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The Tell-Tale Tusk: Acid Rain at the Onset of the Younger Dryas?

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THE TELL-TALE TUSK



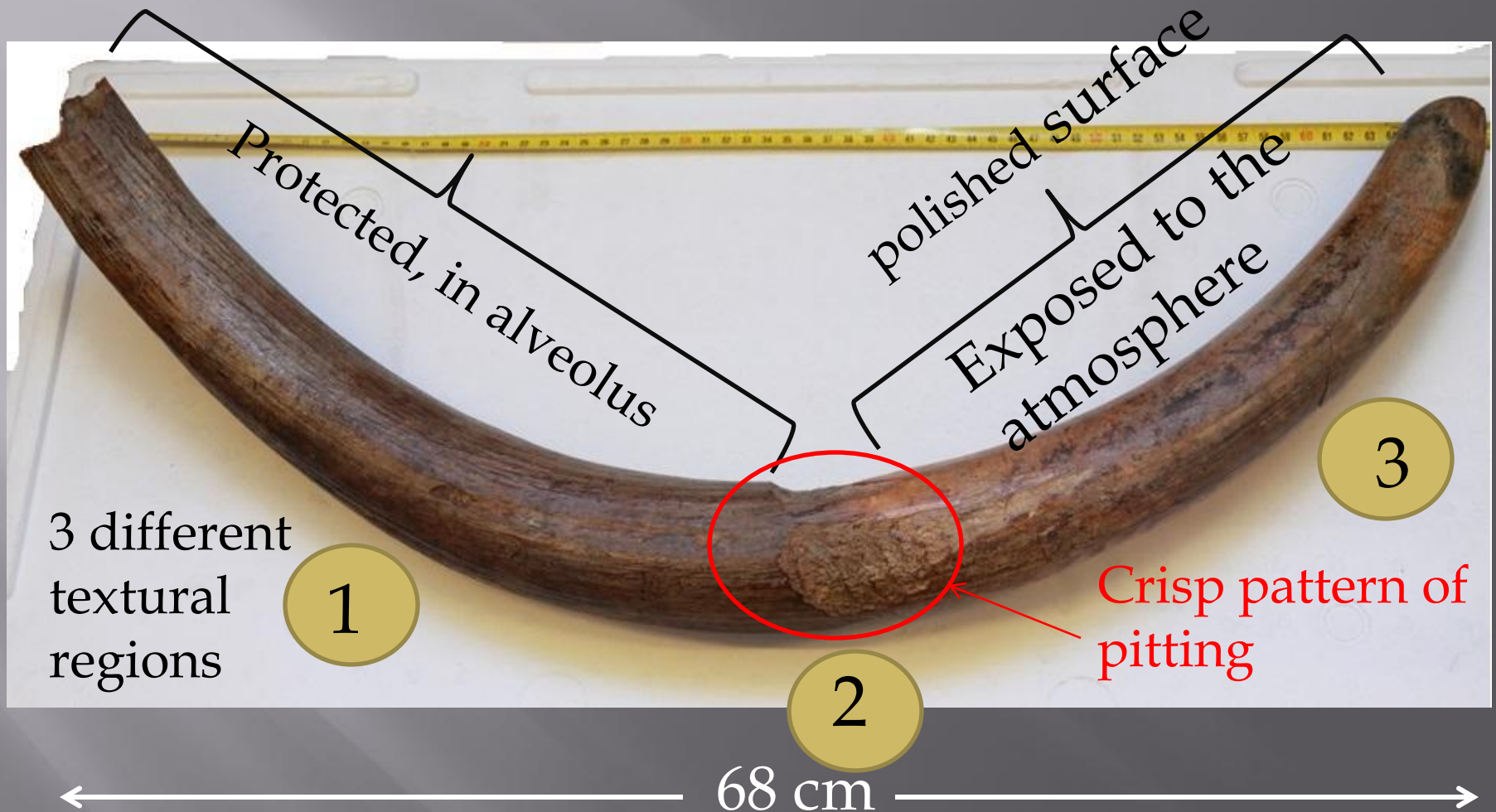
VI International Mammoth Conference
May 8, 2014

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¹University of Tennessee, USA; ²Natuurhistorisch Museum, Rotterdam, NL;

³Independent Researcher, NL

THE TELL-TALE TUSK



Animal was alive during affliction to the tusk, evidenced by the tusk polishing

LATERAL-VENTRAL VIEW



Distinctive pattern near
trunk

Intact –
In the alveolus

Closeup of pitting damage on tusk evident where it emerges from alveolus

VENTRAL VIEW OF TUSK



Closeup of pitting damage on tusk evident where it emerges from alveolus

Global Nitrogen Cycle
ET shock wave



Nitric Acid Rain

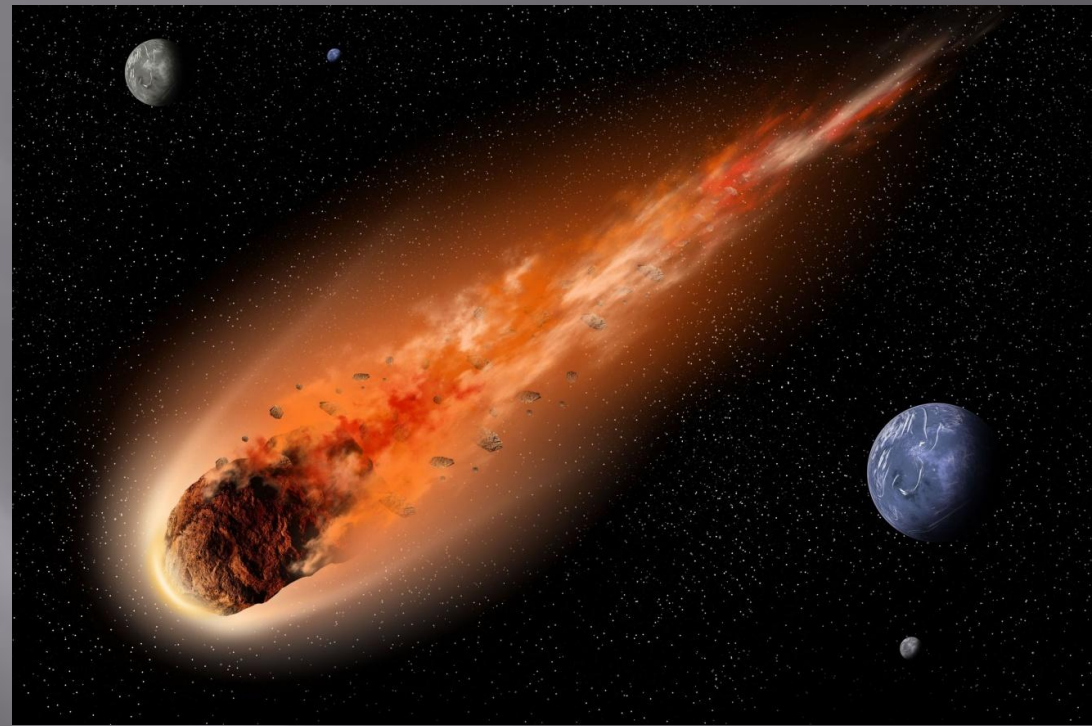
Prinn and Fegley 1987

Toon et al. 1997

} K/T Impact pH of 1 – 2, for a year or longer

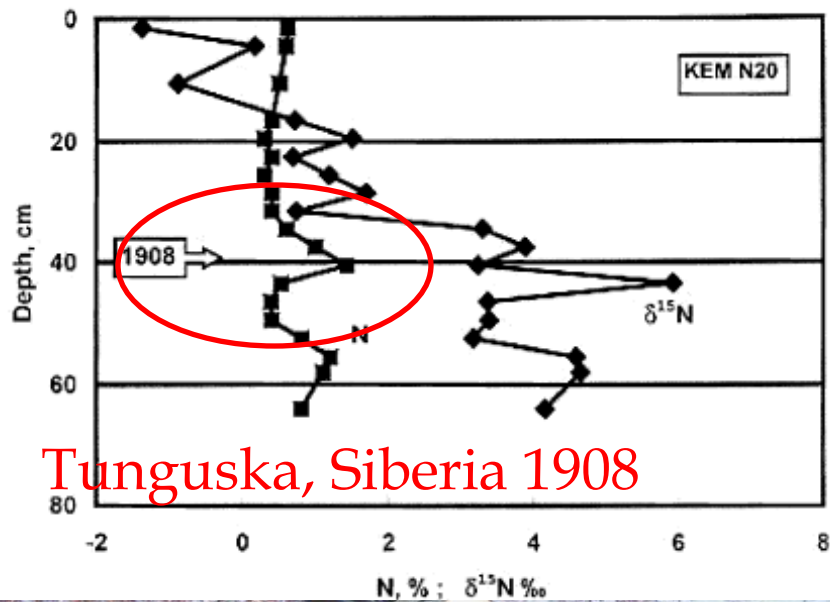
Kolesnikov et al. 1998, 2003

} Tunguska Impact 1908

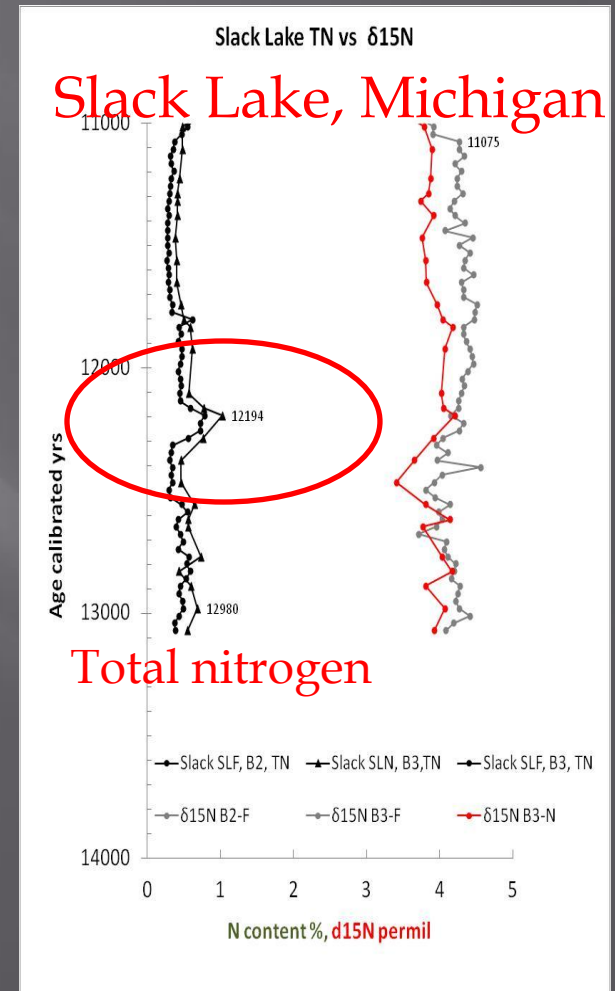


**ACID RAIN FROM
EXTRATERRESTRIAL IMPACTS:
ACID RAIN YD ONSET 13 KA?**

Nitrogen Isotopes in lake sediments



Tunguska, Siberia 1908



Slack Lake, Michigan

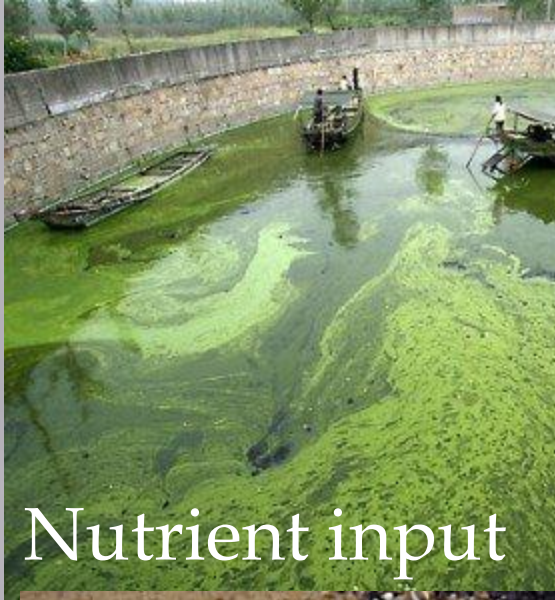
Total nitrogen

Raketka Peat Bog, Explosion Epicenter

Destructive to vegetation



Nutrient input



Carbonate
dissolution



EFFECTS OF ACID RAIN

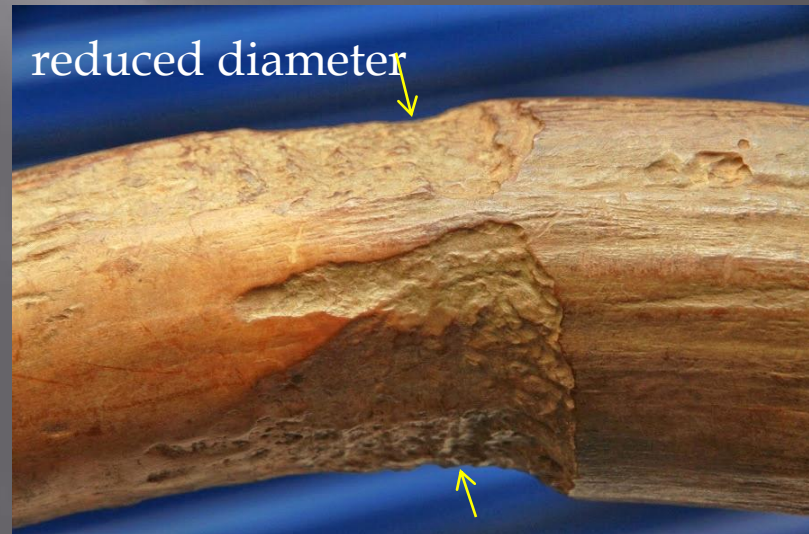
Caddisflies, mayflies, salamanders, snails, brook trout: trophic cascades

Our hypothesis:

Nitric acid rain event ~12,900 years ago as with K/T event (Prinn and Fegley 1987) and Tunguska event in 1908 (Kolesnikov et al. 1998, 2003)

Known

- Some type of acidification occurred
- Tusk diameter is reduced
- Polishing occurred (mammoth was alive during process)
- Preservation of fossils even less likely in corrosive environment

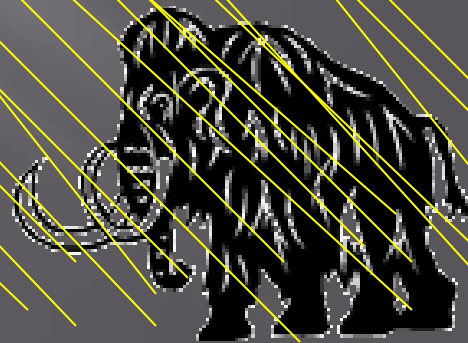
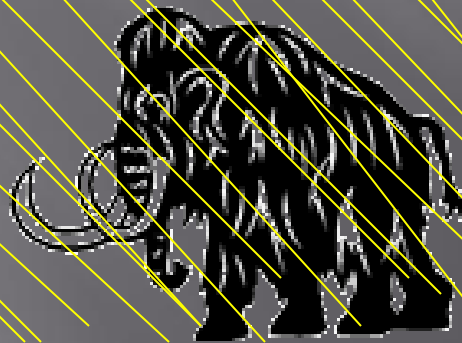


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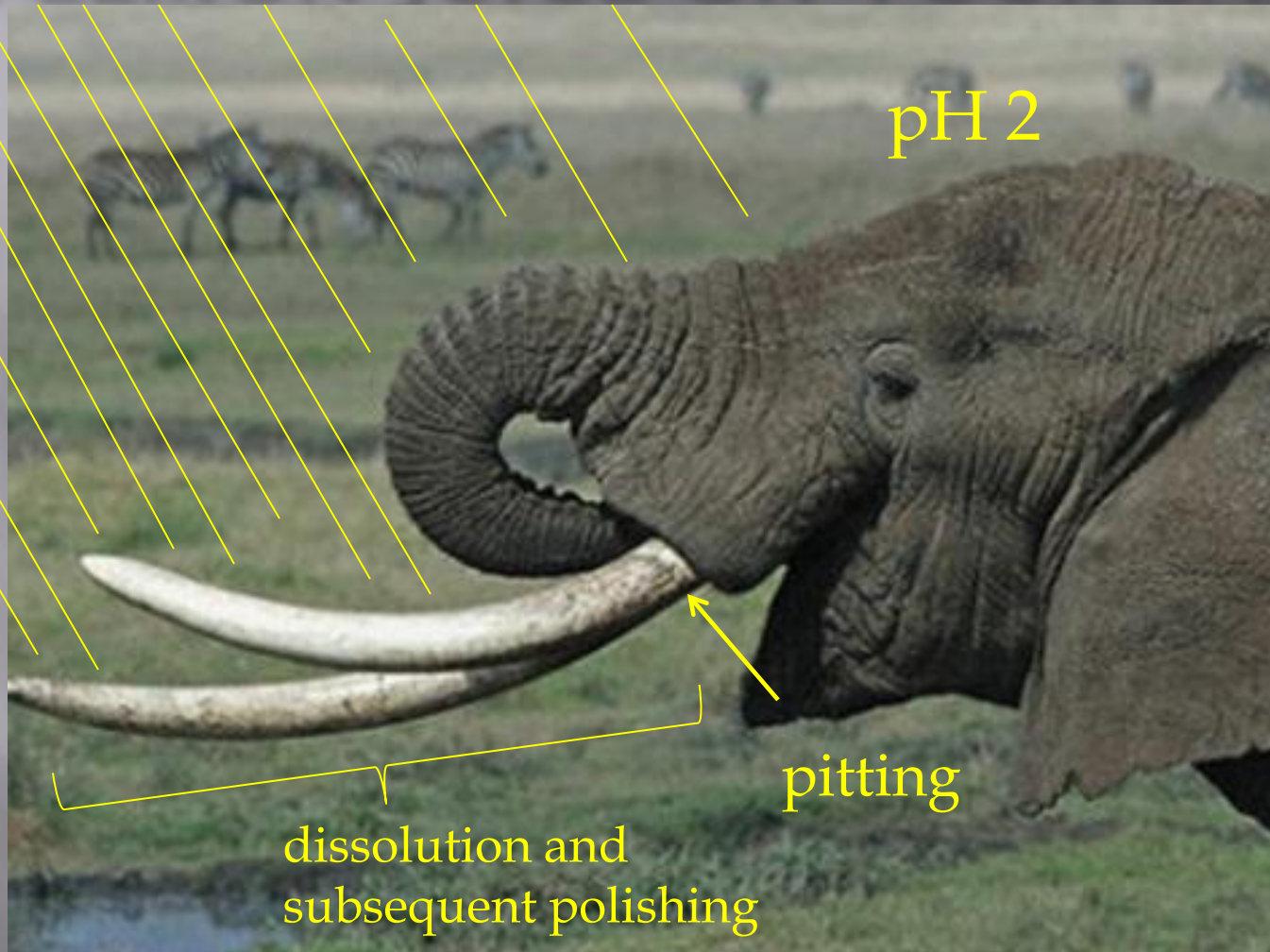
Demonstration with the Tell-Tale Tusk, featuring Dick Mol



Dick_w_tusk.wmv



LIKE LEMON JUICE ON YOUR SALAD



Grazing all day long

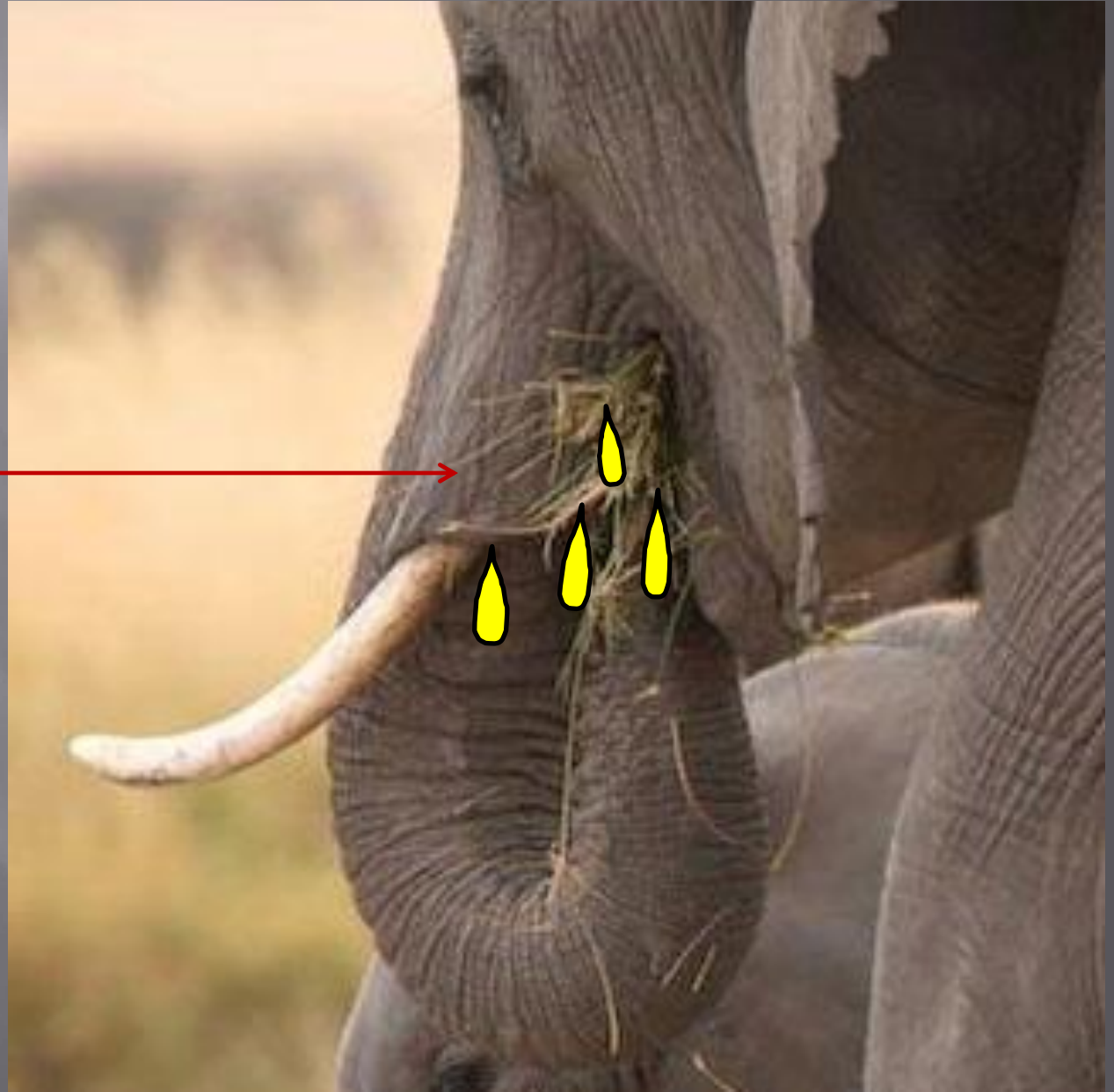
Constant exposure of ivory to acid – dissolves cementum and ivory

LIKE LEMON JUICE ON YOUR SALAD

pH 2

Wet
vegetation

Acid
introduced
under skin
flap near tusk
By feeding
process



Testing the hypothesis



1. Get a radiocarbon date (~12,800 cal yr BP?)
2. Replicate the dissolution pattern by treating ivory with various strengths of nitric acid to simulate the effects of nitric acid rain.
3. Assess how much tusk material is removed by different strengths of nitric acid

THE TELL-TALE TUSK



INITIAL 5 DAY EXPERIMENT ELK ANTLER TINES, LEMON JUICE

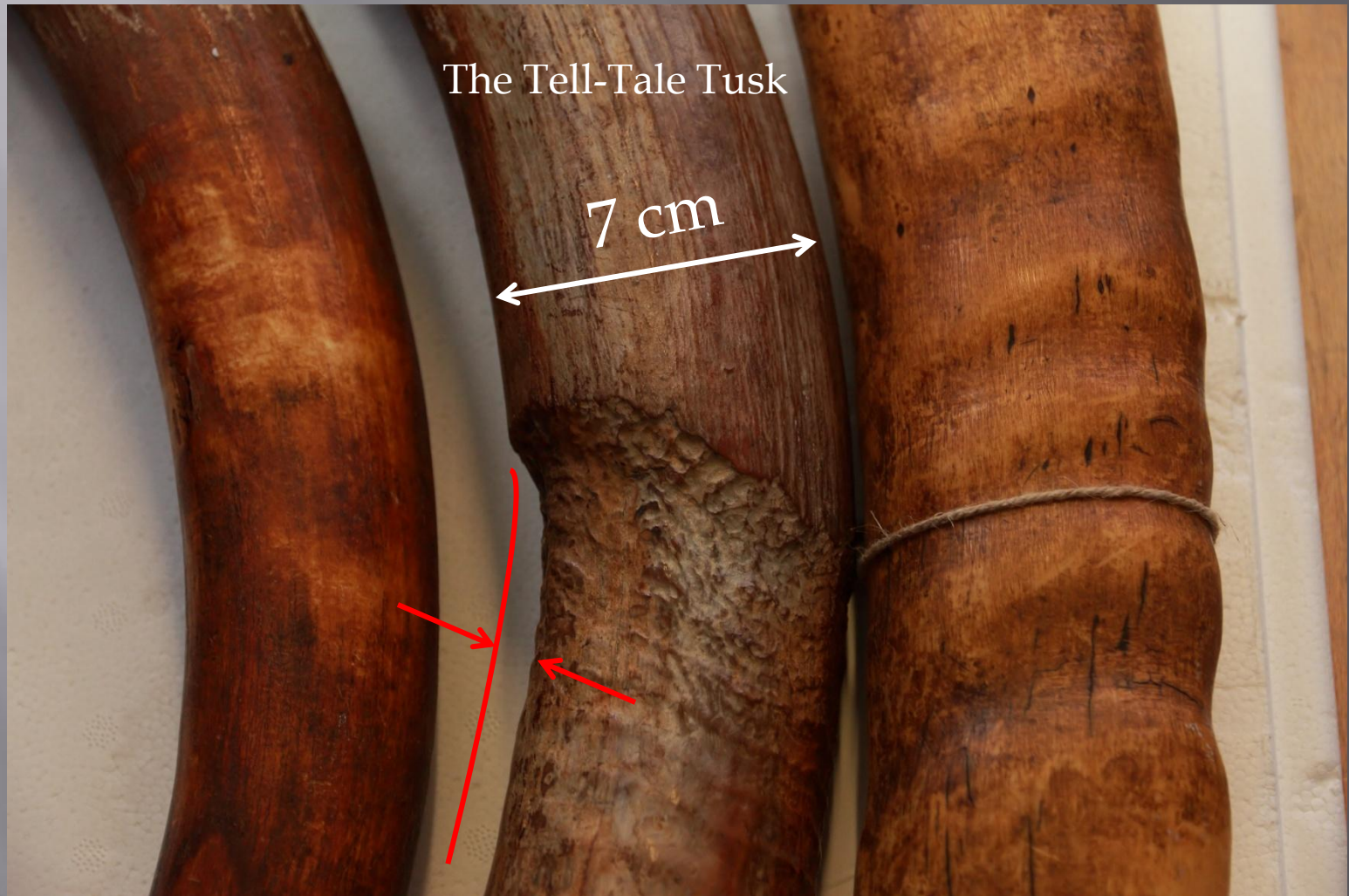
Roughly 4% dry mass lost over
5 days

END
DAY 4
Lemon



Day 0
Lemon Juice
pH 1.79

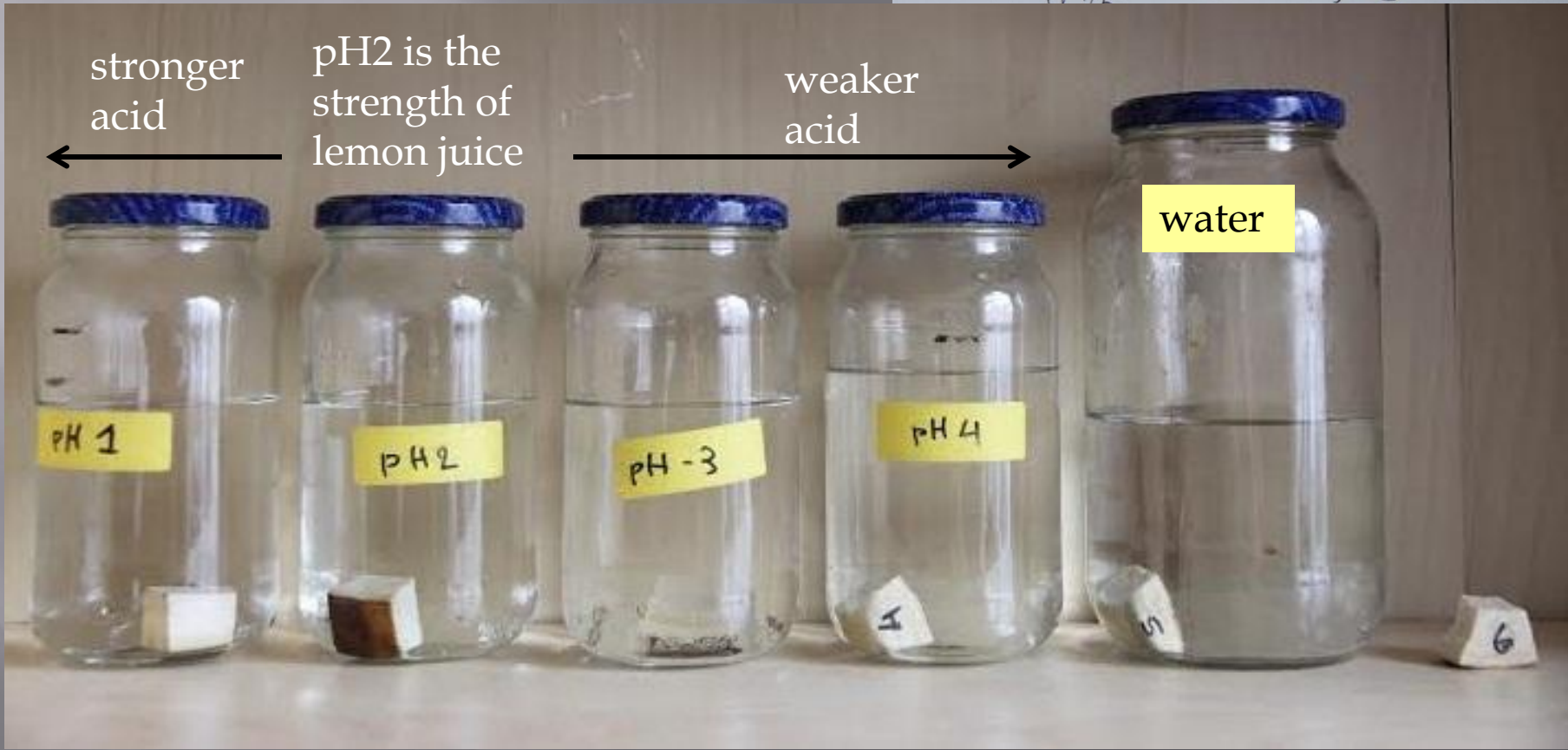
LOSS OF TUSK MATERIAL



Diameter is reduced, mostly from the dorsal side

Ivory Dissolution Simulation Experiment

7.0 is neutral on the pH scale, scale
is logarithmic

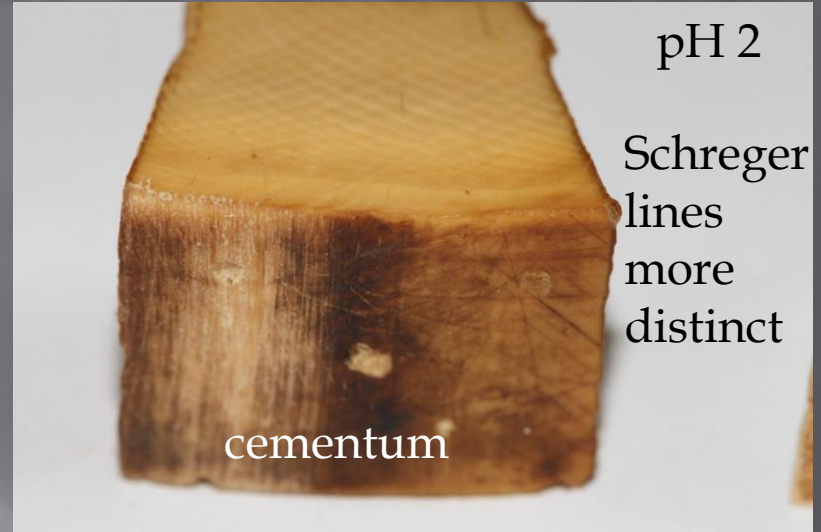


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RESULTS - REPLICATION



pH 0



pH 2

Schreger
lines
more
distinct

cementum

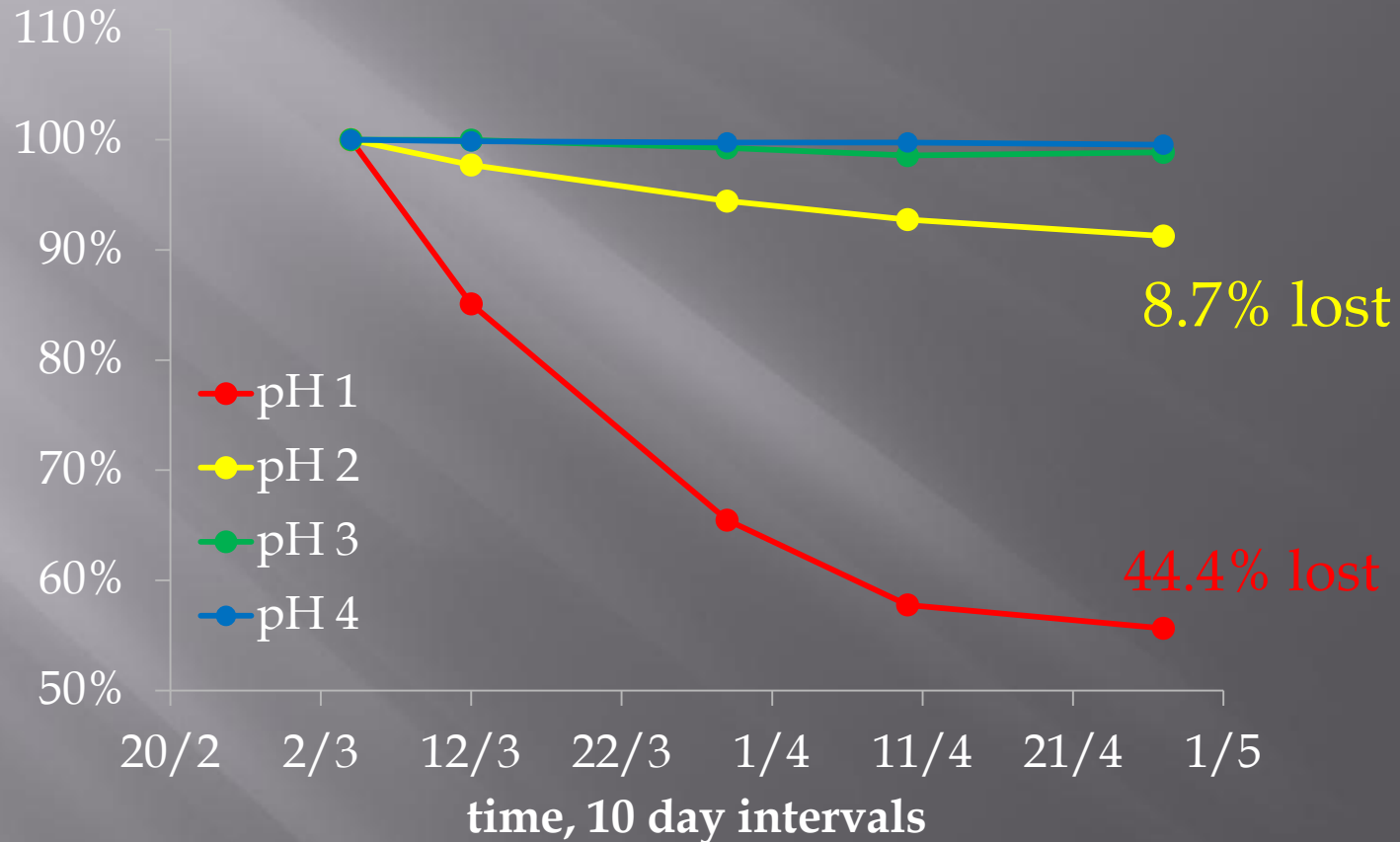


pH 1
dry

THE TELL-TALE TUSK

Results – Mass loss

% Loss of Dry Mass by pH Nitric Acid



THE TELL-TALE TUSK

Summary

Can nitric acid rain explain the dissolution of this mammoth tusk?

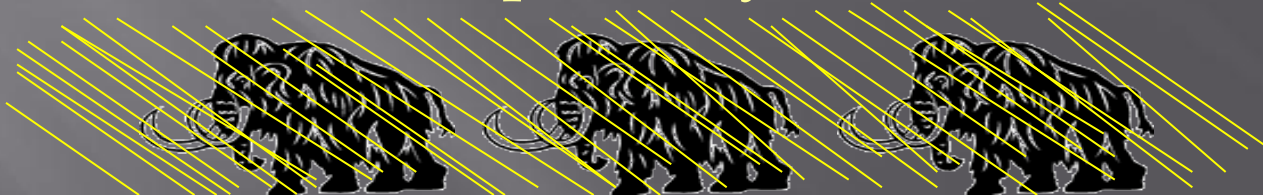
- ▣ Age? - no radiocarbon date yet
- ▣ 9 – 44% dry mass lost in 2 months (pH 2 – pH 1)
- ▣ Replication – tusk and antler material softened
but we have not yet recreated the pattern
Experiments were too static
Ideally we need to test process on an elephant

Future work: Nitrogen isotope analysis

Compare to the North Sea tusk

Experiment using an elephant

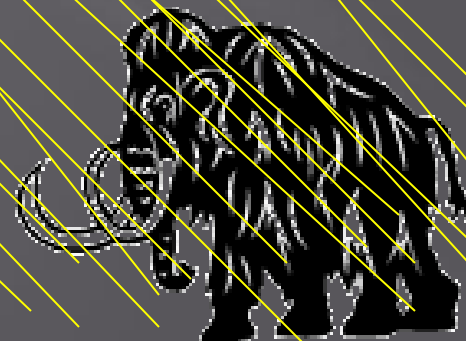
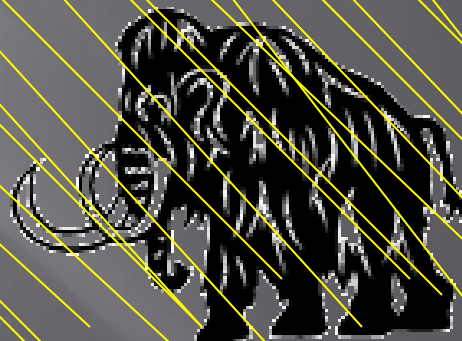
Conclusions: Not disproven yet, need more work



THE TELL-TALE TUSK

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References:

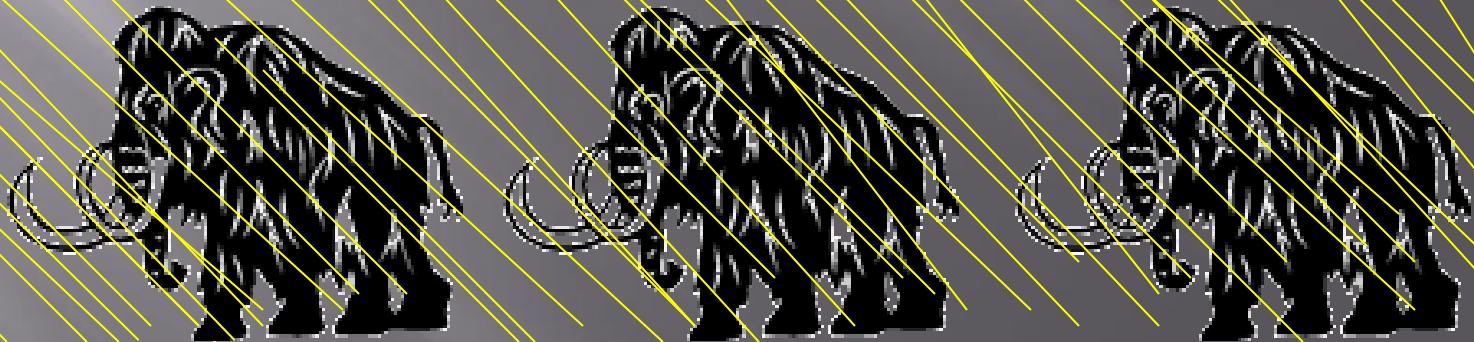
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Joanne Ballard, Dick Mol, Andre Bijkerk, and Jelle Reumer

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If our hypothesis is correct, this has major implications for recent climate change and causation for the mammoth extinction.

If correct, it will lend support to the Firestone et al. 2007 extraterrestrial impact hypothesis.

