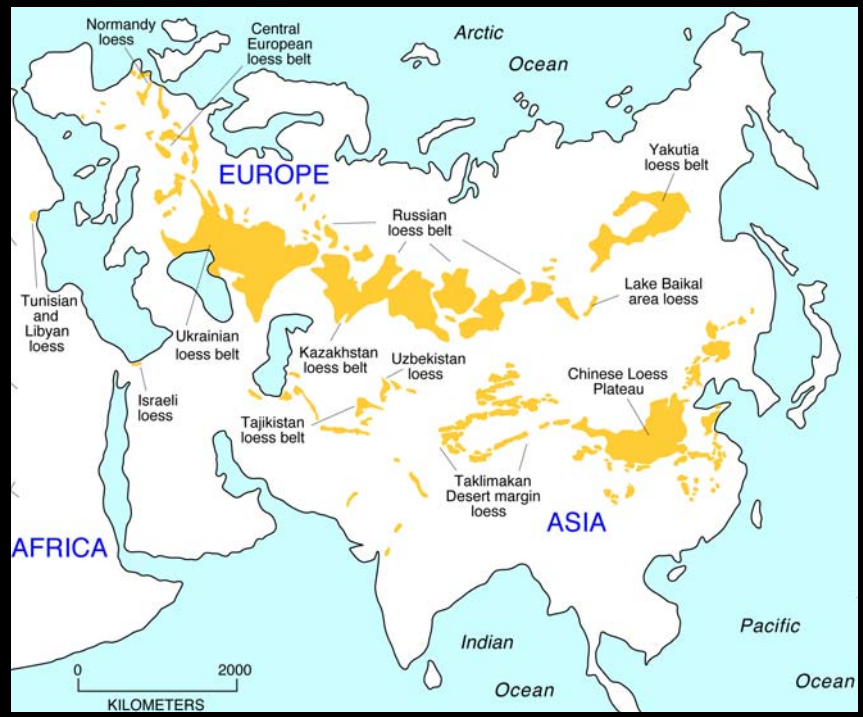
The Pacific Ocean isn't the only one affected: transatlantic dust transport has been confirmed by a 45-year dust trap record by Joseph Prospero, U. of Miami:




Localities around the Atlantic where we have verified African dust additions to soils:
NORTH AMERICA
EUROPE
Mallorca
Bermuda
Florida Keys
Bahamas
Canary Islands
Puerto Rico
Jamaica
Barbados
AFRICA
SOUTH AMERICA
NORTH ATLANTIC OCEAN
MID-ATLANTIC RIDGE
SAHARA
ALGERIA
LIBYA
MAURITANIA
MALI
NIGER
CHAD
NIGERIA
SENEGAL
COLOMBIA
VENEZUELA
Equator

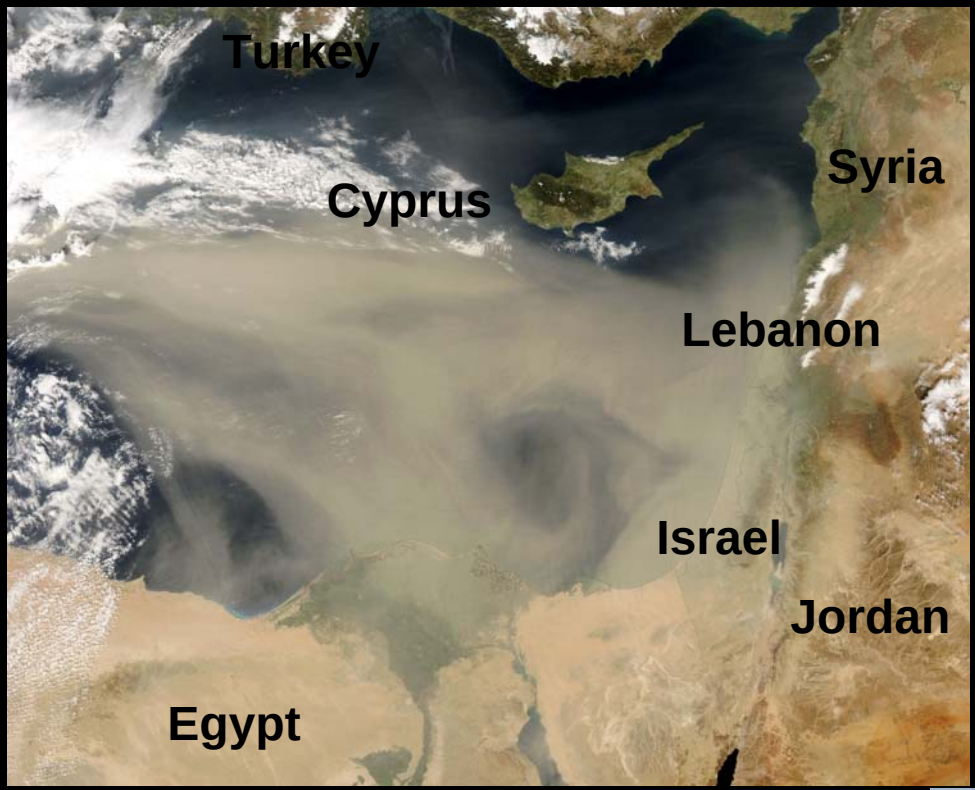
Which brings us to loess, covering approximately 10% of the Earth:

North America



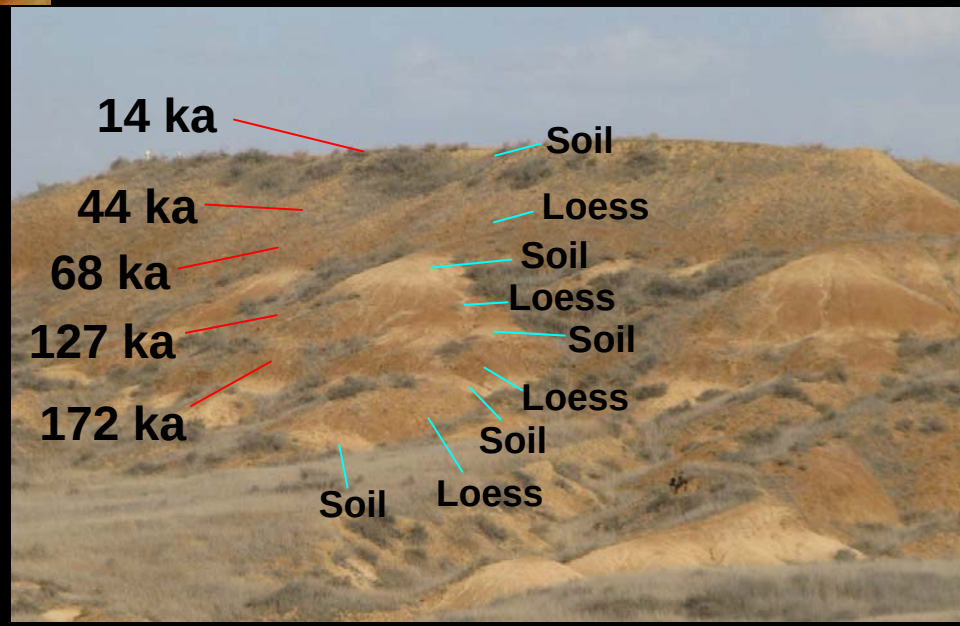
Eurasia

South America

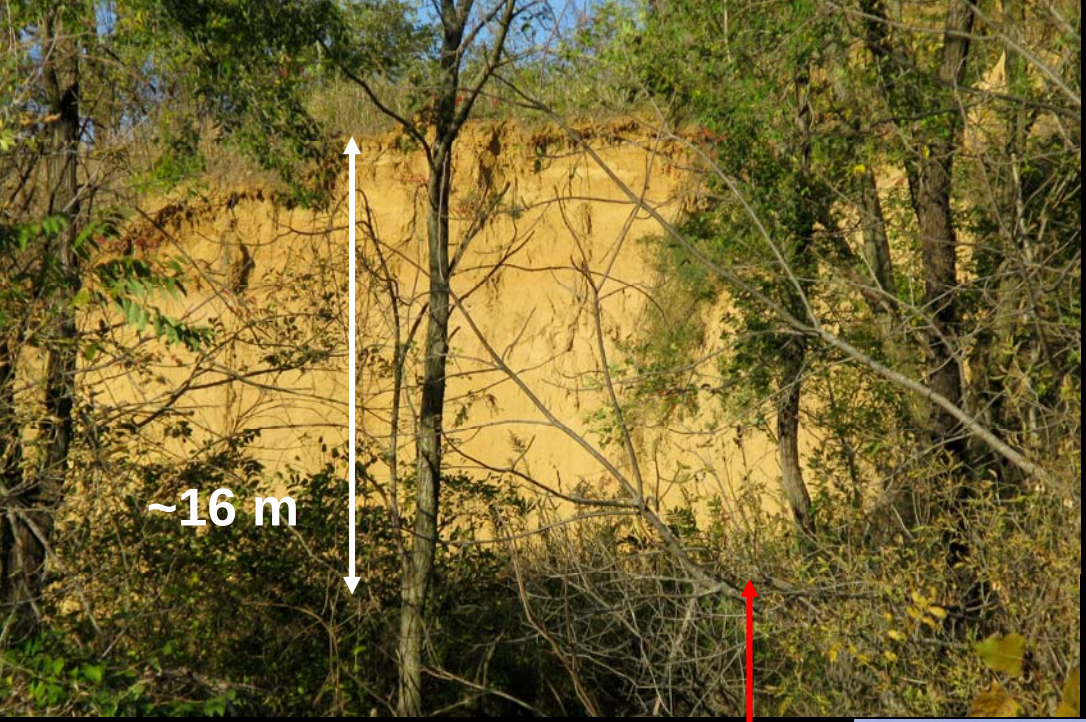


In some regions, repeated low rates of dust flux over geologic timescales results in thick, but quite old loess deposits:

Ruhama Badlands, Israel:



OSL ages from Weider et al., 2008, J.Pl.Nutr.Soil Sci.

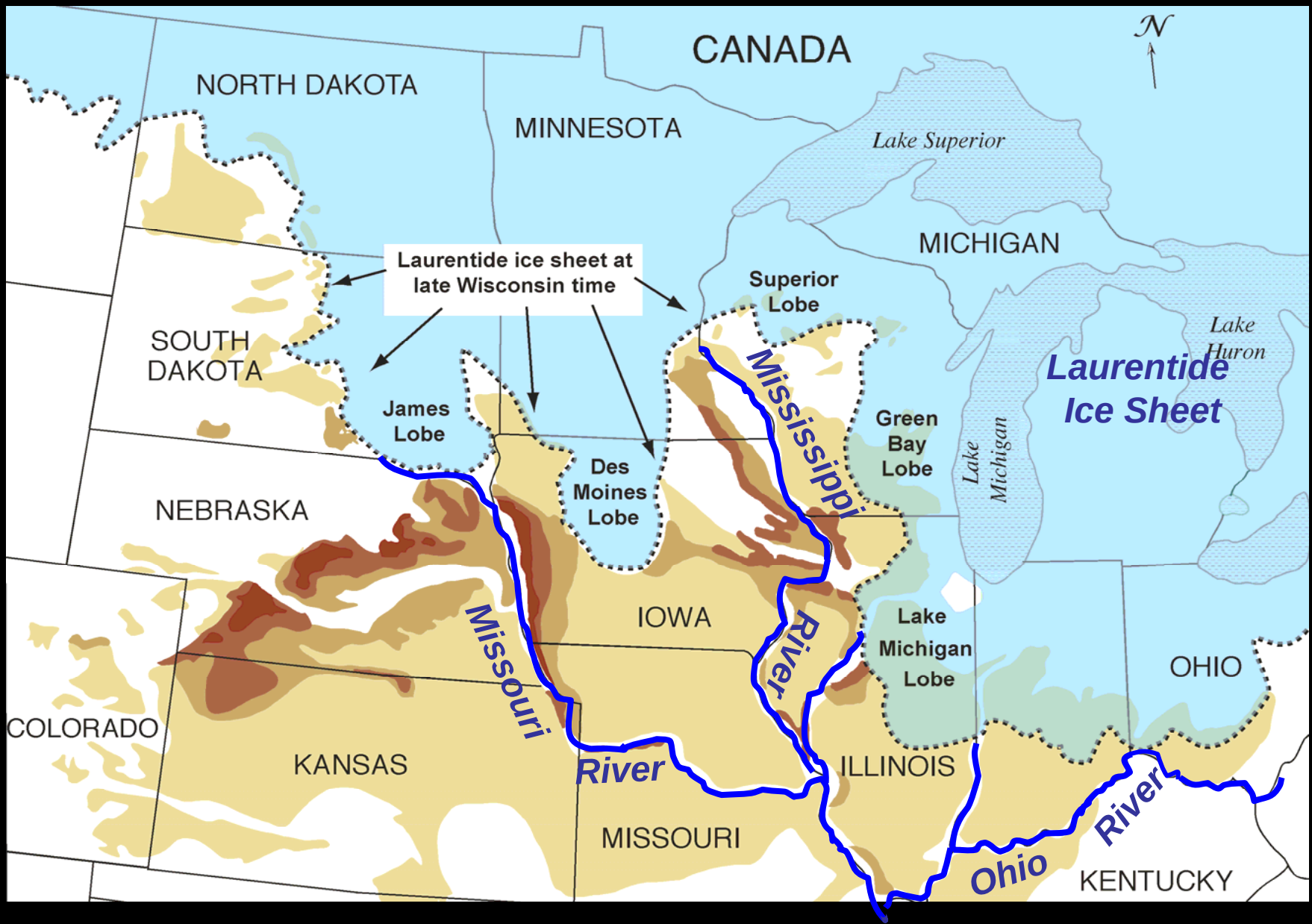


In other regions, tens of meters of loess were deposited during the last glacial period alone

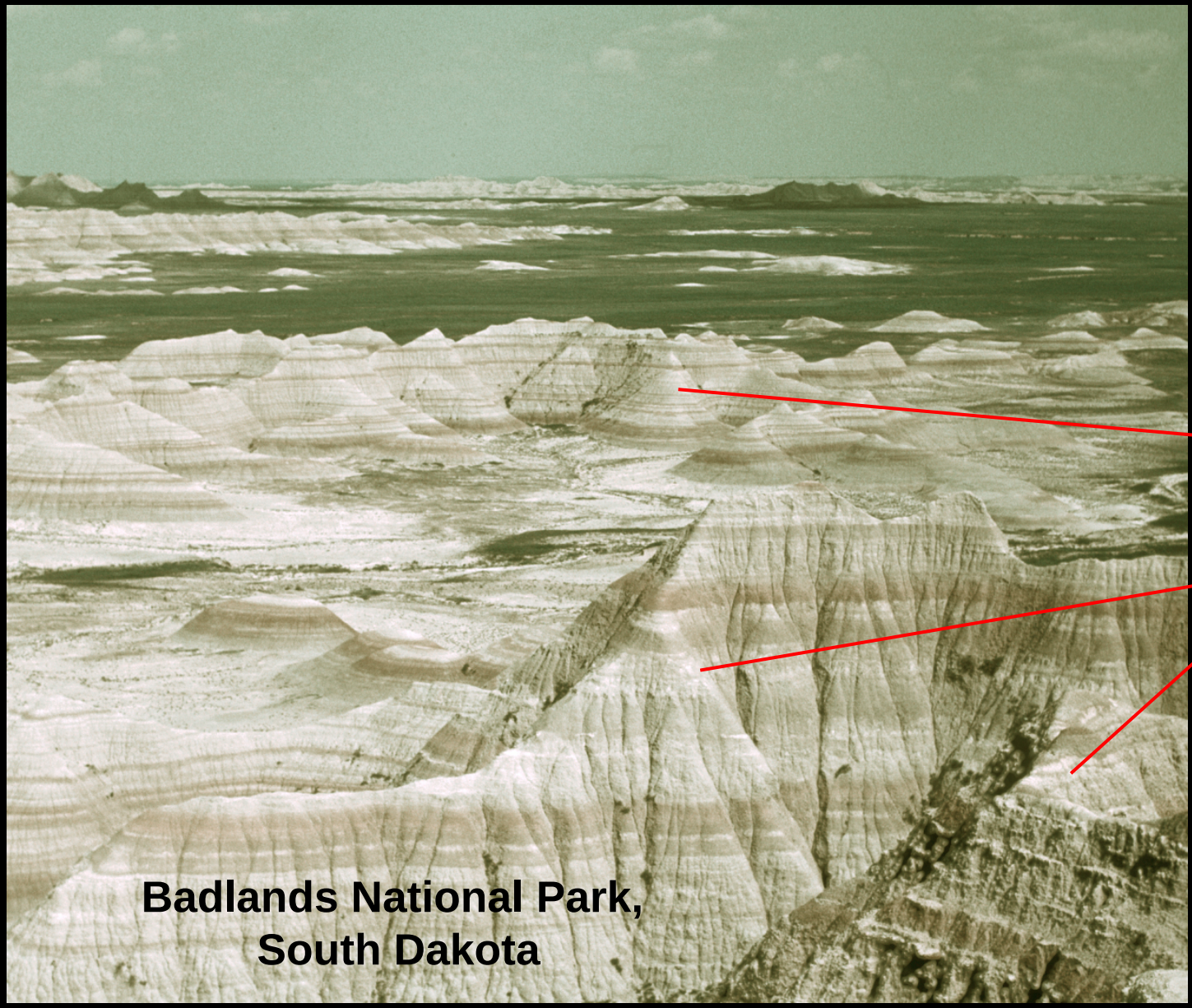
Morrison, Illinois: glaciogenic loess from the Mississippi River

Loveland, Illinois: glaciogenic loess from the Missouri River

Much loess in North America came from rivers draining ice sheets, such as the Mississippi, Missouri, and Ohio:



However, loess in the Great Plains is *non-glaciogenic*:



Badlands National Park,
South Dakota

Great Plains loess is derived from volcaniclastic siltstones of the White River Group

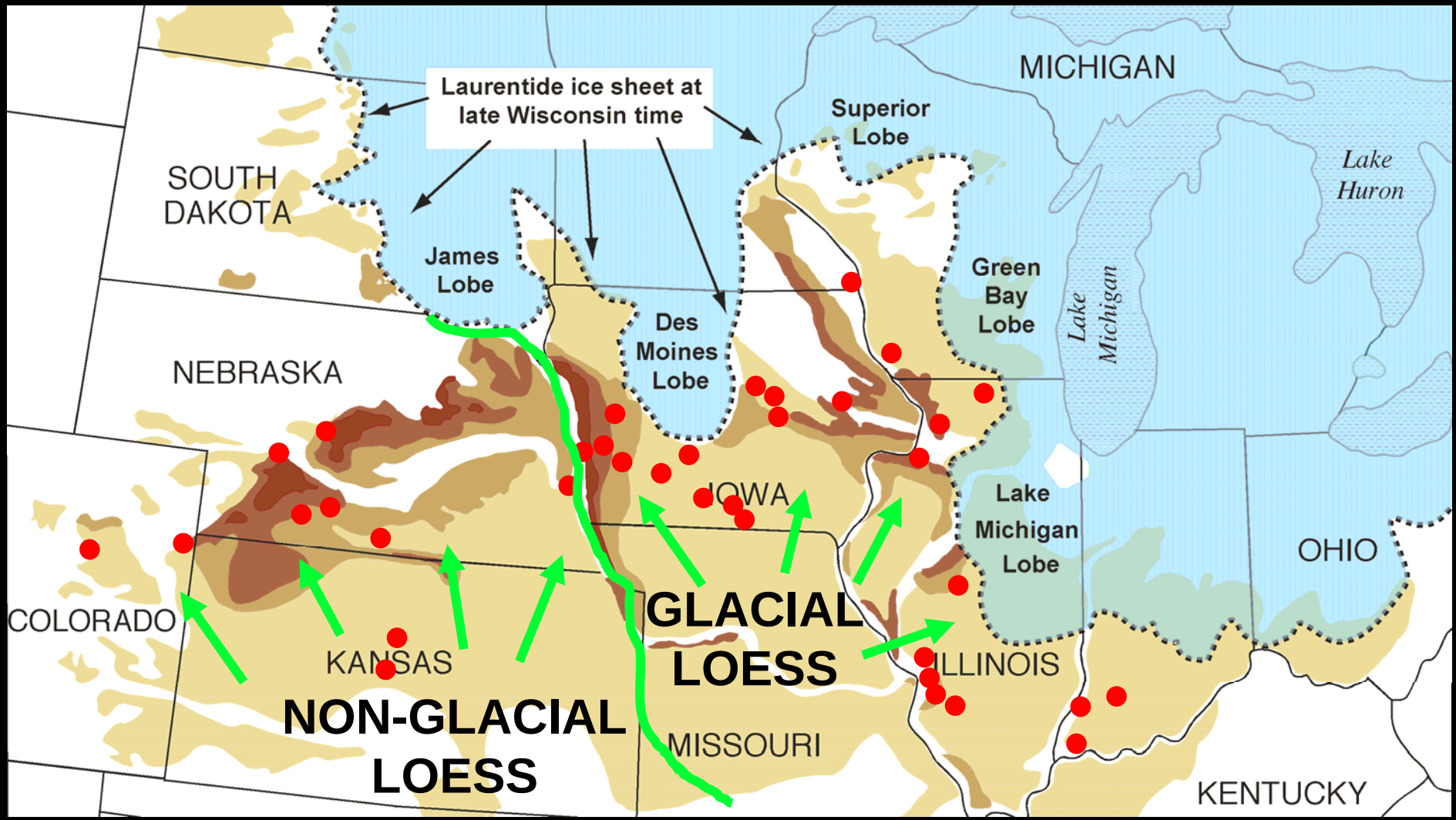
Nevertheless, Great Plains loess can have extraordinary thicknesses (47 m at Bignell Hill, Nebraska)

Bignell Hill, Nebraska

Eustis, Nebraska

Despite different origins, glacial and non-glacial loess deposits are about the same age, ~28,000 to 12,000 yr

This suggests a common CLIMATE forcing, not supply-related



CONCLUSIONS:

There are geologic records of dust deposition in a wide variety of archives, spanning the geosphere, hydrosphere, cryosphere and pedosphere

Ice core records, lake records, deep-sea records and loess records all indicate greatest dust deposition during glacial periods, especially the last glacial period

Last-glacial loess records have the same age range, regardless of whether the loess is glacial or non-glacial

This all suggests a very dusty, last-glacial planet, perhaps due to (a) stronger winds; (b) drier climates; (c) less vegetation and (d) a decreased intensity of the hydrologic cycle

The extraordinary situation of a dusty planet must have had profound effects on the global radiation balance, ocean fertilization, and soils and ecosystems