Astronomy 150: Killer Skies
Lecture 10, February 8

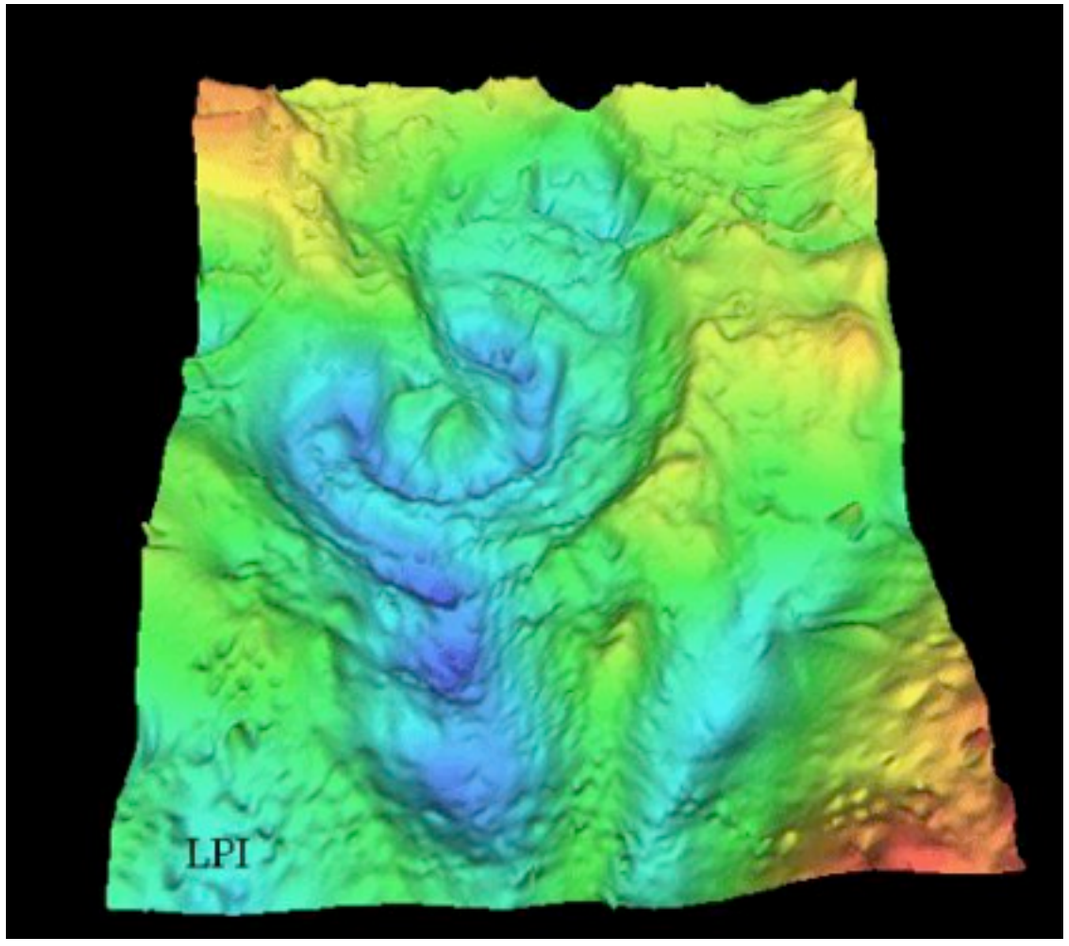
Last time: Meteors and the Earth

Today: T. Rex and the Crater of Doom!

Assignments:

- HW 3 due Friday at start of class
  office hours today after class

Lost Cellphone last time--let me know if you found it



http://apod.nasa.gov/apod/ap000226.html

http://www.jpl.nasa.gov/releases/98/yucatan.html

Planetarium Show: Extended Run

tomorrow: last show designed for Astro students, sold out

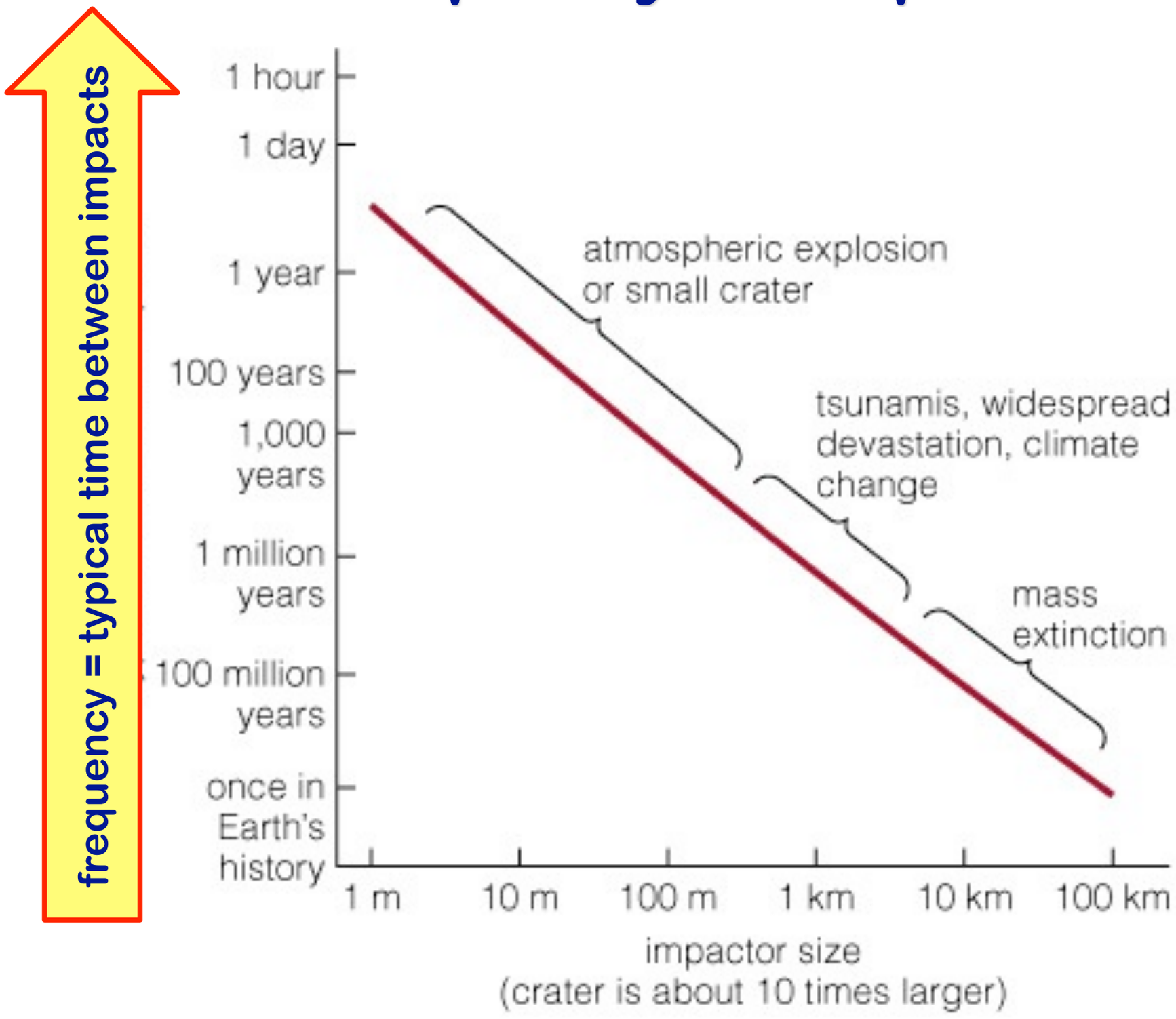
but: may go to general public weekend shows on “Prairie Skies” or “Black Holes”

reports officially due Feb 24, but can hand in anytime until then

Would you go if another Astr student show is added next week?

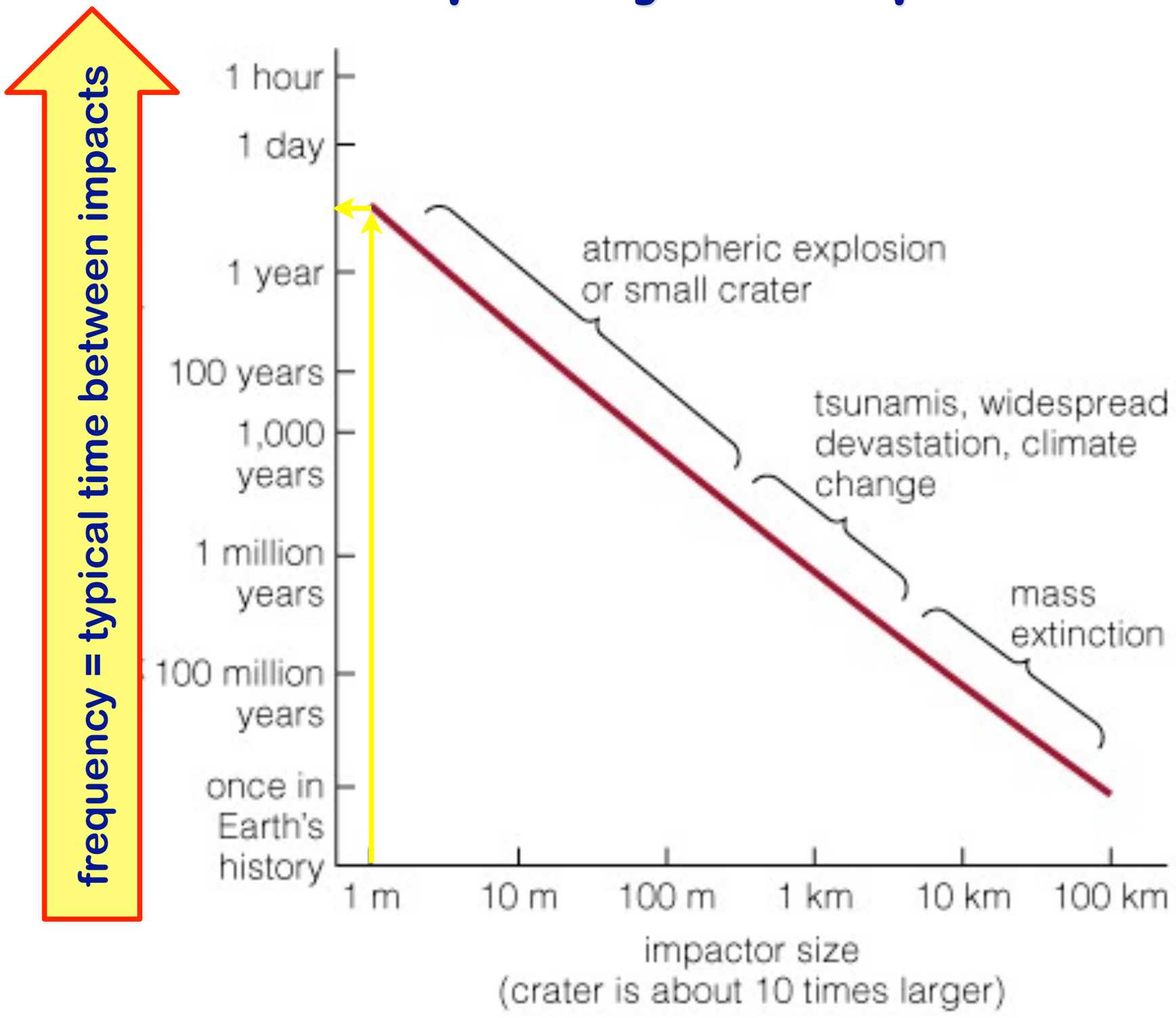
A. yes
B. no--I haven’t gone yet but will do solar and night observing instead
C. no--I have already gone to the Planetarium

Threat Assessment:
Frequency vs. impactor size



impactor size: gives idea of how much damage

Threat Assessment:
Frequency vs. impactor size



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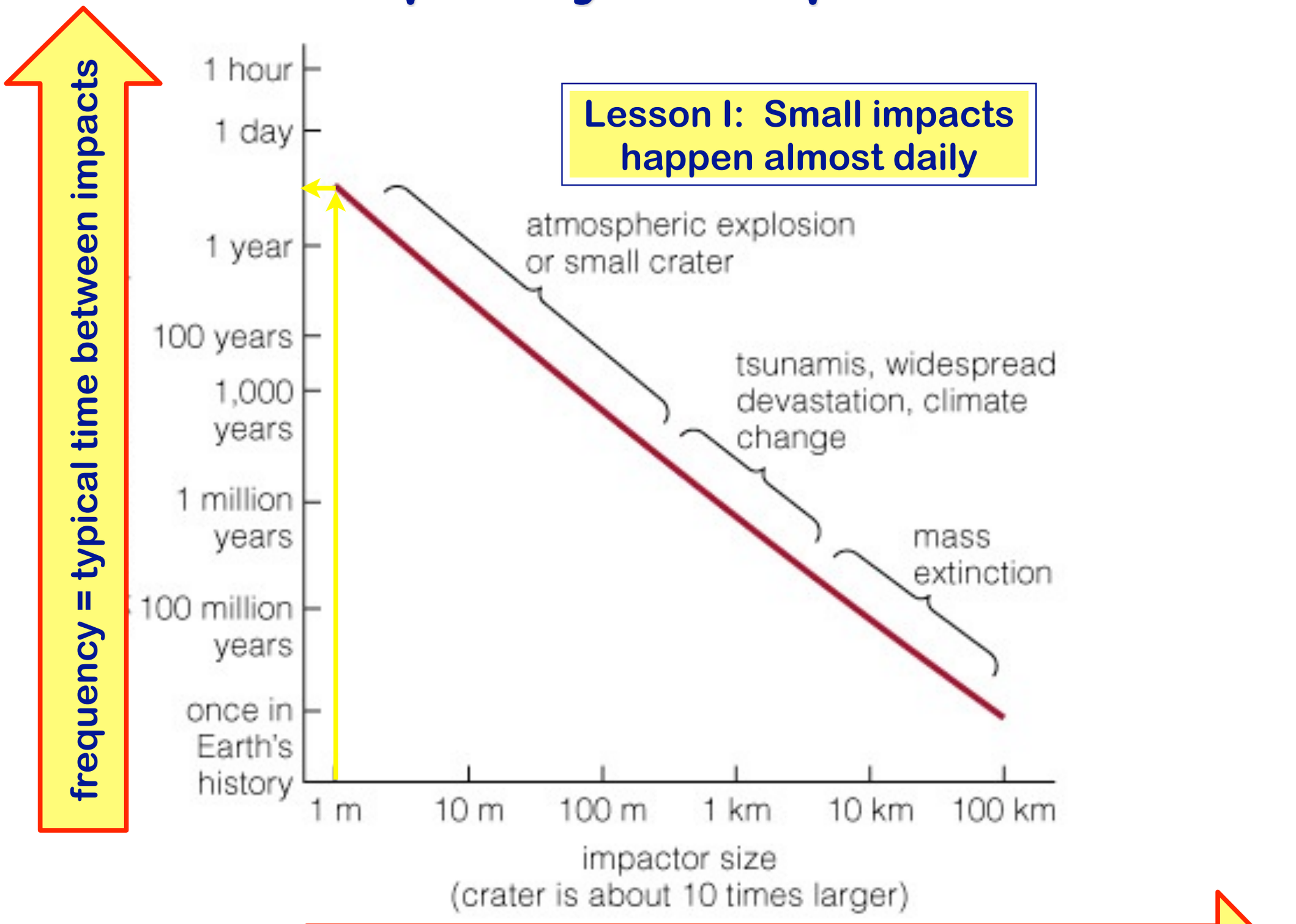
Lesson I: Small impacts happen almost daily



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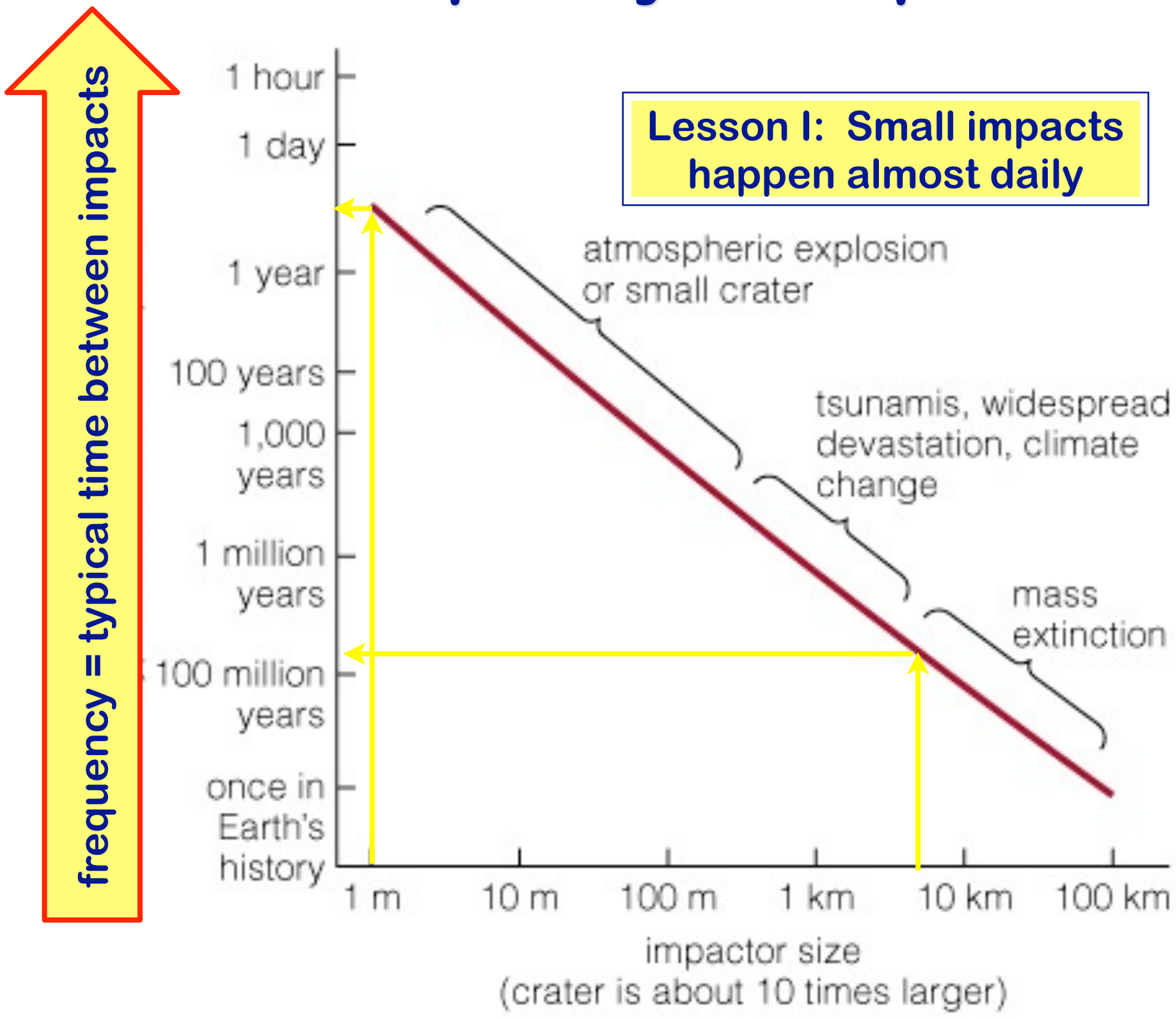

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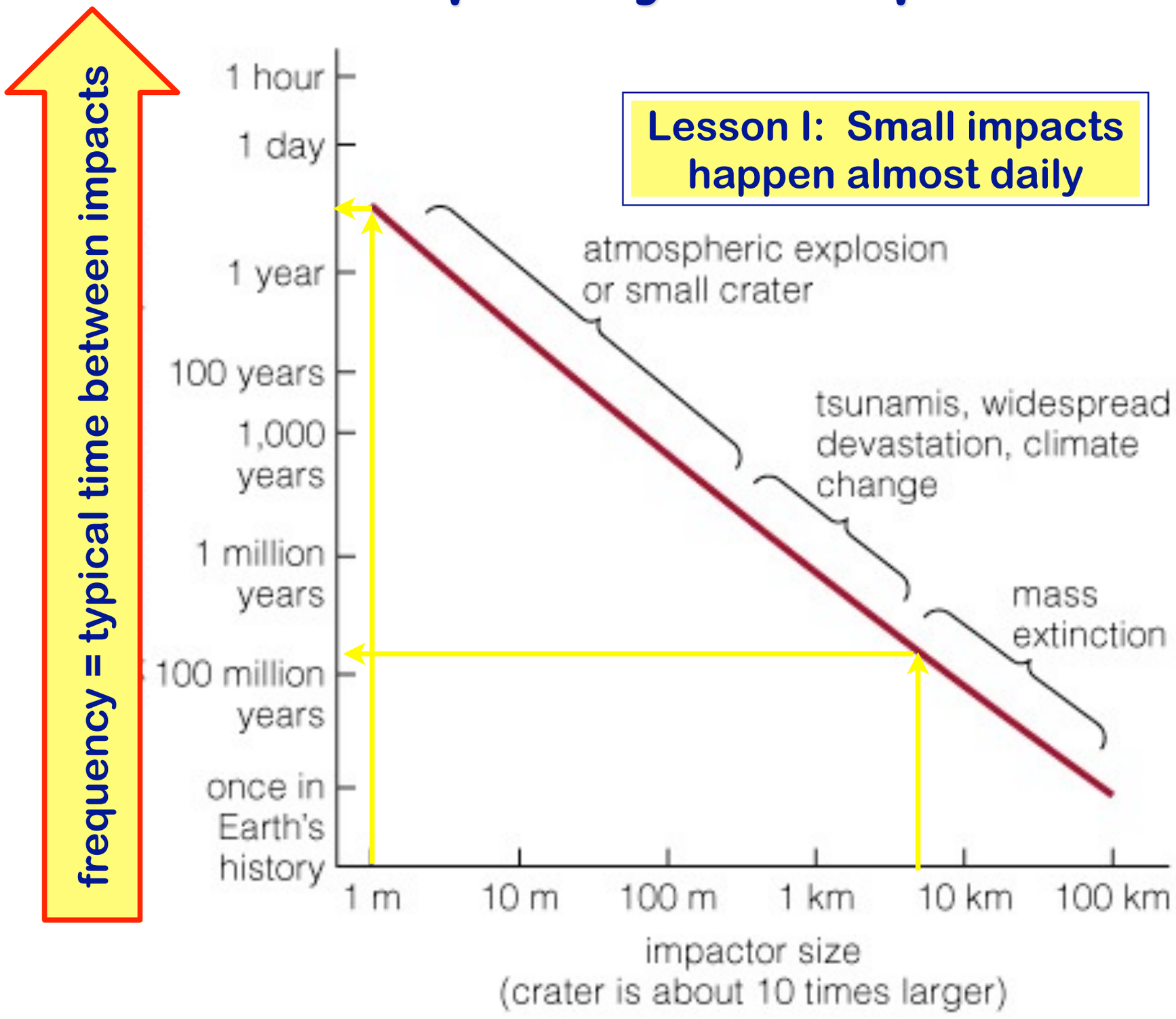

Lesson I: Small impacts happen almost daily

Lesson II: Impacts large enough to cause mass extinctions typically around 100 million yrs apart

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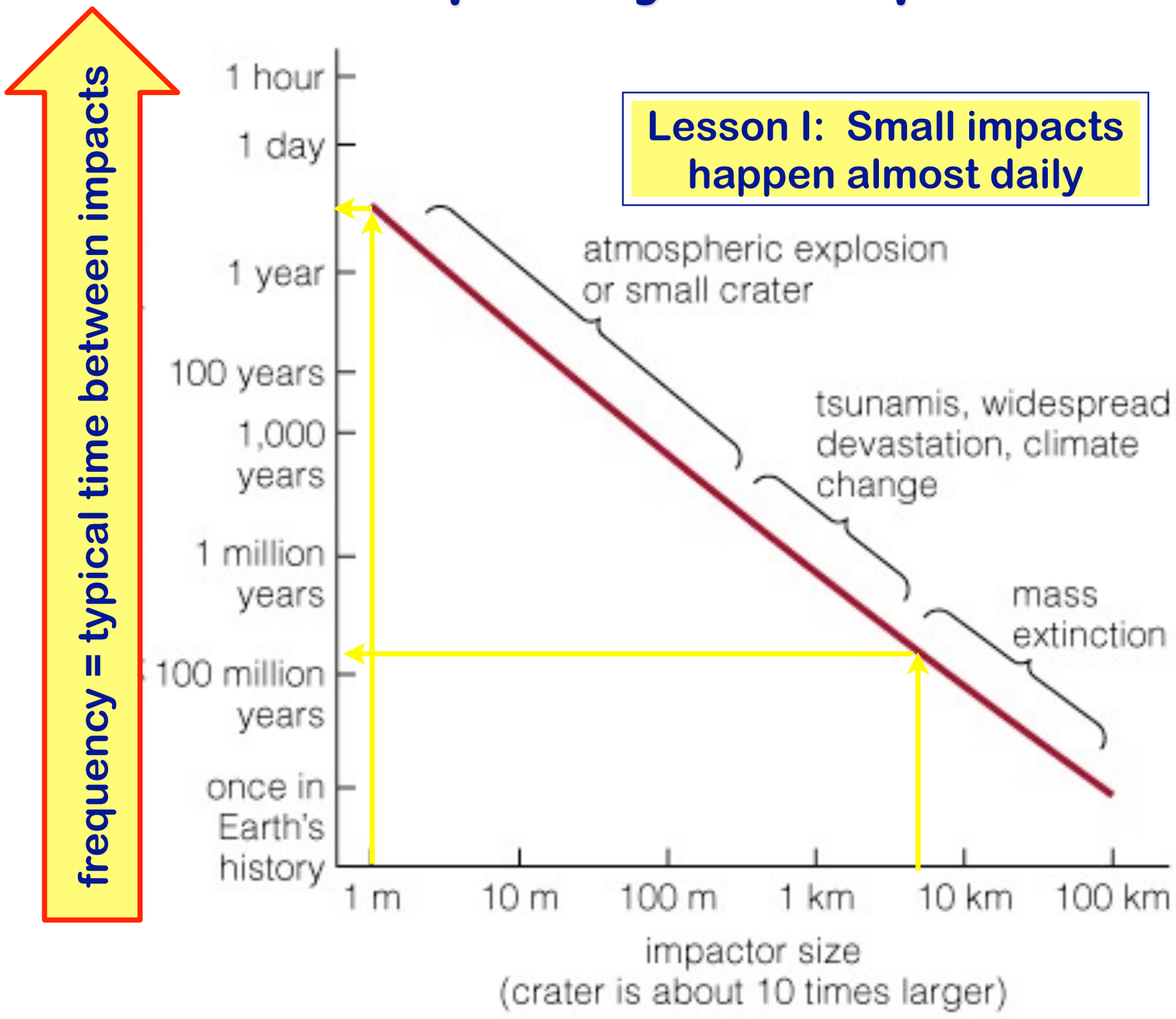

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Lesson II: Impacts large enough to cause mass extinctions typically around 100 million yrs apart

Lesson III: life on Earth > 3000 million yrs: many dangerous impacts over that time!

impactor size: gives idea of how much damage

Effects of an Impact on Earth

Impact crater - how big?

Tsunami (if impactor hits the ocean)

Firestorm

Acid Rain

Climate Change

Death from Above?

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Bad news:

- extinction-level impact essentially guaranteed during the > 3 billion year time life has been on Earth
- Killer Skies could (and did) play an essential role in biological evolution
- to make matters worse: impact rates are averages--individual events occur effectively randomly--can't predict next one based on average rate

Death from Above?

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Good news:

- over shorter timescales, extinction threat is very unlikely

  here: "short" = up to millions of years
- There has not been any evidence of anyone being killed by a meteorite.

  Although there are stories…
- But, there is evidence of people being hit!

Ann Elizabeth Hodges (Sylacauga, Alabama)

Nov 30th, 1954 2:46 pm, Ann was dozing on the couch, when a meteorite (8.5 lbs) crashed through the roof, bounced off a radio, and hit her on the side!

Mbale meteorite
Uganda, 1992

Meteorite broke into many pieces, a small one of which (3 grams) hit a tree, then a young boy in the head.

http://home.wxs.nl/~terkuile/meteorites/mbale/mbale.html

Tunguska, Siberia: June 30, 1908

Estimated ~50 meters across meteoroid

Exploded 5-10 km above the surface

Blast energy ~15 MT

(Megatons TNT)

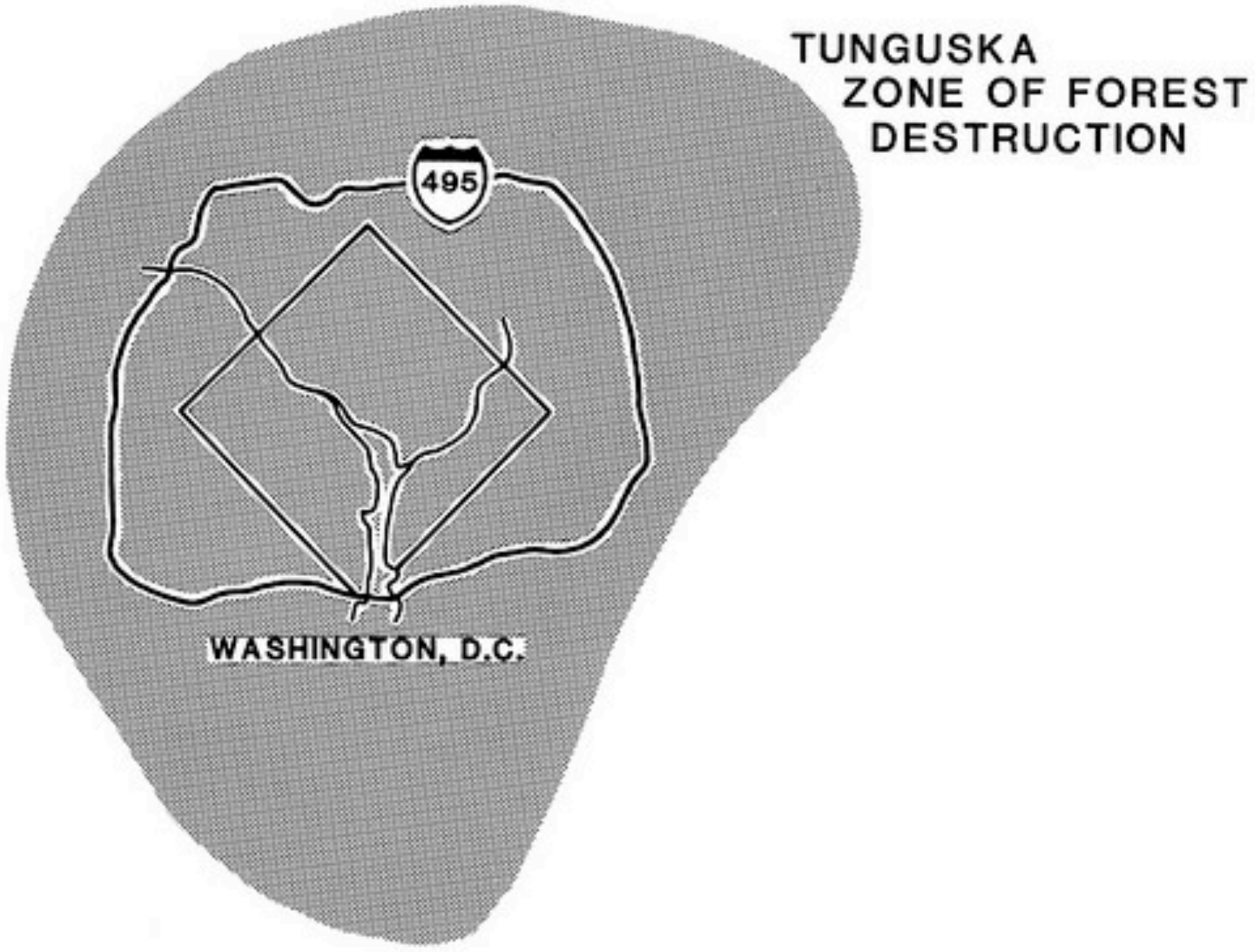
No confirmed impact crater

Location of the Tunguska impact

Artist's conception of Tunguska air blast

near Tunguska Ground Zero
19 years (!) after impact

The explosion leveled 2,150 square km of forest - about 80 million trees!
Trees lay in radial ("spokes") pattern centered on ground zero



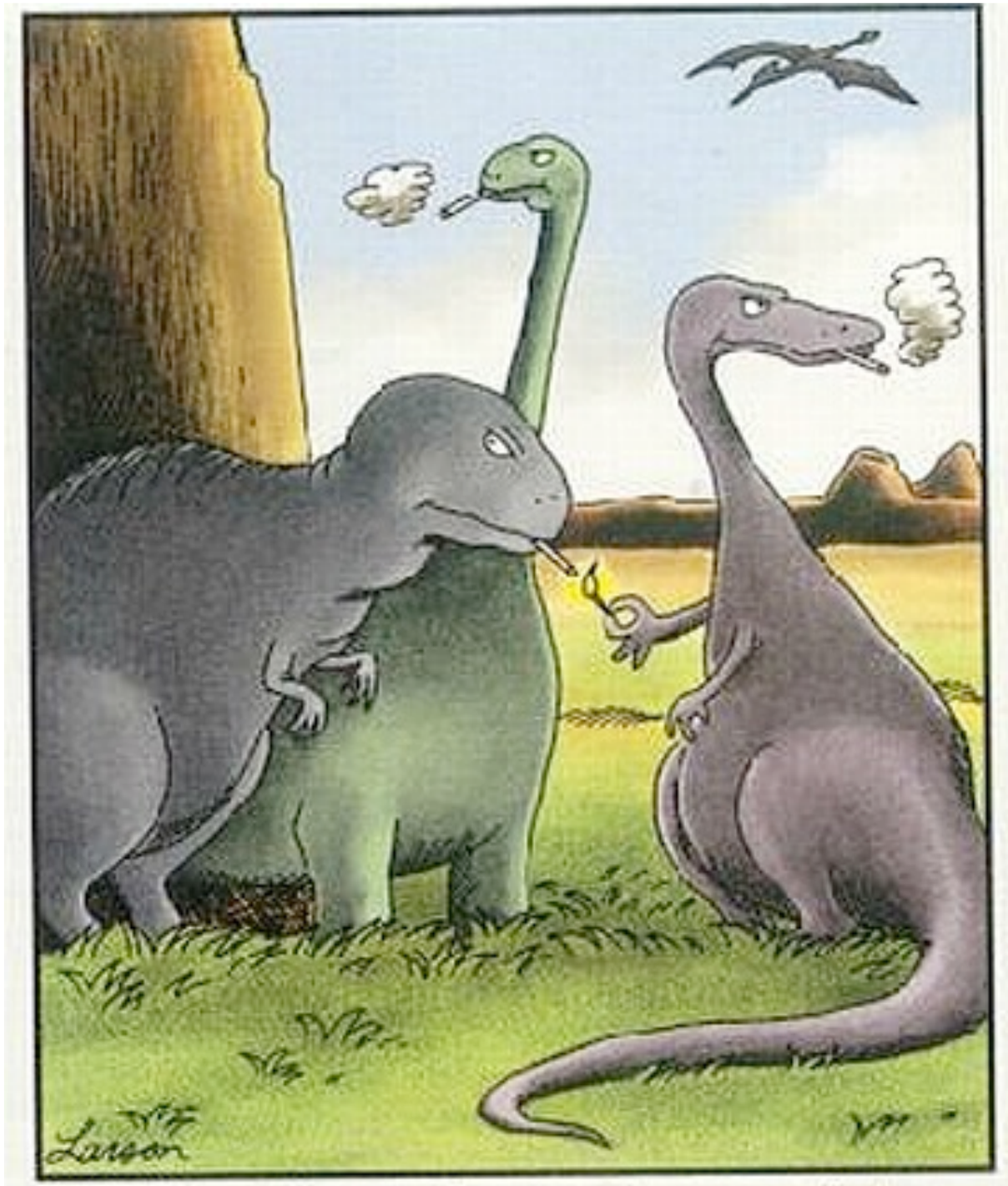
Area of devastation from the Tunguska impact compared to Washington DC

What Killed the Dinosaurs?

65 million years ago, 75-95% of all the species on Earth disappeared

2nd largest known mass extinction in geological history

Was an asteroid collision to blame?



The real reason dinosaurs became extinct

Cretaceous-Tertiary (KT) Boundary

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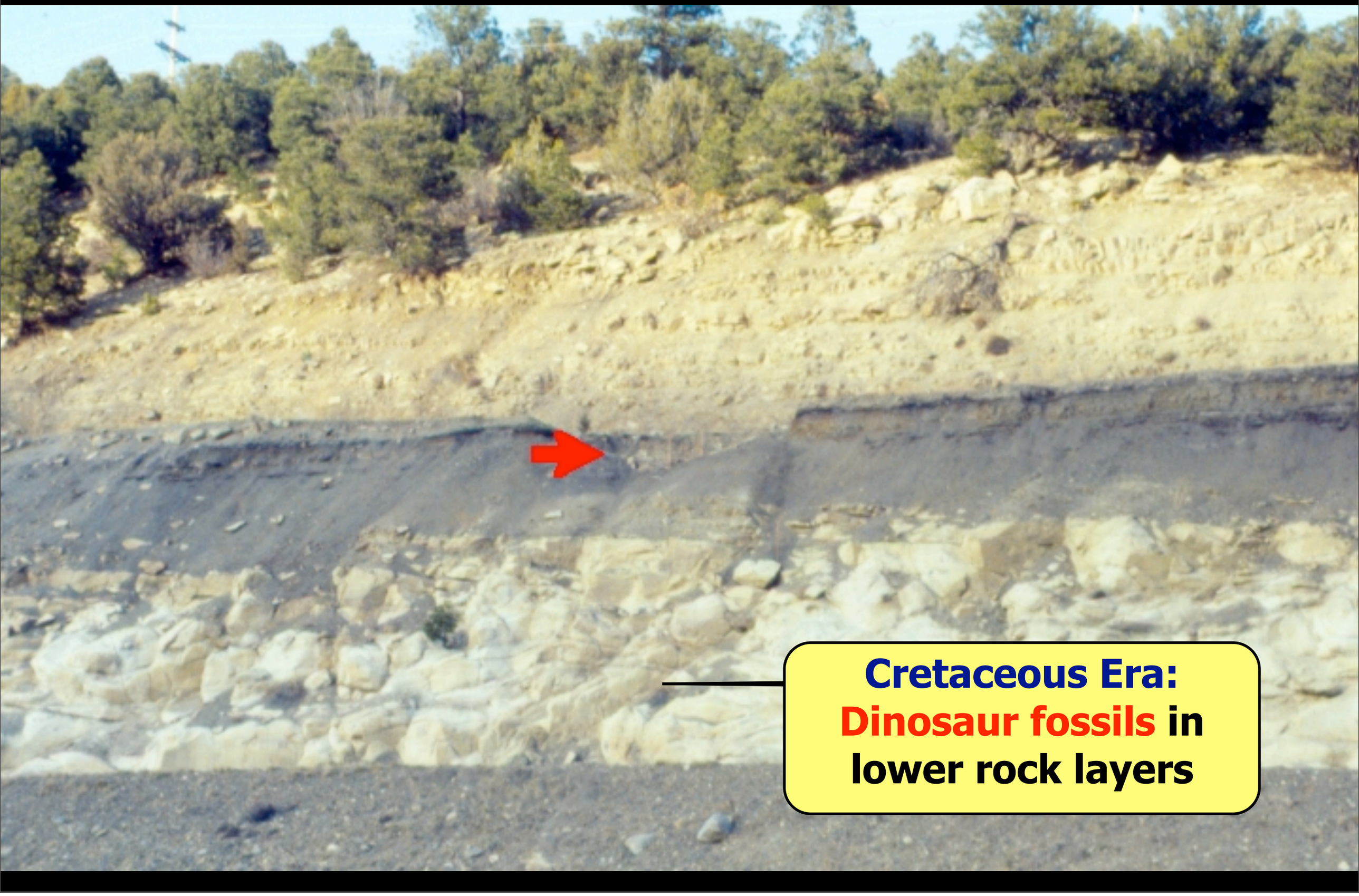

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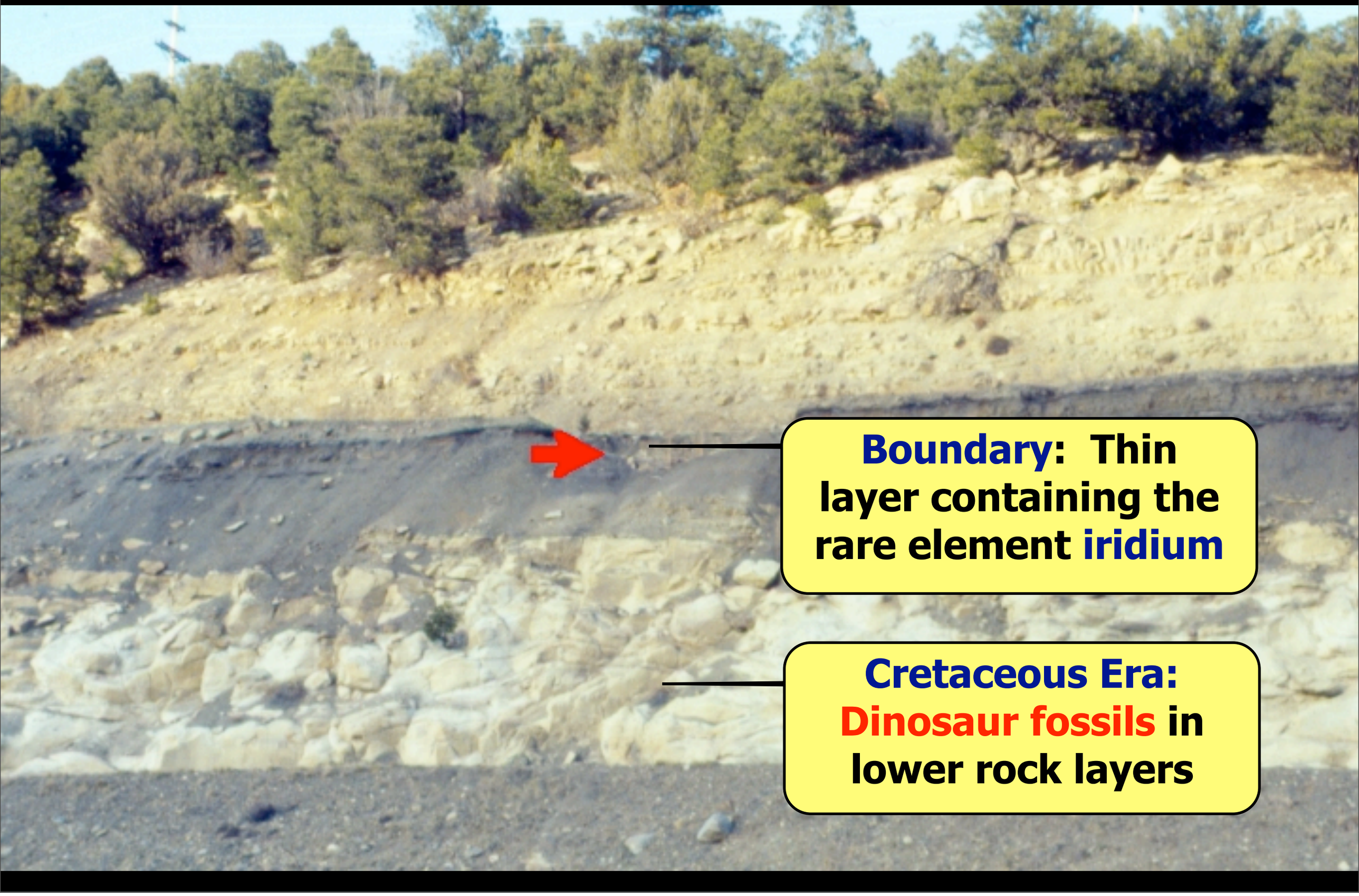

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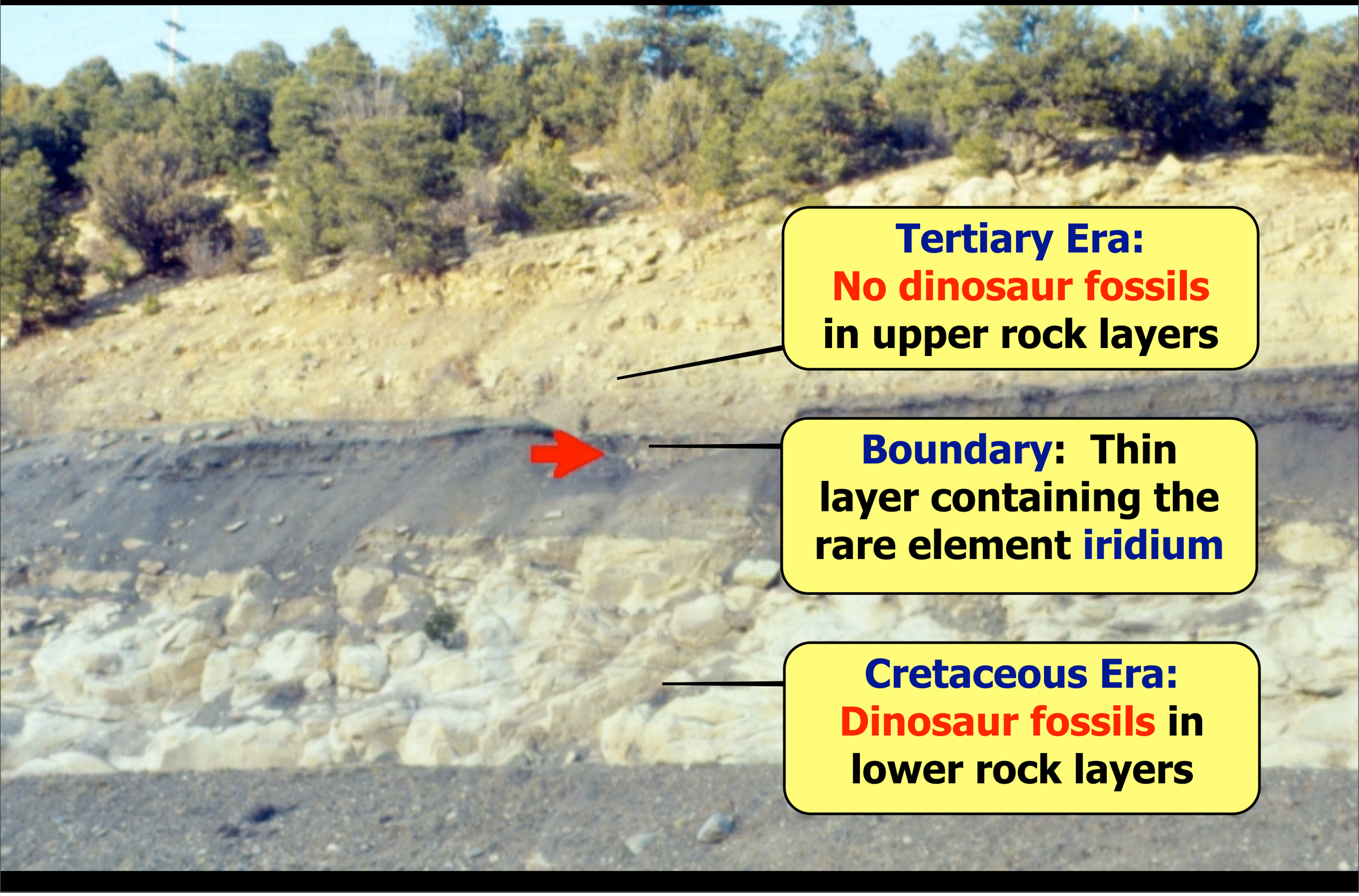

Iridium: Evidence of an Impact

In 1980, a worldwide layer of iridium was found

Laid down 65 million years ago

Iridium is an element that is very rare in Earth rocks, but is often found in meteorites!

The iridium layer - evidence of an impact 65 million years ago

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Luis and Walter Alvarez: Dino CSI

http://newscenter.lbl.gov/feature-stories/2010/03/09/alvarez-theory-on-dinosaur/

K/T Boundary: Iridium Layer

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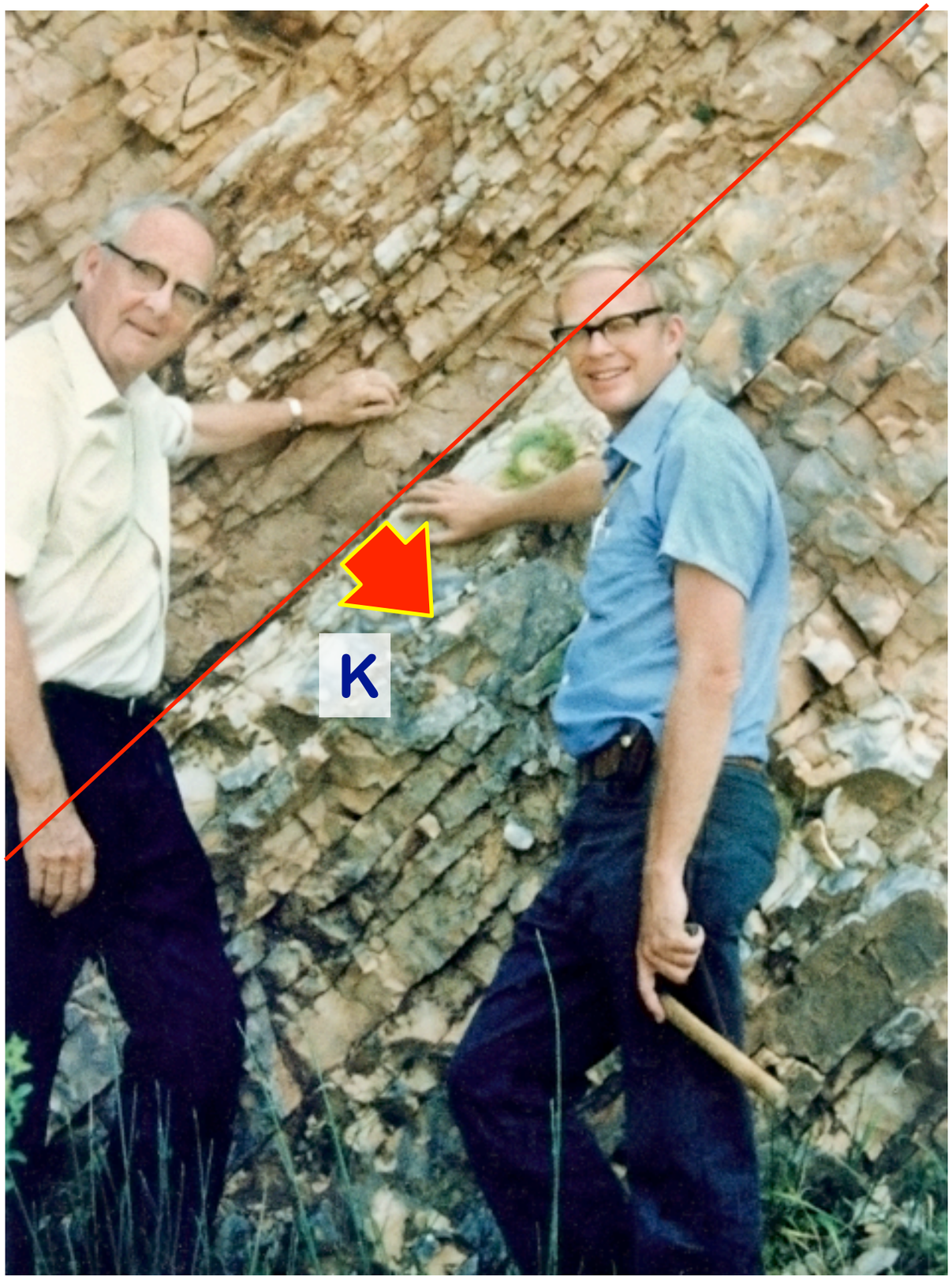

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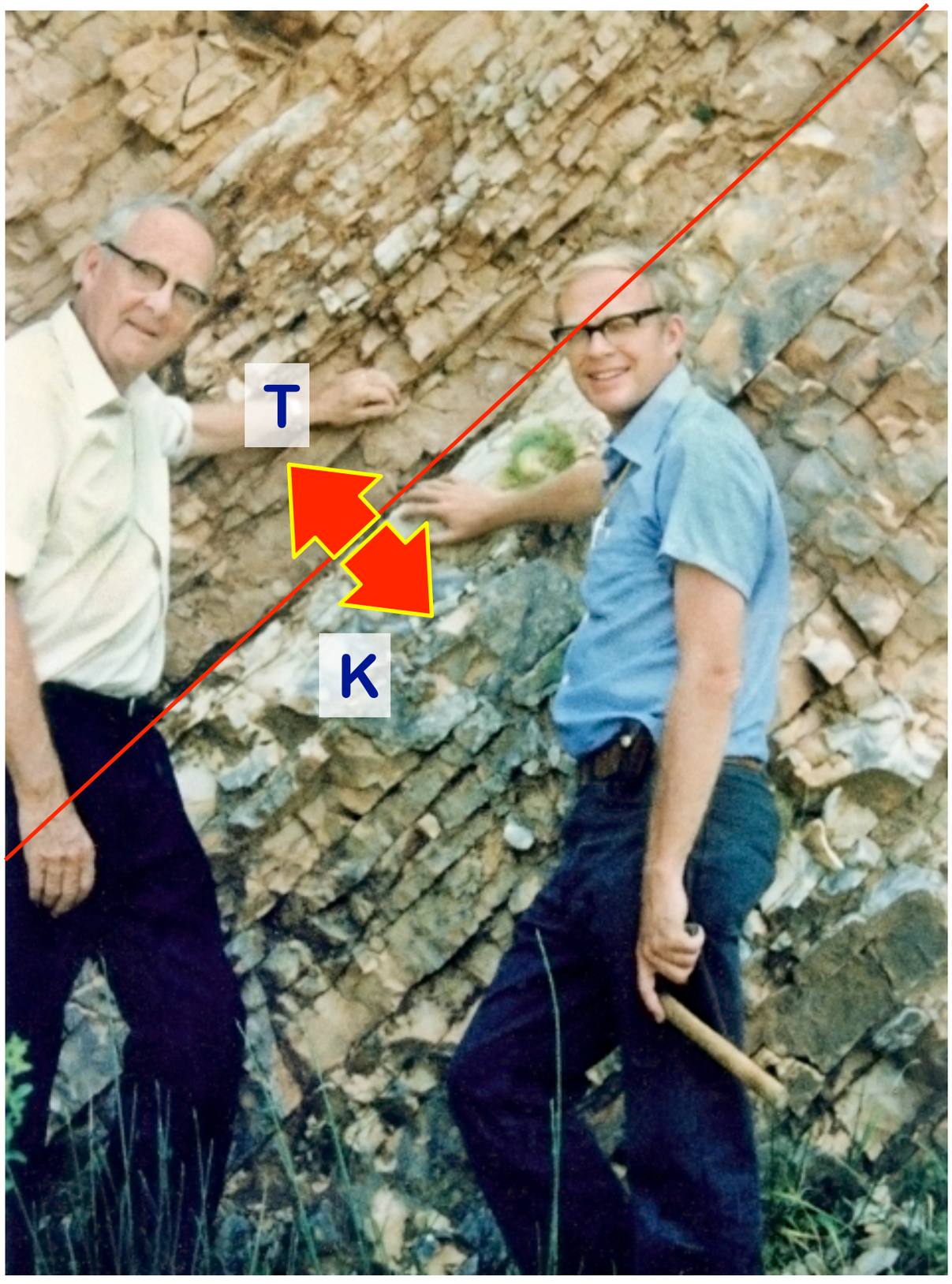

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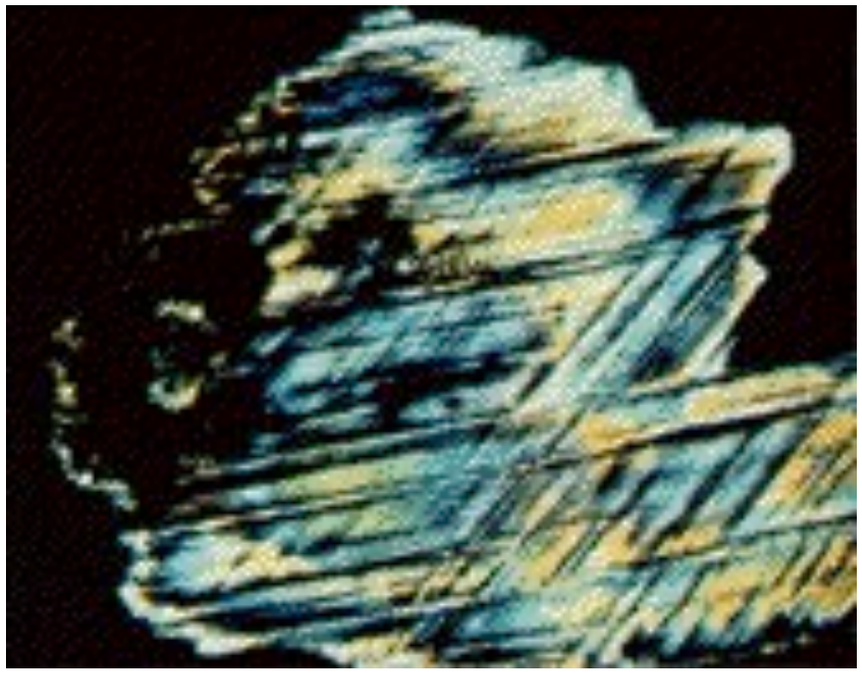
Other meteorite evidence

Spherules

- Melt droplets formed in the impact
- Dispersed globally

Shocked quartz

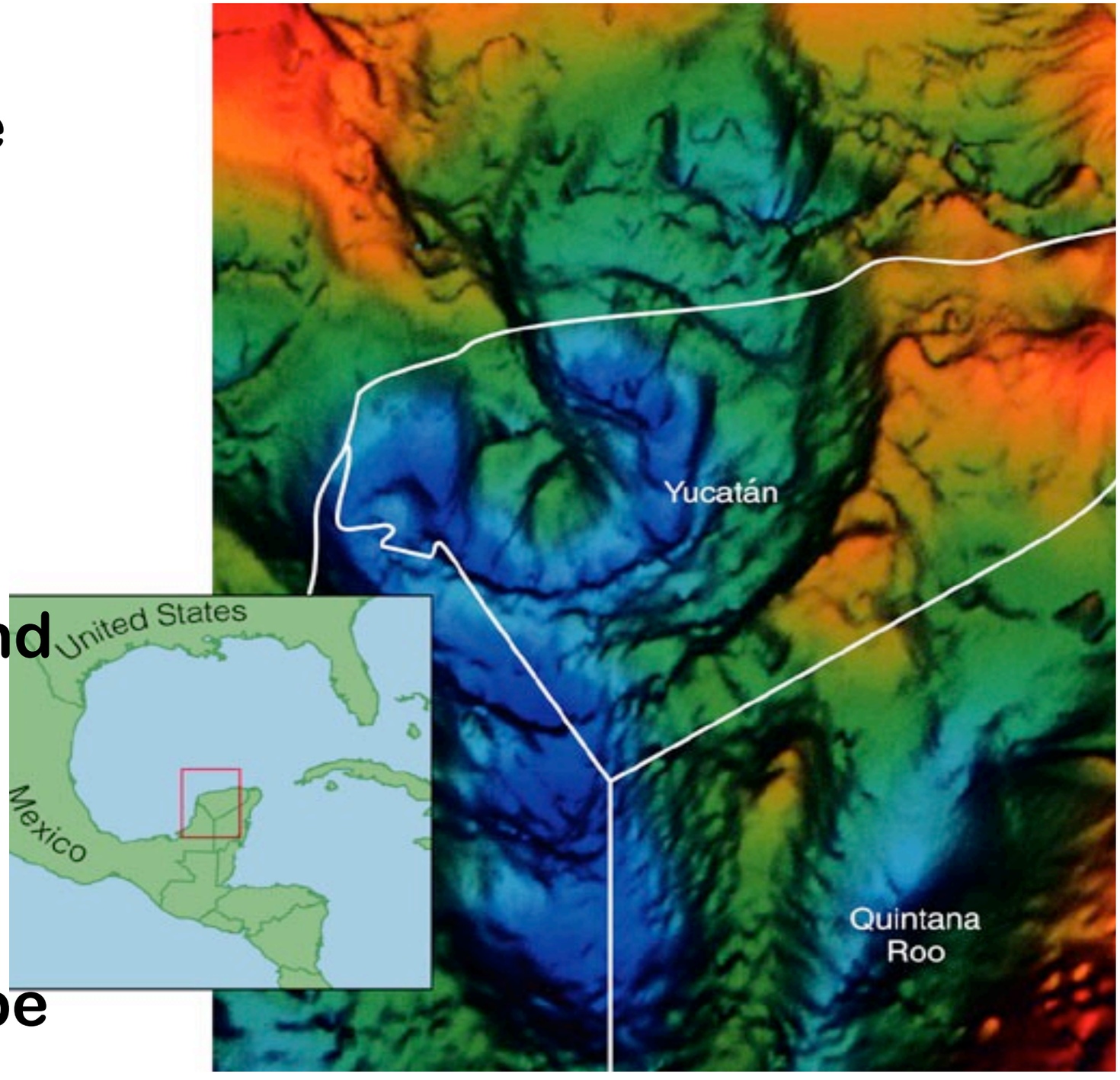
- Requires high pressures
- Often found near impact sites



Impact Site: The Chicxulub Crater

200 km diameter crater

- under the northwest corner of the Yucatan peninsula of Mexico
- centered on village of Chicxulub



beneath ground zero:

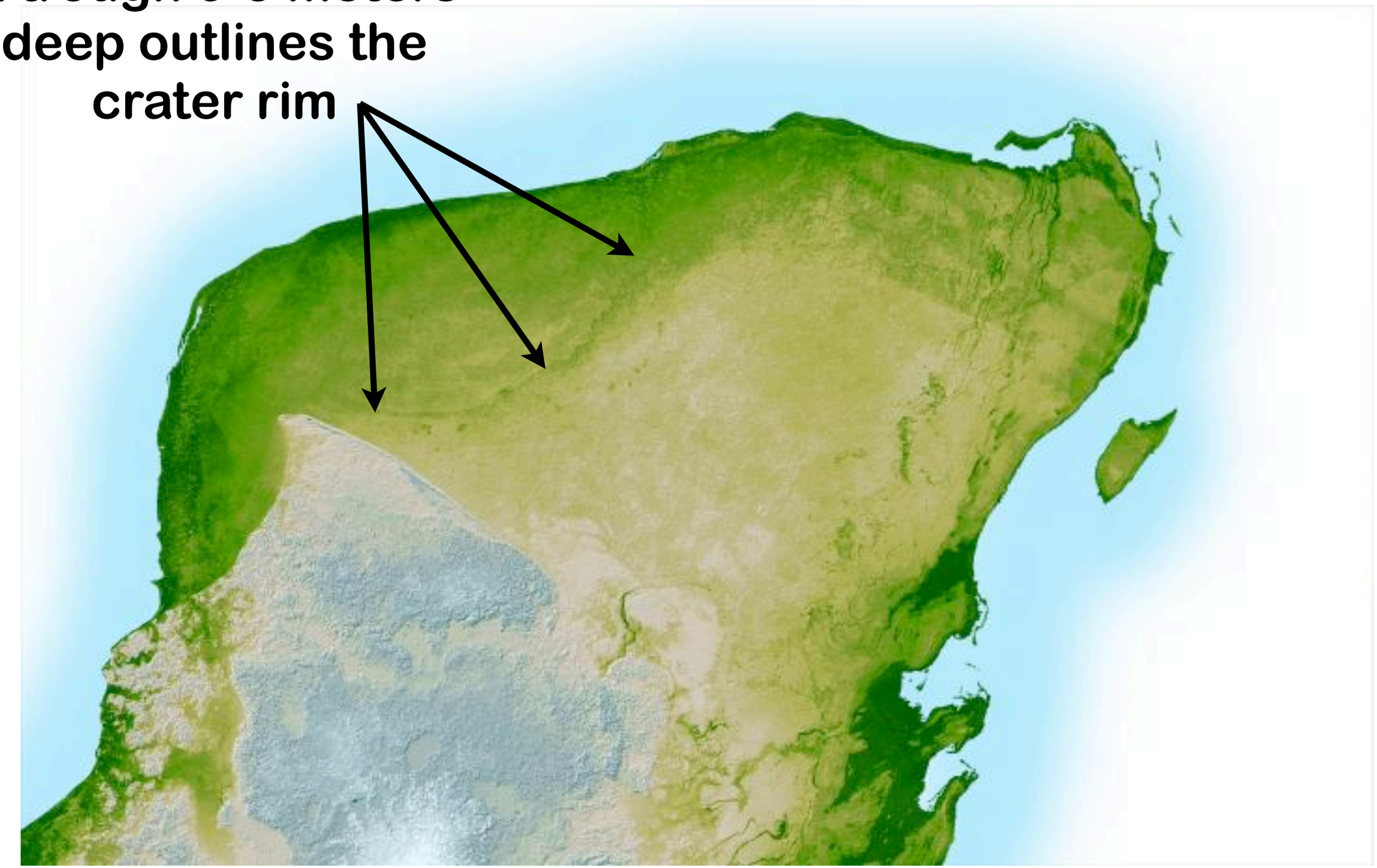
- glass = flash melted sand
- radioactive dating:

  65 million years old

From crater size:

- Impactor estimated to be 10 km across

A trough 3-5 meters deep outlines the crater rim



Today, the crater has <u>almost</u> completely eroded away

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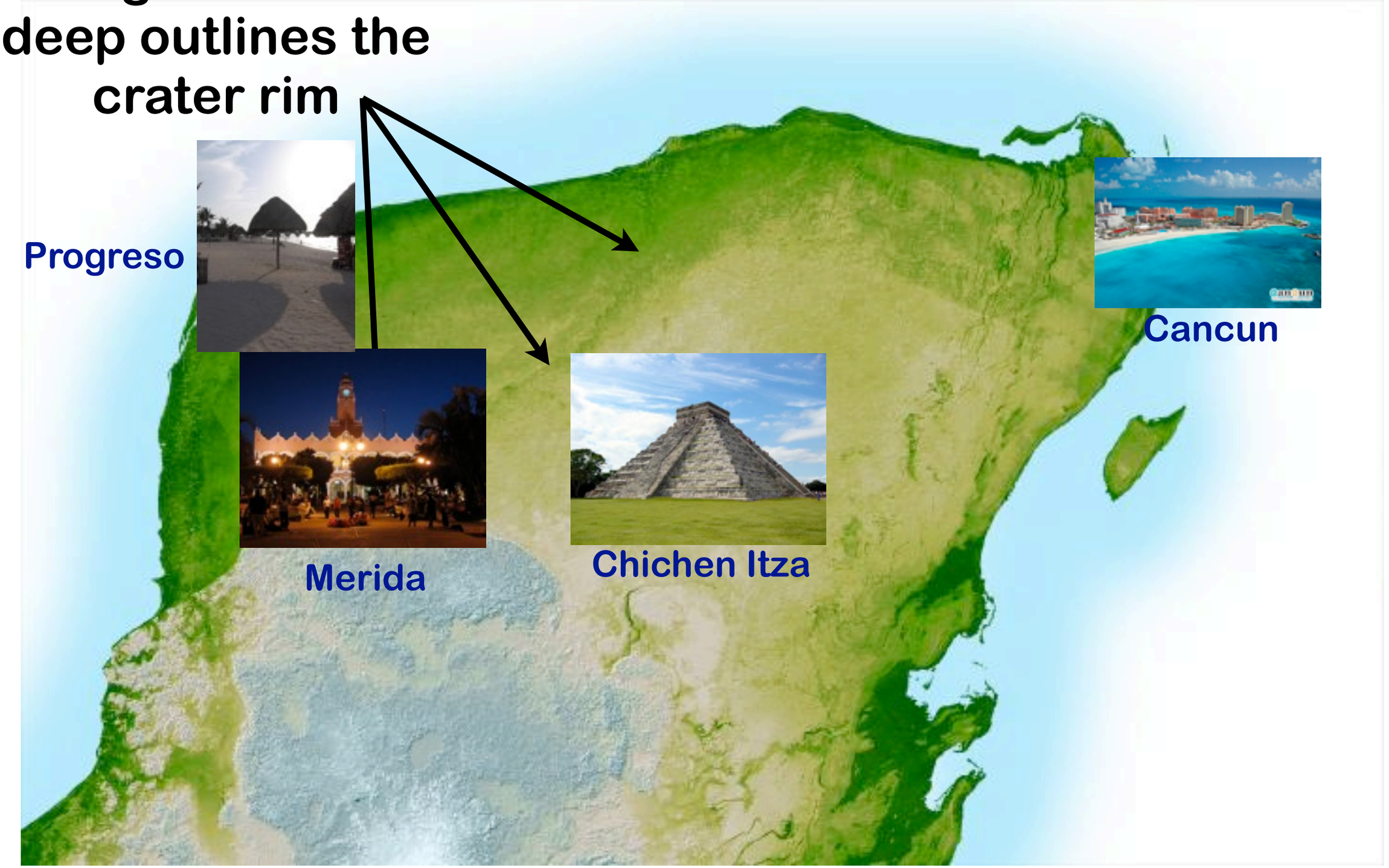

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CHICXULUB PTO
"EL PURUX"
TORTAS
TACOS
TAMALES
TAMBOTTOS

Chicxulub 2007:
Signaling for a Fair Catch

The Hammer of Doom

Likely KT impactor:

- Diameter: 10 km
- Composition: Rock

  though still not known if impactor was asteroid or comet
- Mass: 1.3 trillion tons
- Impact speed: 20 km/s

  = 45,000 mph

Impact!

Punches a hole in the atmosphere

Send large amounts of debris 100 km up

- 10 trillion tons of material!
- Debris rains back down around Earth

If asteroid hits ocean, water recovering crater floor vaporizes to steam

Impact lofts debris to fall back to Earth

The Big One

Impact Energy: capability to do damage
6×10^7 Megatons of TNT

- Equivalent to about a million H-bombs!
- Thousands of times more than the world's entire nuclear arsenal

Produces an earthquake of 12.4 magnitude

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Produces an earthquake of 12.4 magnitude

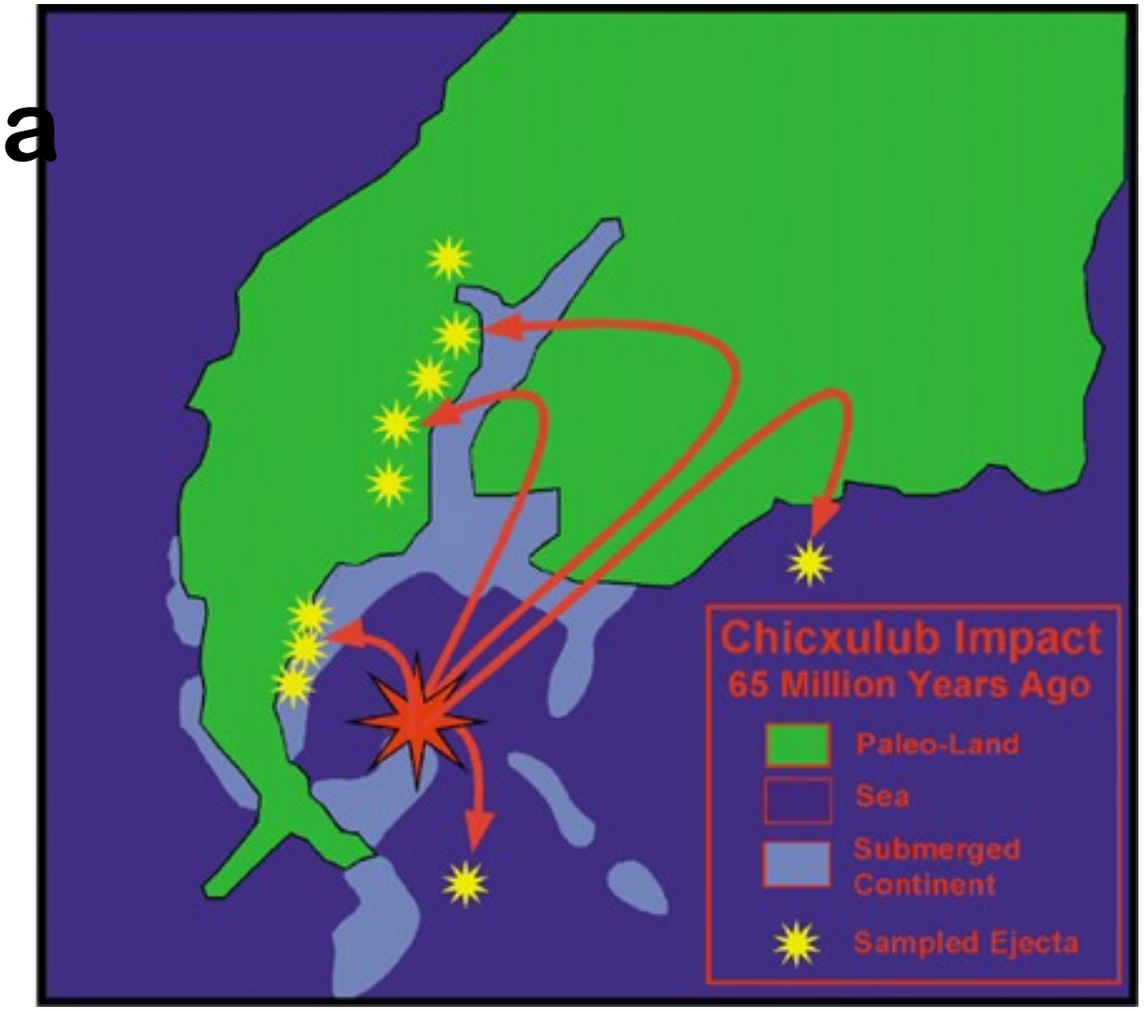
If the asteroid hits the ocean, it will create a tsunami

Chicxulub Impact

At the time, shallow seas covered what is now the northern Yucatan Peninsula

Tsunamis radiated out across the Gulf of Mexico

Slammed into Central and North America



How tall would the tsunami wave be?

- Depends on distance from impact site

Distance	Height
300 km	1.3 km
1,000 km	550 m
3,000 km	250 m
10,000 km	100 m

Material ejected from the impact reenters the atmosphere, setting fires around the Earth!

Acid Rain

Heat from the impact cooks the atmosphere

- produces nitric and nitrous acids

Creates a worldwide deluge of acid rain:

- Damage to foliage
- Kills upper ocean organisms

Nitrates set off chemical reactions which destroy the ozone layer

- removes sheilding from Sun's UV rays

Acid rain would cause additional devastation

Climate Change: Impact Winter

Within a day, dust and soot from fires would block out the Sun

Plunging the world into darkness for as long as a year

Temperatures drop, greater than during the Ice Age

Cool period may last a decade

Without sunlight, the Earth would freeze after the impact

Climate Change: Global Warming?

Burning of plants and killing of plankton releases large amount of CO_2 gas

After the impact winter, a warming period may follow

Temperatures rise for about 100 years

i>clicker question

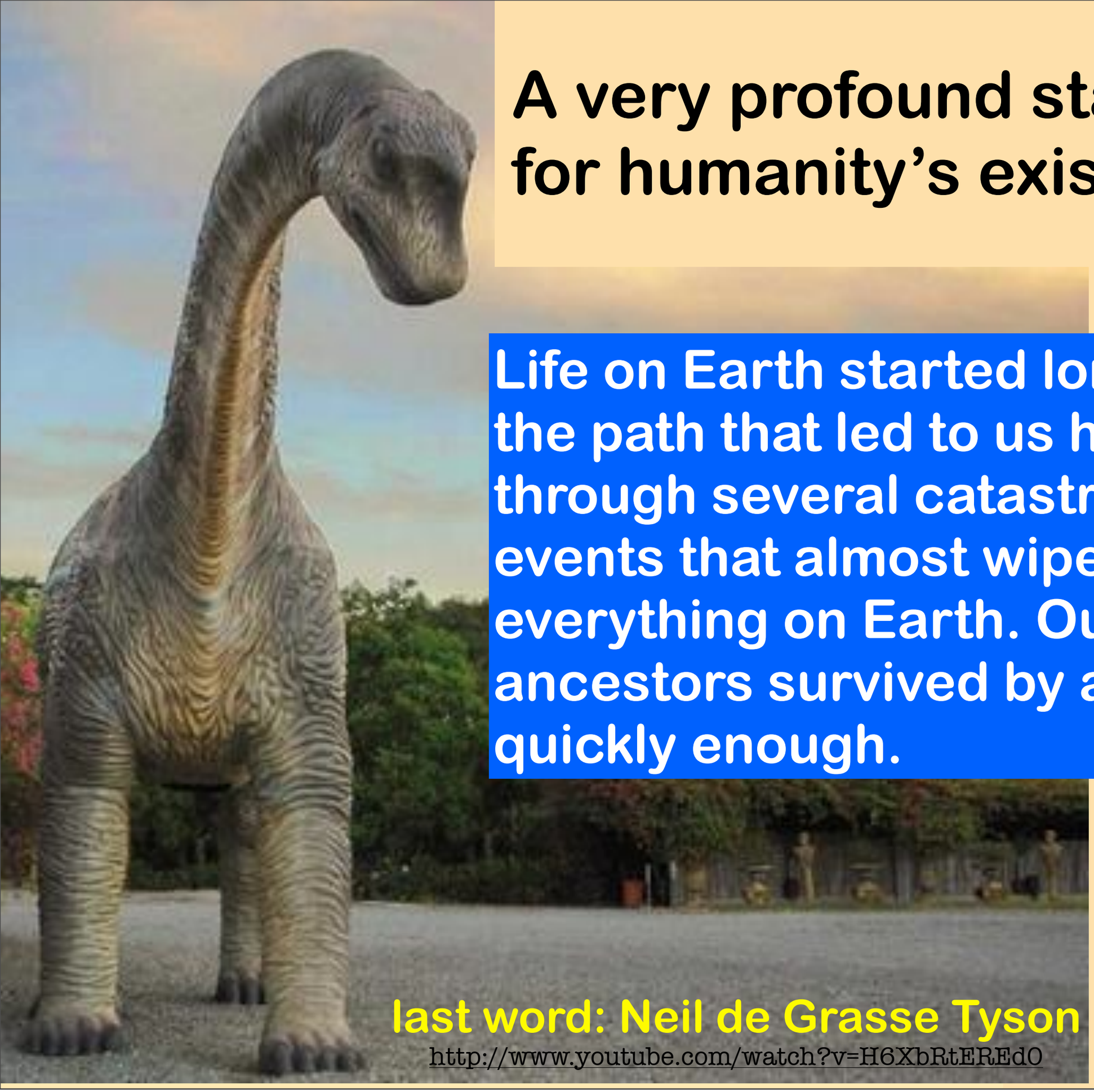
Suppose there had been no major impact in the last 65 million years. What might Earth be like today?

A. Mammals would have evolved differently; humans might not be here.

B. Humans would be directly competing with dinosaurs for food.

C. Dinosaurs would have evolved into humans.

A very profound statement for humanity's existence



Life on Earth started long ago, but the path that led to us had to go through several catastrophic events that almost wiped out everything on Earth. Our ancestors survived by adapting quickly enough.

last word: Neil de Grasse Tyson

http://www.youtube.com/watch?v=H6XbRtEREd0

On the bright side,
It could be worse...

science-based simulation of largest impact likely over history of Earth

http://www.youtube.com/watch?v=zc4HL_-VT2Y