Impact did not Cause Climate Change, Extinction, or Clovis Termination at 12.9 ka

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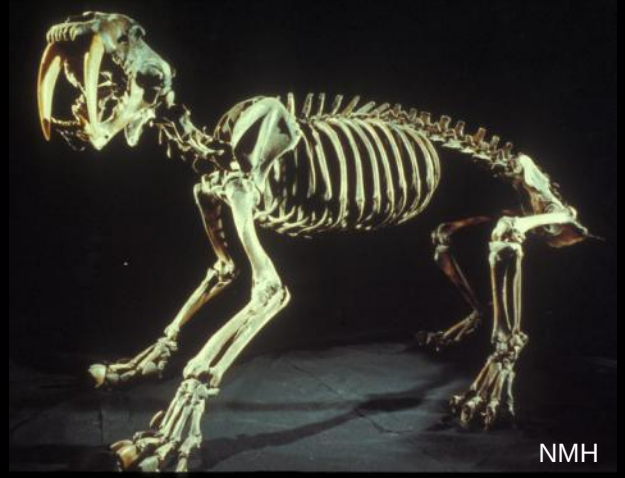
The YD Impact Hypothesis as stated by Firestone et al. (2007)

- Comet
- 4 km in diameter (10^7 megatons)
- Fragmented and dispersed over large area
- Low-elevation angle
- Target: Laurentide ice sheet

Firestone RB, West A, Kennett JP, Becker L, Bunch TE, et al., (2007) Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions and the Younger Dryas cooling. PNAS, 104:16016–16021.

NMH

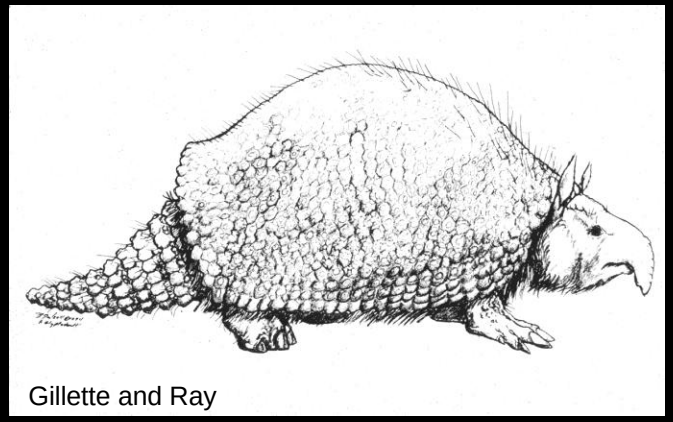
AMNH



NMH

LACM

AMNH



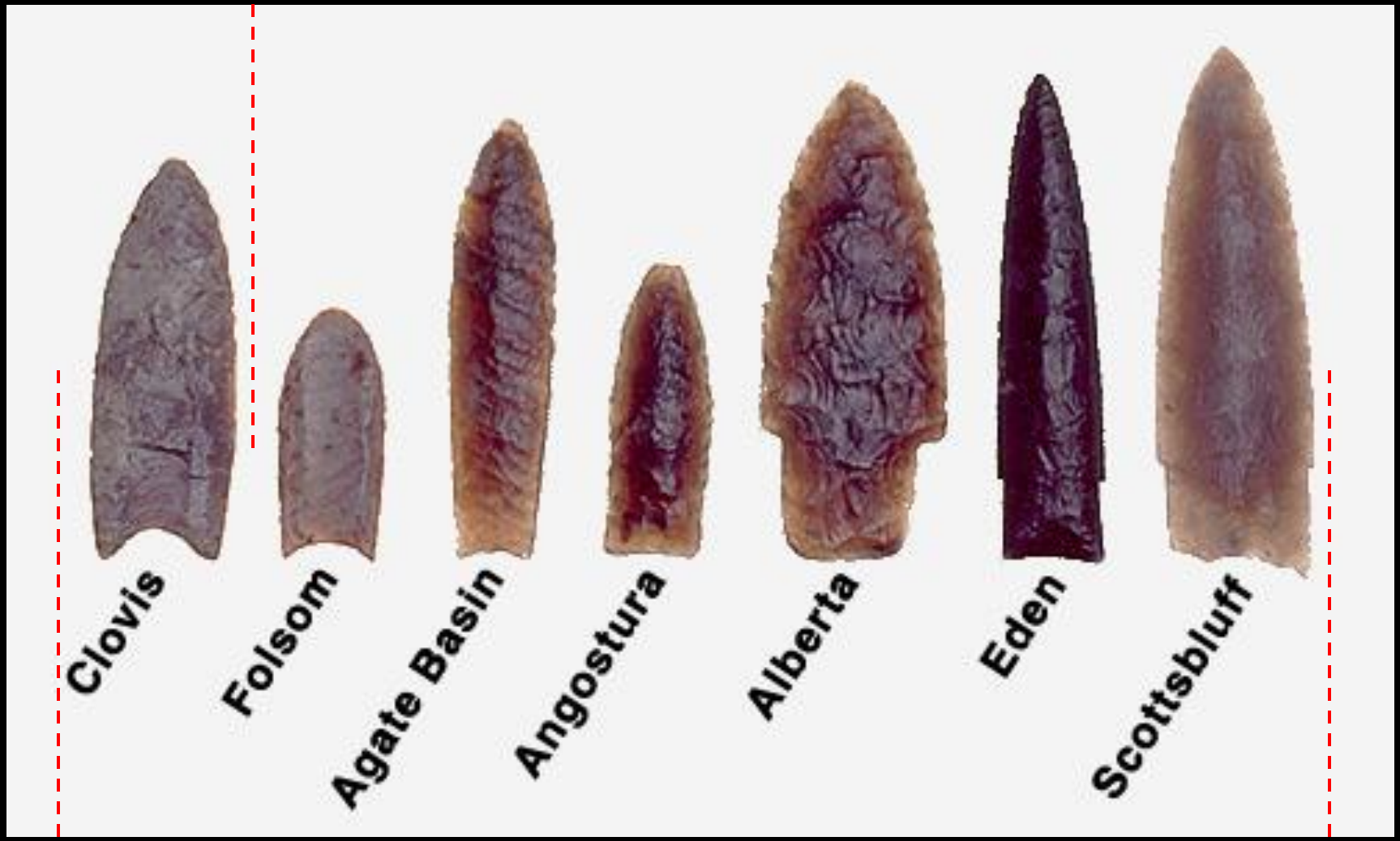
Gillette and Ray

D. K. Grayson

V. Holliday

Paleo Style Changes Over Time

12,900 yrs BP



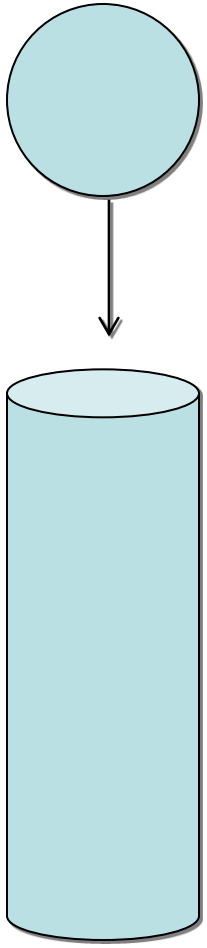
~13,500 yrs BP

~10,000 yrs BP

Arguments against YD Impact

- ✓ Physical impossibility
- ✓ Statistical impossibility
- • Lack of physical model
- ✓ Lack of physical evidence
- ✓ Irreproducibility (also see Pinter et al., 2011, “Requiem”)
- • Archeology
- • Stratigraphy
- • Extinctions
- ✓ Paleoclimate/paleoecology
- ✓ Radiocarbon dating irregularity

Physical Impossibility



4-km diameter comet

- Effective volume of displaced air is about 4 times volume of putative comet.
- Density of air is about 1/1000 that of comet.

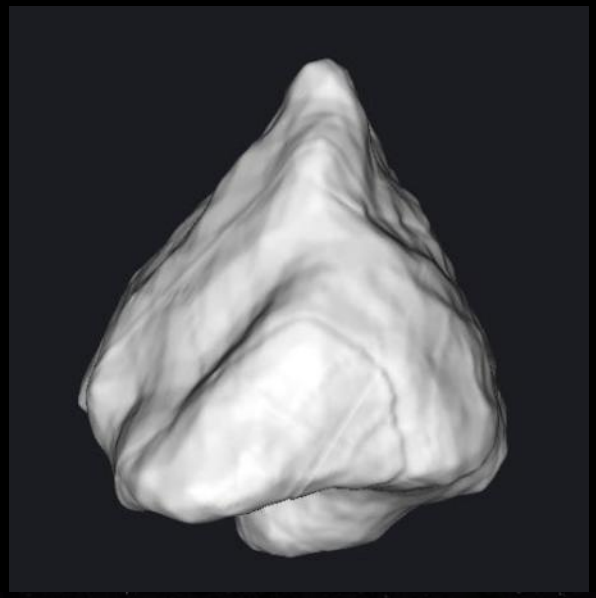
8-km atmospheric scale height

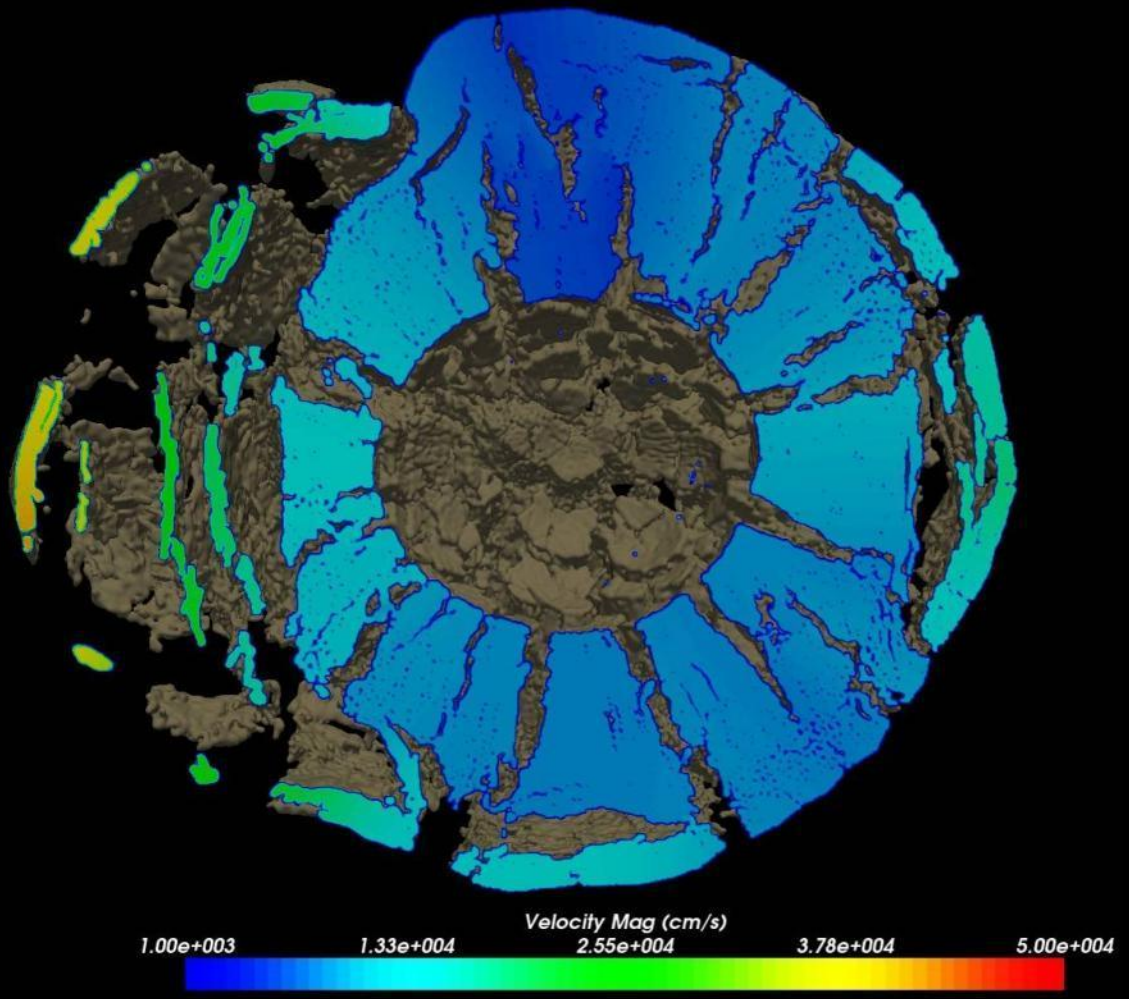
M_a « M_i : Atmospheric effects are negligible

Velocity decreases by ~0.1%

4-km comet cannot stop or explode

Physical Impossibility





No lateral force to separate fragments

"Exploding asteroid" provided shake-down problem for Red Storm supercomputer and scientific visualization tools

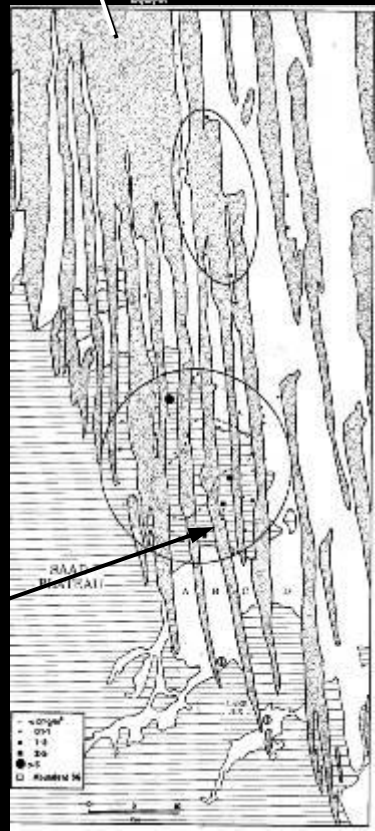
Animation available on Youtube (http://www.youtube.com/watch?v=e4HCTcQ-IWA)

Lack of Physical Evidence

Meteor Crater is four times older than YDB (2.5 Mt explosion)

YDB hypothesis suggests equivalent of > 1 million Meteor Craters

2006: “Ancient Asteroid” documentary



National Geographic animation for “Ancient Asteroid”

Animation available on Youtube
(http://www.youtube.com/watch?v=9qa-Txb0QA4#t=6m22s)

“…it's an impossible scenario and I couldn't verify as accurate something that I think is impossible.”

Mark Boslough email to TV6, May 19, 2006

(feedback on animation of Boslough & Crawford, 1996, simulation of fragmented asteroid)

AGU Press Conference, 2007 (Acapulco)

"…we think a similar thing happened for this event."

Allen West, AGU press conference, May 2007
(referring to animation of "impossible scenario")

Press conference available on Youtube (http://www.youtube.com/watch?v=I2ld-lohrPw#t=4m47s)

Statistical Impossibility

Number of 10^7 Mton NEOs that collide with Earth every 13,000 years (on average) = 0.001

Fractional area of Laurentide ice sheet = 0.01

Fraction of NEOs that are comets = 0.01

Fraction of comets that are broken = 0.001

Fraction of time broken comet is Earth-sized = 0.001

Fraction of impacts that are grazing = 0.01

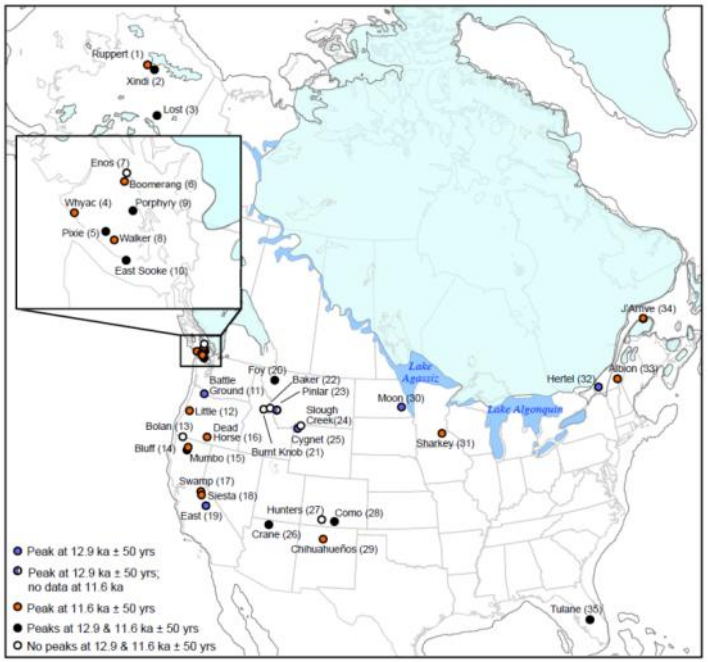
A priori probability of putative YDB impact = 10^{-15}

Expected recurrence interval = 10^{19} years

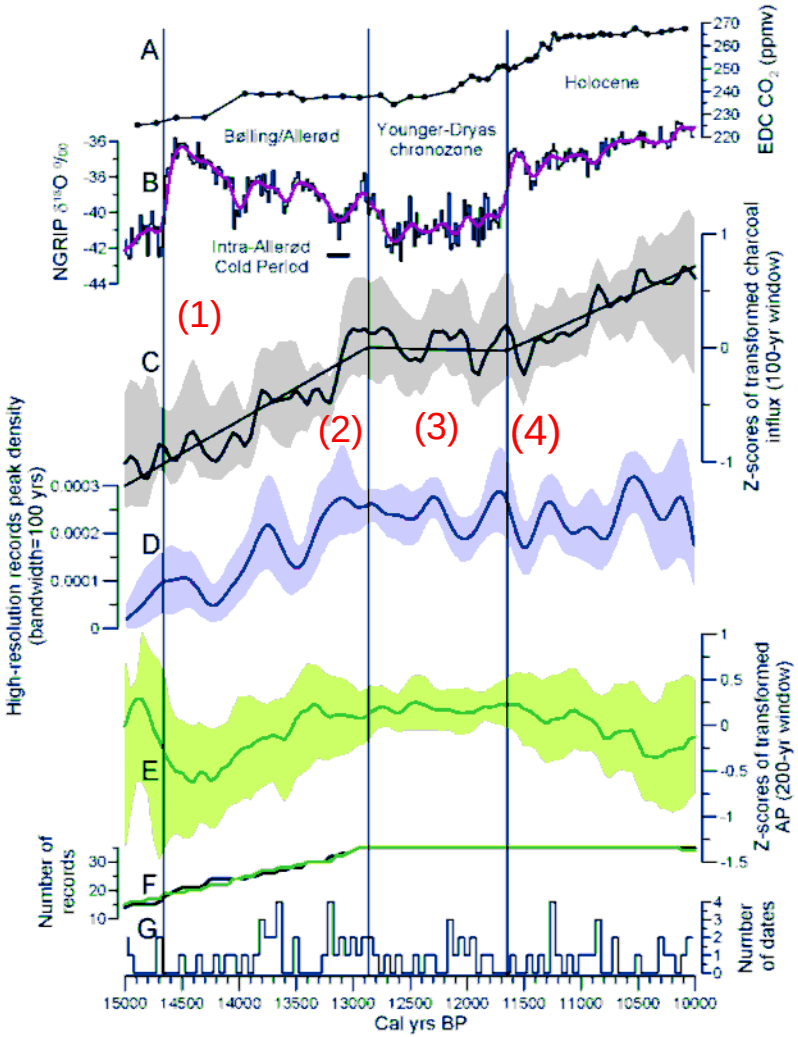
Paleoecology

North American sedimentary charcoal records (n=35) from the YD show that “the entire continent” (as argued by J. Kennett) was not on fire.

Large, scattered fires occurred asynchronously throughout the YD interval.



(Marlon et al. 2009)

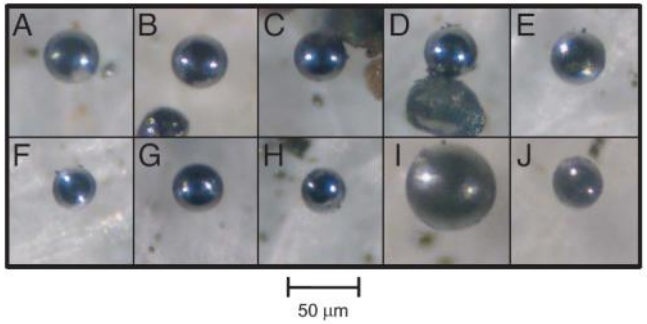


(1) Biomass burning increases with deglacial warming during B/A
(2) Peak in biomass burning at 13.2 ka
(3) Biomass burning levels off during YDC
(4) Peak in biomass burning at end of YDC, and resumption of increase

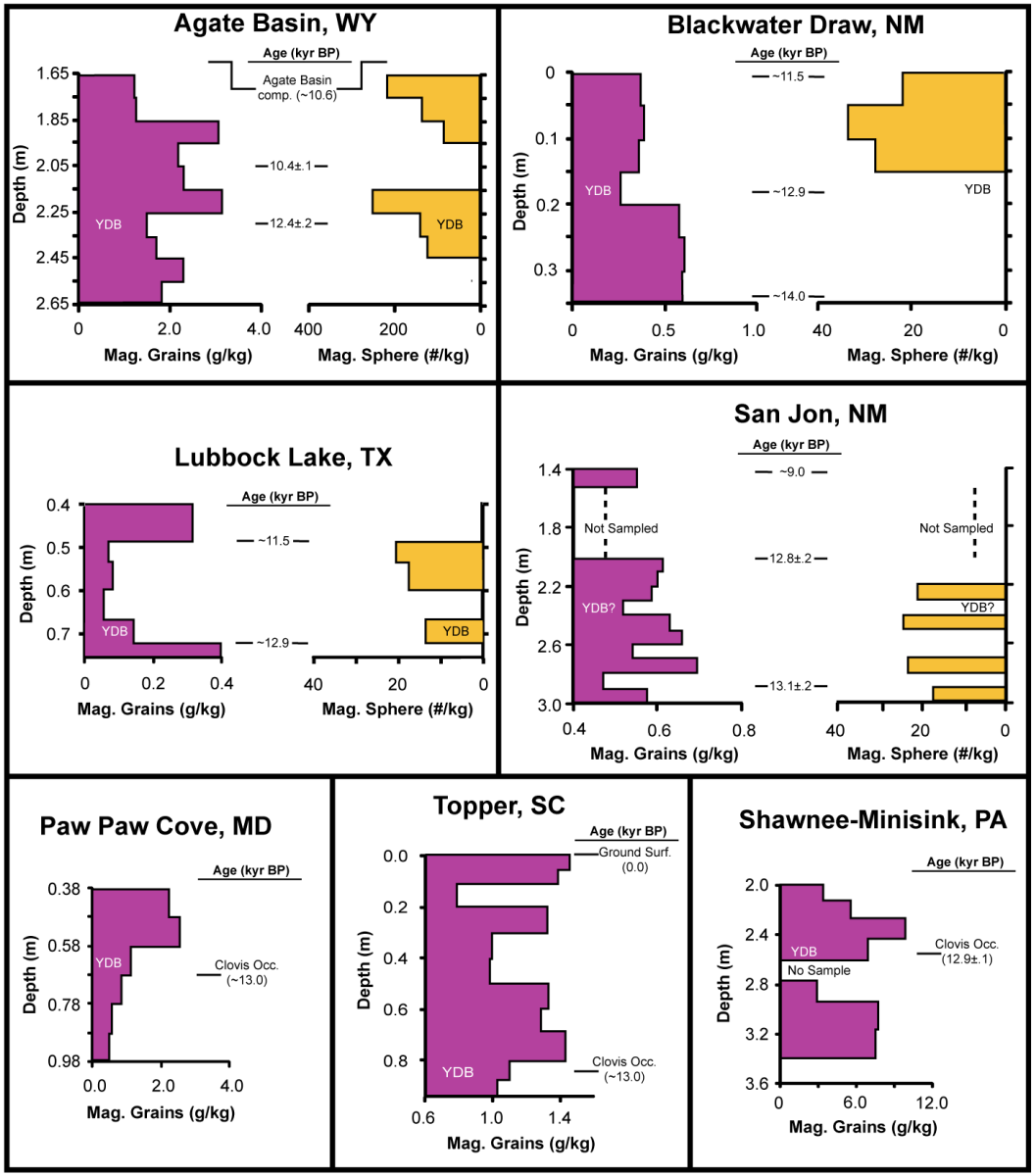
T. Surovell

Irreproducibility

- For seven sites and two of Firestone et al.'s impact markers, we found no peaks unique to YDB samples.
- These are two of the most reliable markers in the Firestone et al. (2007) study, which showed very strong peaking at the YDB.
- Microspherules occur sporadically throughout late Quaternary sediments.
- Magnetic grains are ubiquitous and do not exhibit enhanced concentrations at the YDB.

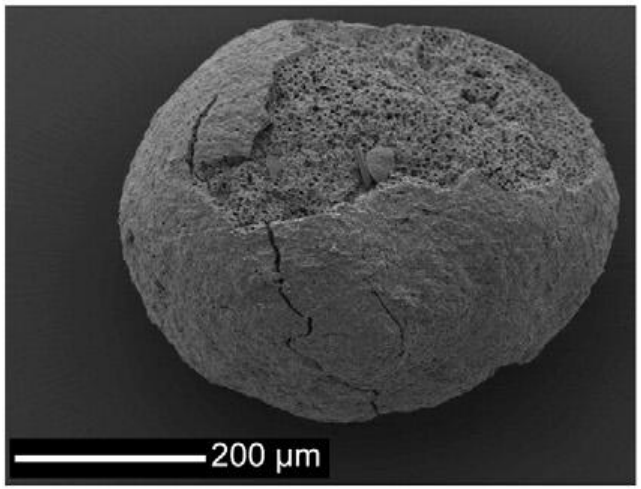


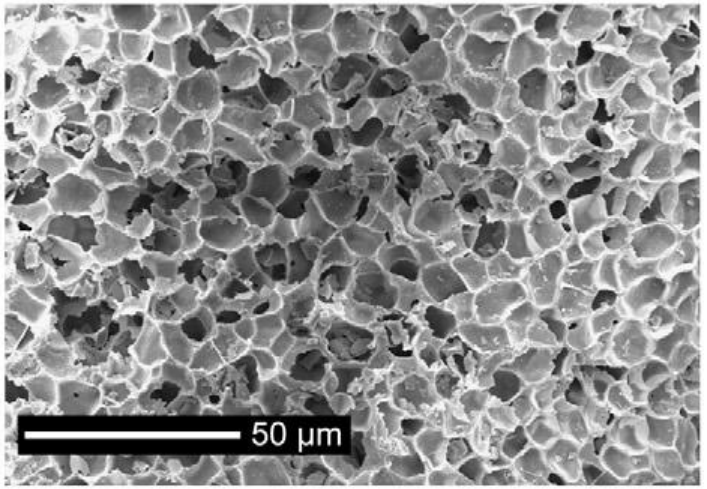
Magnetic microspherules from non-YDB samples.



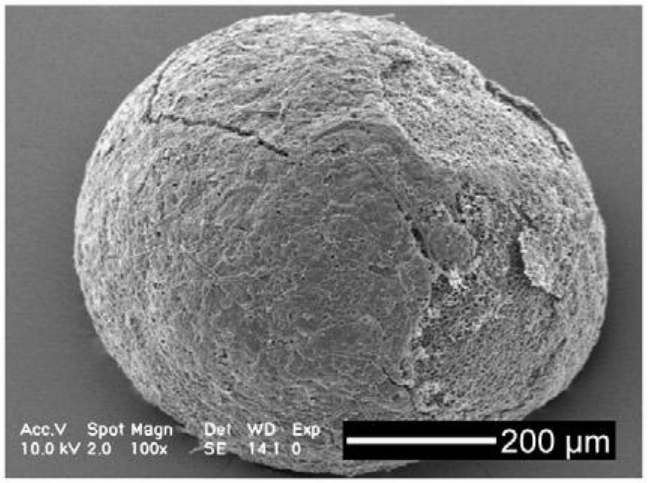
Irreproducibility

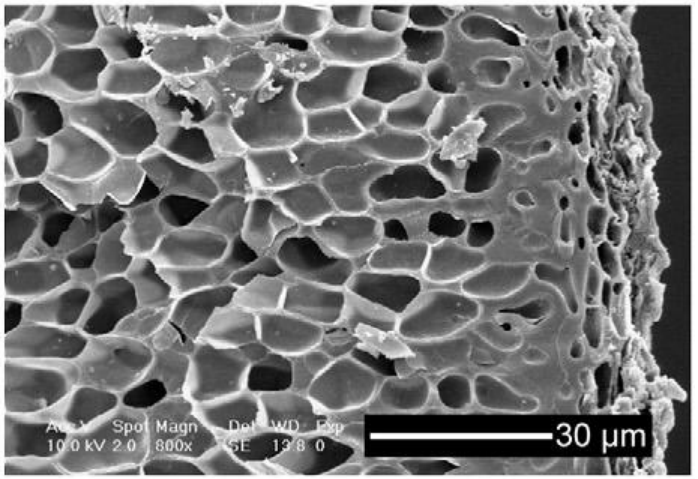
Spherules from AC-003, YDB unit according to Kennett et al. (2008)





Fungal sclerotium from *Cenococcum geophilium*





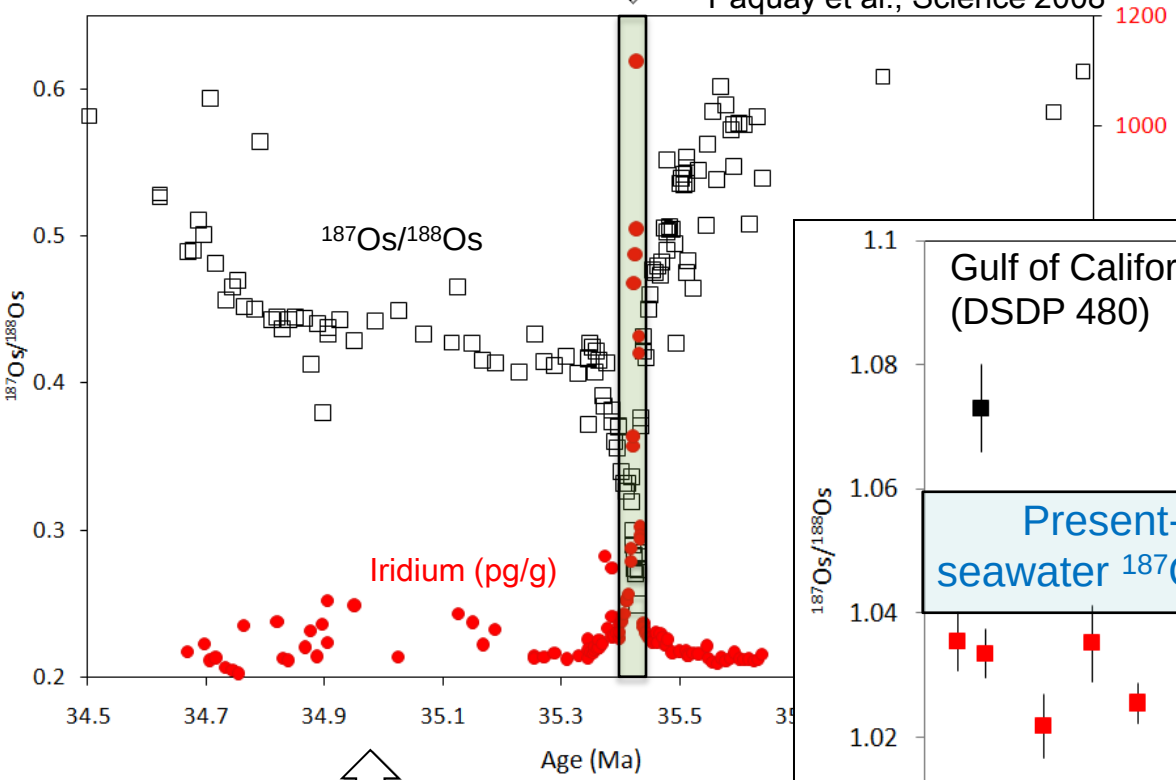
The Younger Dryas impact hypothesis: A requiem (Pinter et al., 2011)

Irreproducibility

Seawater $^{187}Os/^{188}Os$ declines from 0.5 to 0.24 after the Popigai impact hit followed by 100,000 years recovery

Late Eocene (Popigai, 35.43 Ma)

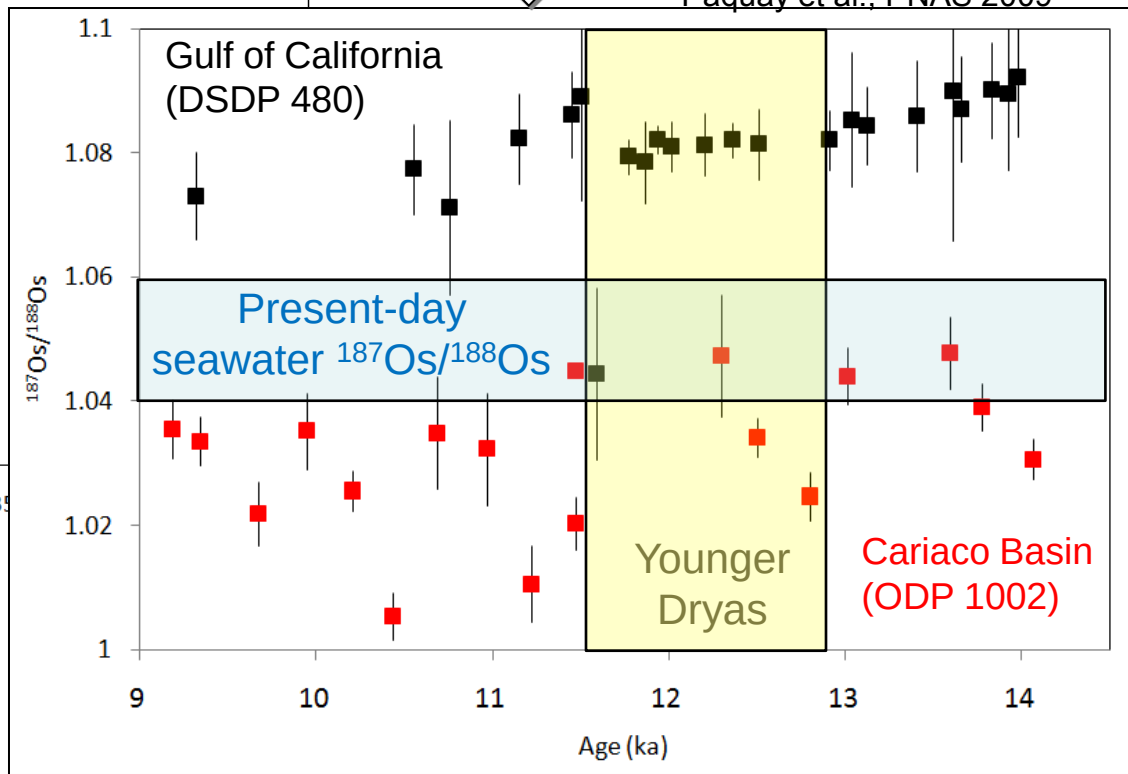
Paquay et al., Science 2008



This is how a cosmic impact changes the seawater osmium isotopic composition

No significant change in Os during YD that would result from chondritic impact

Paquay et al., PNAS 2009

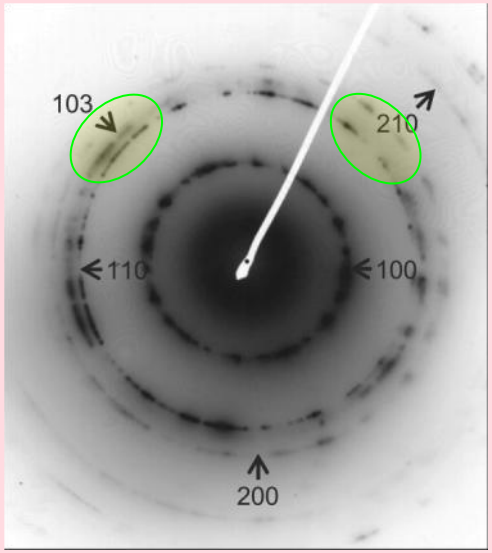


Diamond Misidentification

Kennett et al. (2009) reported abundant Lonsdaleite nanodiamonds.

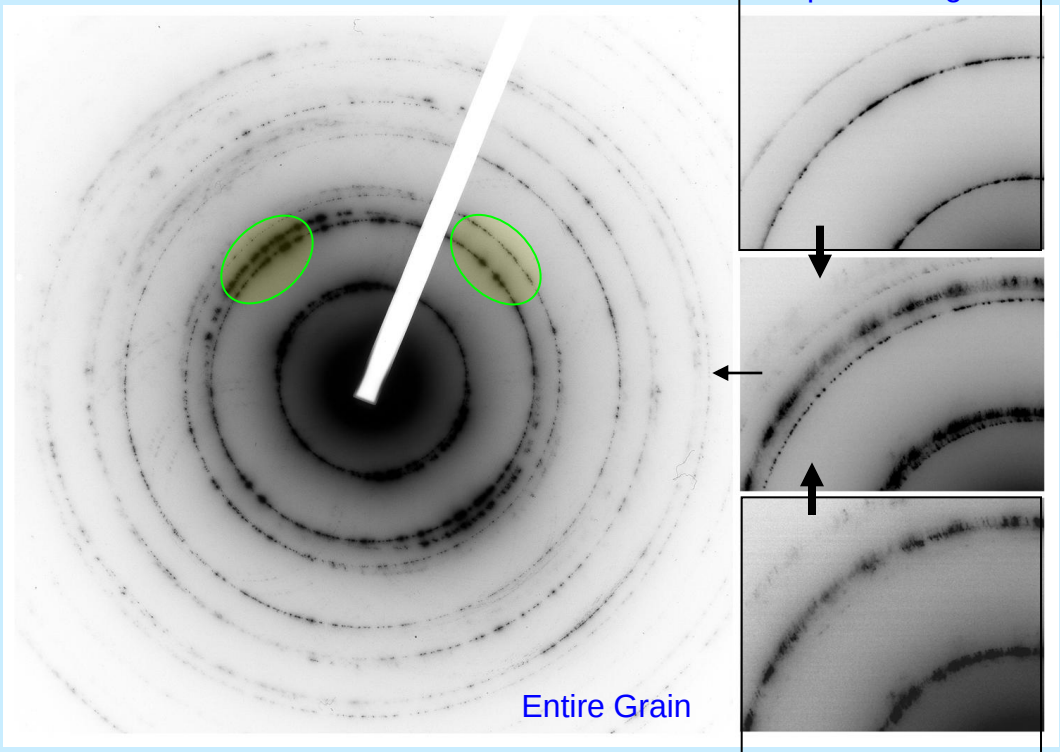
Lonsdaleite would be the strongest evidence of impact because it is often associated with impact shock features where it has been found to occur naturally.

Reported as Lonsdaleite



Kennett *et al.* 2009

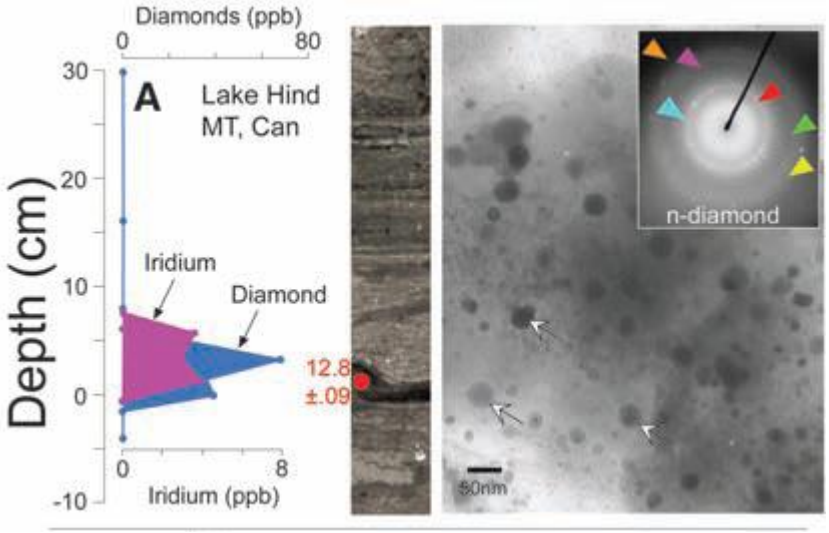
Actually: Graphene/Graphane Aggregate



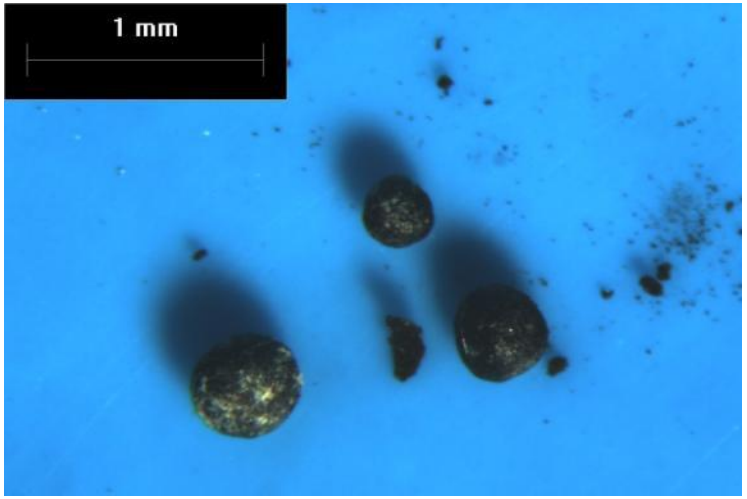
Daulton *et al.* 2010

- Missing Lonsdaleite reflections in Pattern => it is not Lonsdaleite.
- Asymmetry in Pattern => heterogeneous mixture of two phases.

Radiocarbon dating irregularity



Kennett et al., PNAS, 2009



Gainey spherules received from Allen West
Dated at 207 ± 87 years BP

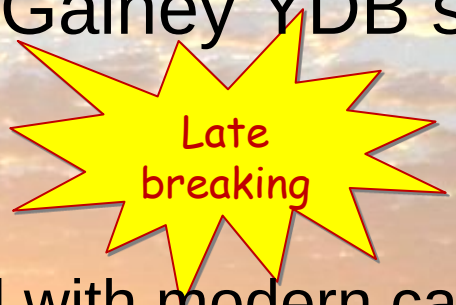
- Kennett et al. (2009) reported nanodiamonds at 6 YDB sites.
- Gainey, MI had highest concentration, at 3700 ppb.
- Allen West provided 16 carbon spherules from the YDB at Gainey.

- Radiocarbon age of first tested Gainey spherule is 207 ± 87 years BP.

Late breaking

Conclusions

- The YD impact hypothesis, as stated, is not possible, either physically or statistically
- Much of the putative evidence for a YD impact is irreproducible or nonexistent
- New radiocarbon age for Gainey YDB spherule suggests that:



1) Samples are contaminated with modern carbon spherules
2) Diamonds, if present, may be in the modern spherules