Shared Set of Spatial Relationships Observed Between Tektite Strewn Fields and Their Correlated Astroblemes

Reliable Modus Operandi or Purely Coincidental?

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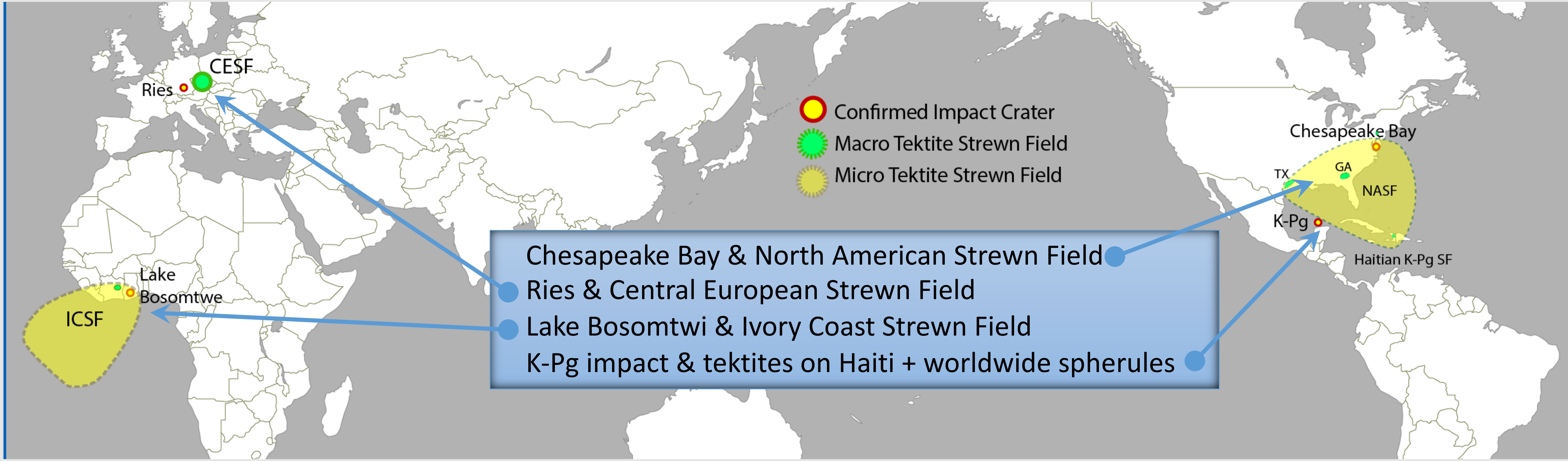
Tektite Strewn Fields

- “Tektite” named after the Greek tēktos or “molten.”
- ~200 Impact structures are confirmed on Earth
- Only 4 are convincingly linked to macro tektite strewn fields
- These are very special events, suggesting a special class of cosmic impacts
- Oblique? Hydrous Target?
- Tektites known since pre-historic times by early humans
- Only corelated with impact structures 50 years ago



Searching for the Missing Crater?

"History does not repeat itself, but it sure does rhyme. " S. Clemens

Ries Crater
Tektite Distribution

- 15 Ma age, 15 km diameter
- Asymmetrical Distribution 57º arc
- No tektites within 200 km of crater
- Juxtaposition of Ries and smaller Steinhelm no longer relevant

Fig 1, Artemieva, et al , 2002, Numerical modeling of tektite origin in oblique impacts…Bulletin of the Czech Geological Survey, Vol. 77, No. 4,

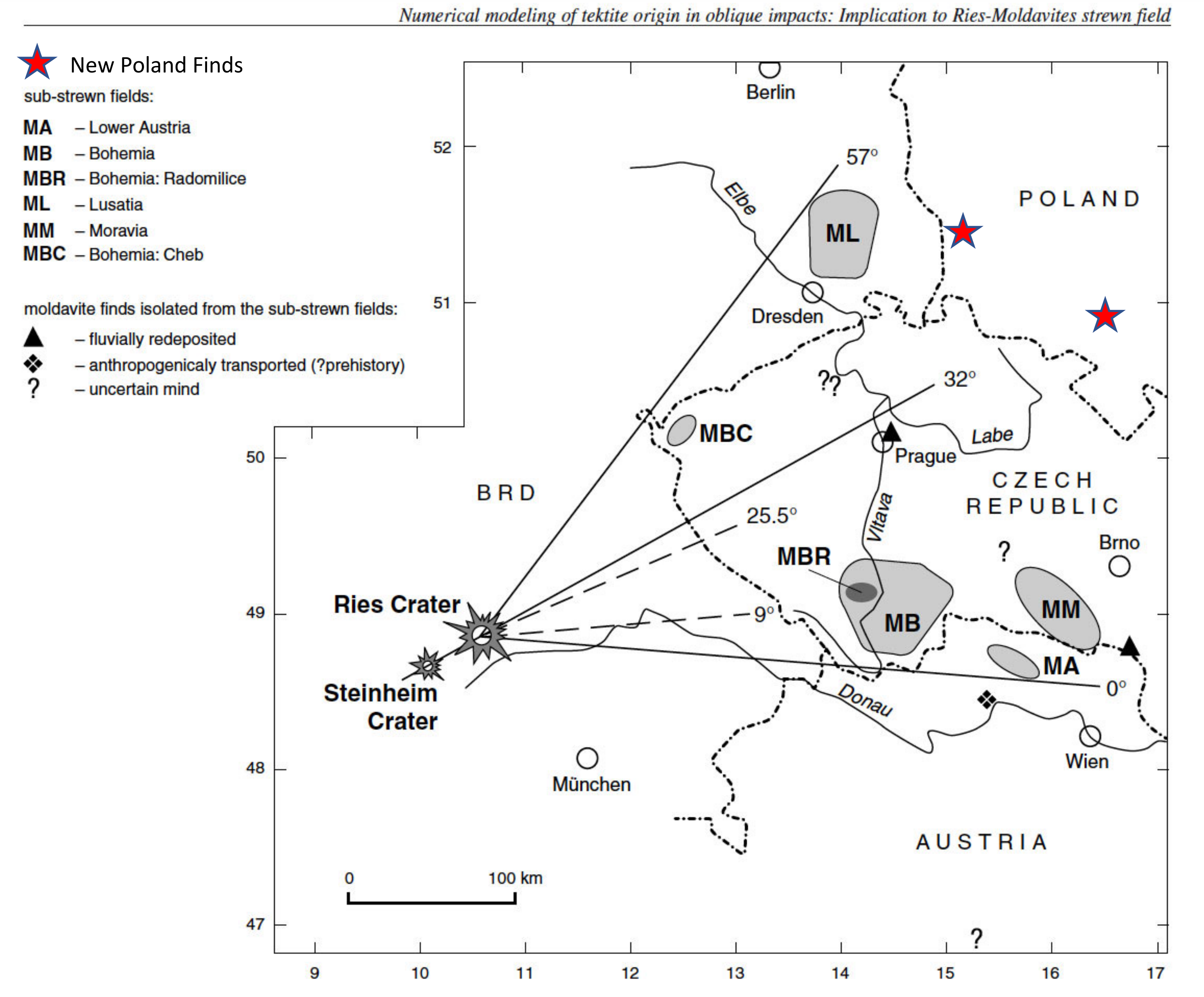


Figure 1. Map of Central Europe showing the Ries and Steinheim craters and the Moldavite strewn field (modified after Lange, 1996); the sub-strewn-fields are hatched and explained in the legend; dashed lines (9° to 25.5°) define the fan within which coherent melt lumps are observed on the inner slope of the Ries crater rim.

Ivory Coast Tektite Distribution

- 1.07 Ma age, 11 km diameter
- Tektites 300 km from crater
- Asymmetrical Distribution ~10º arc
- Likely witnessed by Paleo humans

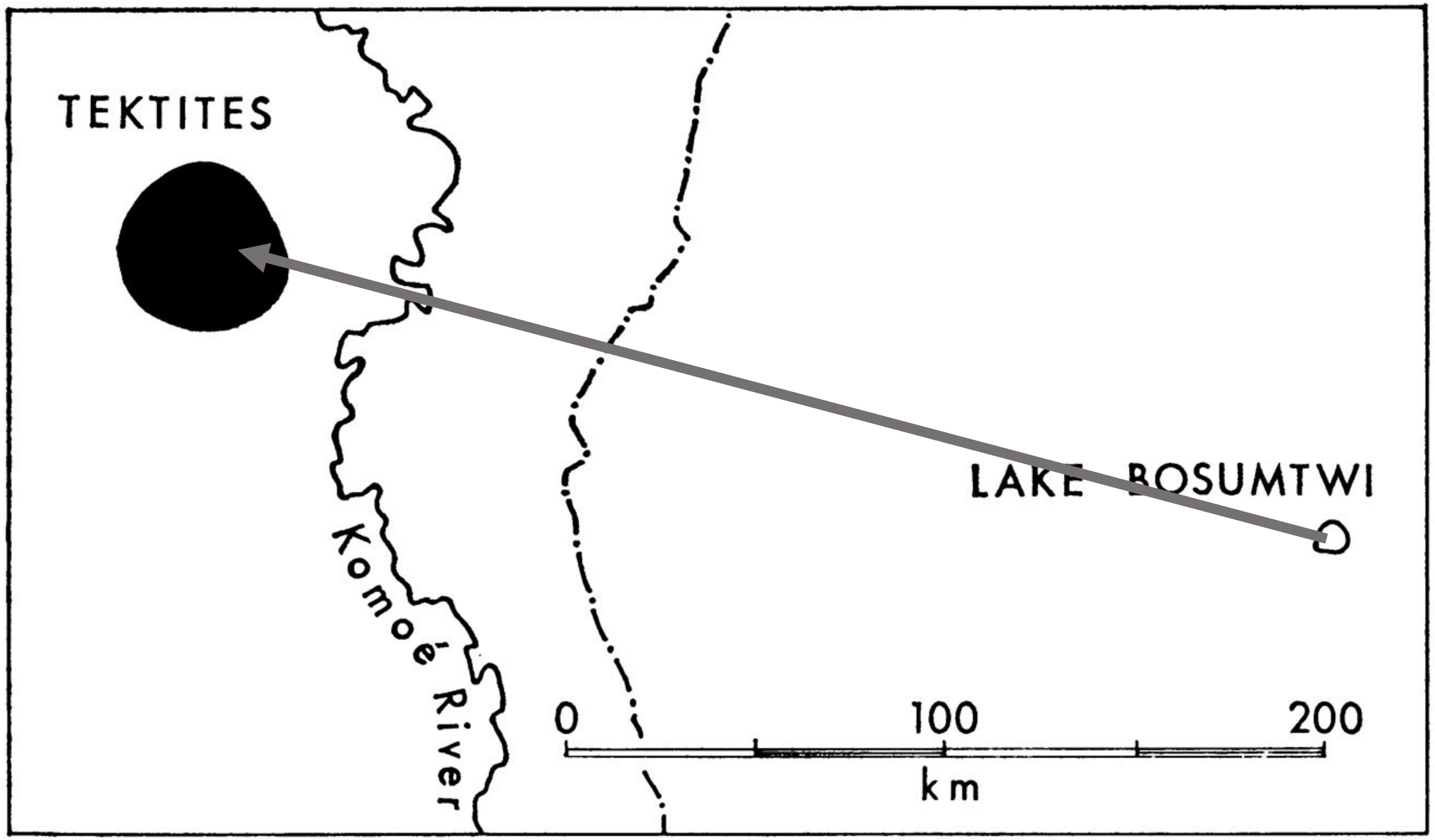
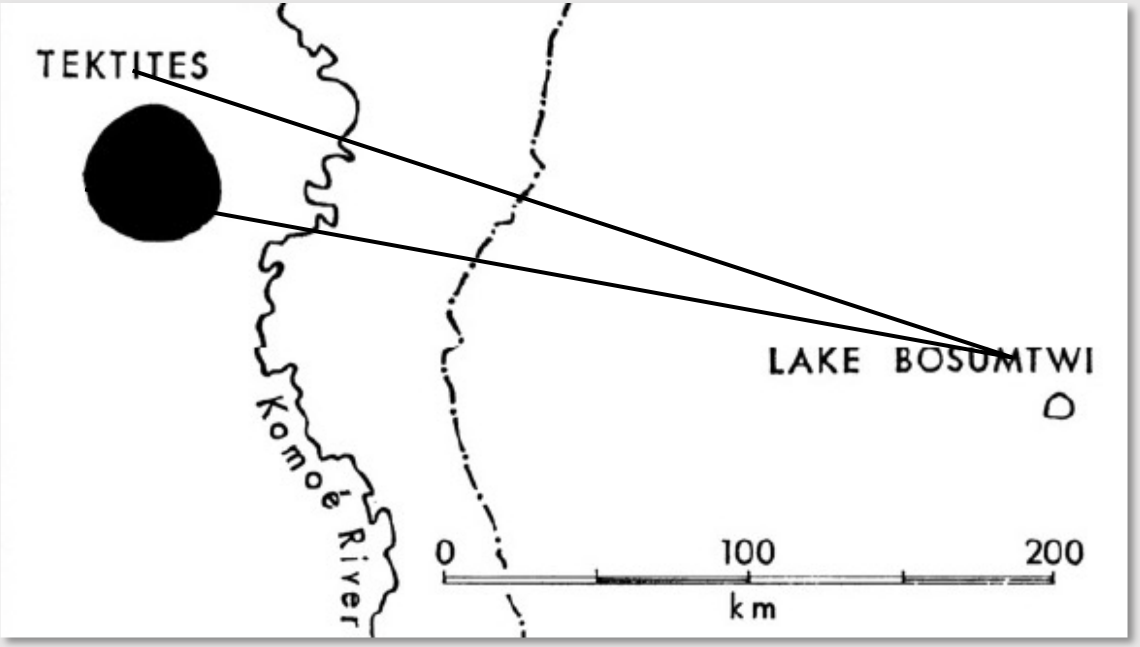


Fig. 1. The Bosumtwi crater in Ghana and (solid area) the approximate area where the Ivory Coast tektites are found.

Fig 1, Henry Faul, 1966, *Tektites Are Terrestrial*, Science Vol 152, Issue 3727

Ivory Coast Crater Tektite Distribution



These did not travel 300 km through the atmosphere. They traveled there on a suborbital trajectory through a blown-out atmosphere.

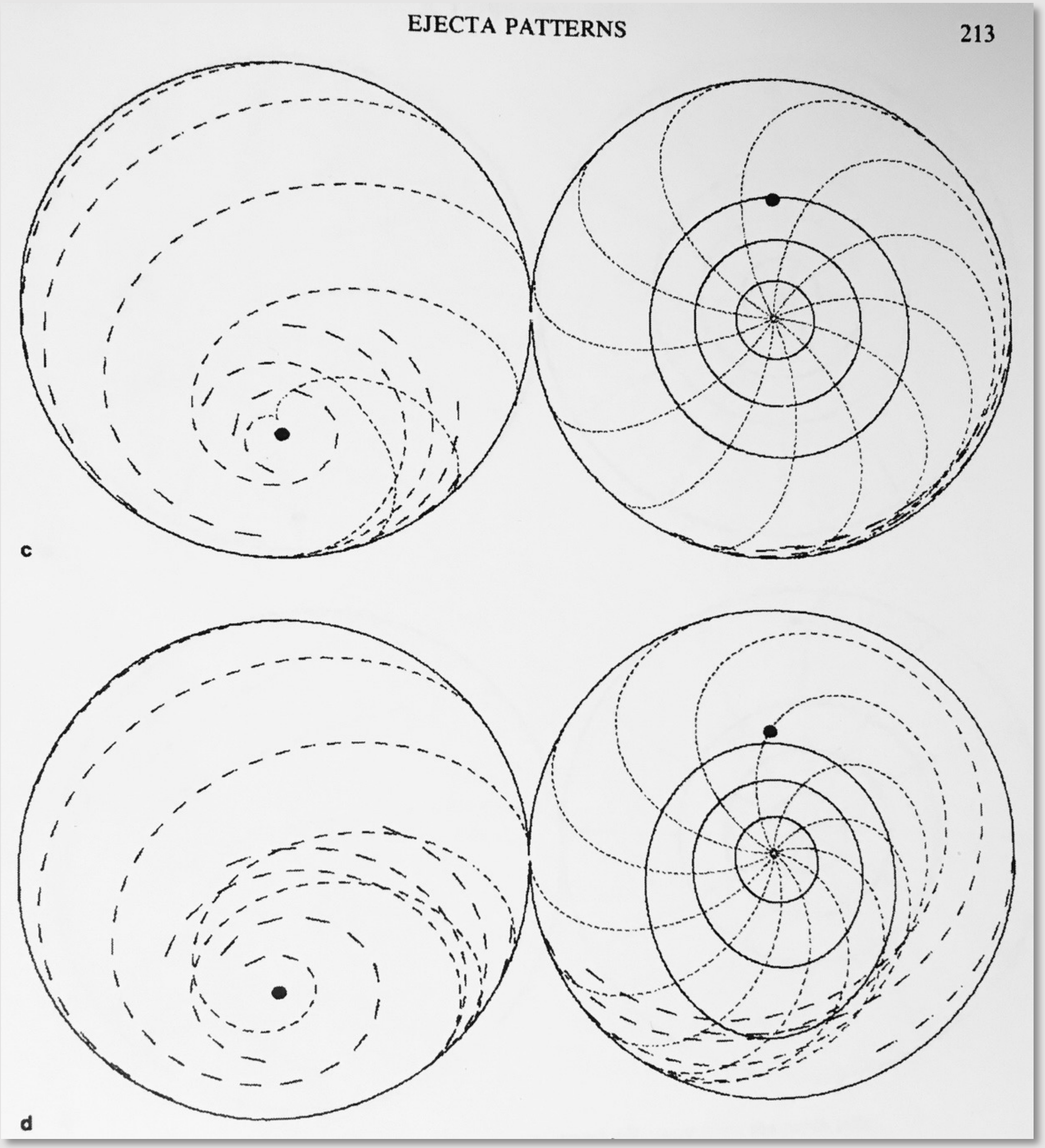
Suborbital trajectories do not map as straight lines on flat maps. They also don't travel on great circle routes.

Alain Carion and Ivory Coast Tektites. Photo by Mr. F.

Rare, pricy, small specimens

Distal Ejecta – Tektites Trajectories

- Computation engine built to derive and plot trajectories for distal ejecta
- Engine uses Dobrovolskis' process
- Computations performed for launches from extensive range of latitudes
- Simple transposition yields plots on globe from launch longitudes
- Plots for viable range of launch azimuths and kinetic energy
- New Tool from Thomas Harris available: GSA SP 553, p. 271–292

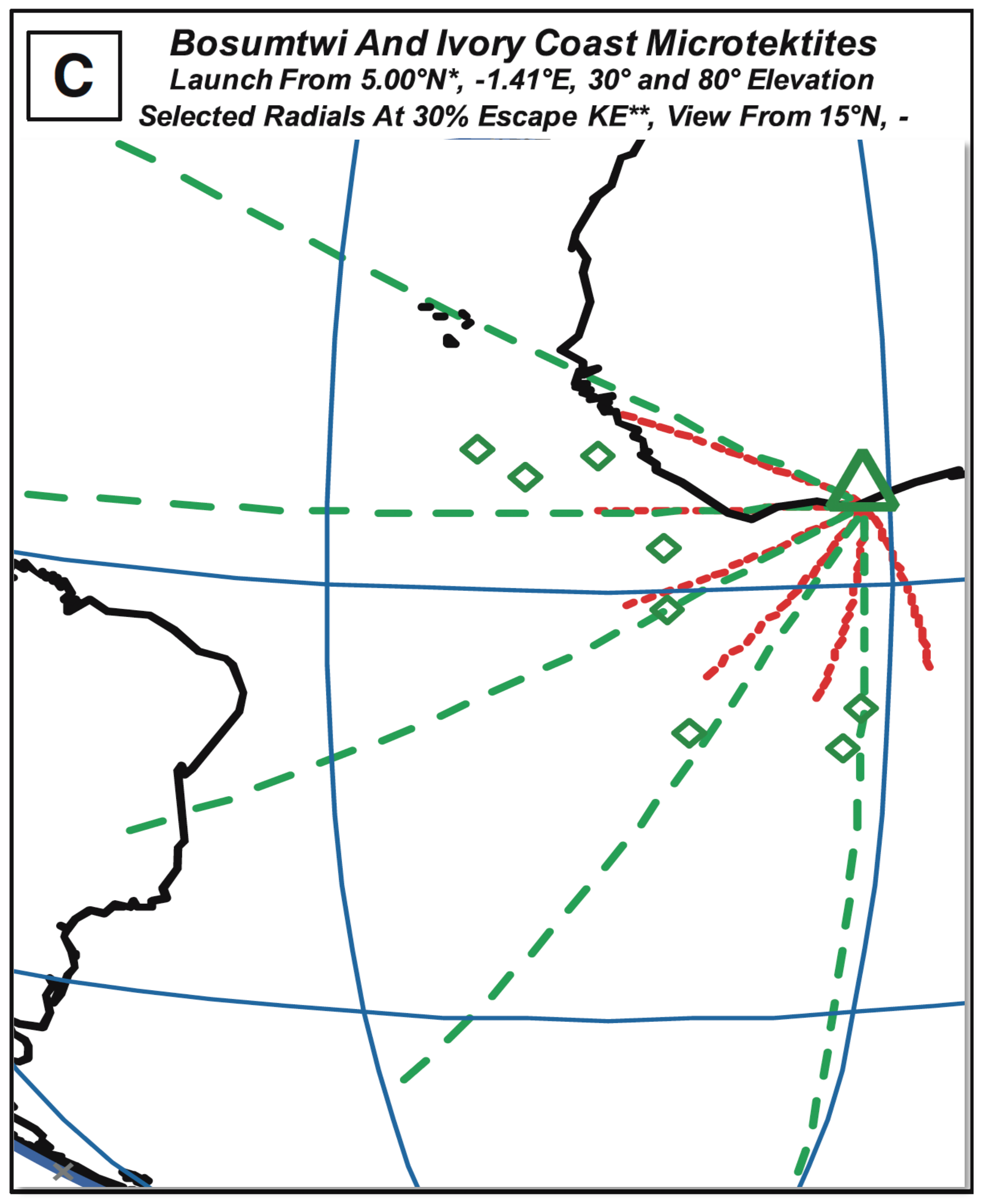


A. Dobrovolskis, 1981, *Ejecta Patterns Diagnostic of Planetary Rotations*, Icarus #47 pp203-219

Lake Bosumtwi impact structure

- Microtektite Distribution from Lake Bosumtwi
- Tool supports increments of 5º launch location
- Shows differences using same KE (30% Escape) for two elevations (80º & 30º) on selected radials
- Each dash along is 1% KE increment (30∞ to 45%)
- Impactor did not have a CPU to calculate minimum energy nor minimum time

Figure 4 C, Harris, T.H.S., 2022, Terrestrial ejecta suborbital transport and the rotating frame transform, In the Footsteps of Warren B. Hamilton: New Ideas in Earth Science: GSA SP 553, p. 271–292, https://doi.org/10.1130/2021.2553(23).



North American Tektite Distribution

- Correlated with Chesapeake Bay Impact
- 80 km diameter, 35 Ma
- Asymmetrical Distribution ~30º arc
- No tektites within 900 km of crater
- Offset scales with impact energy

Fig 1, Henry Faul, 1966, *Tektites Are Terrestrial*, Science Vol 152, Issue 3727

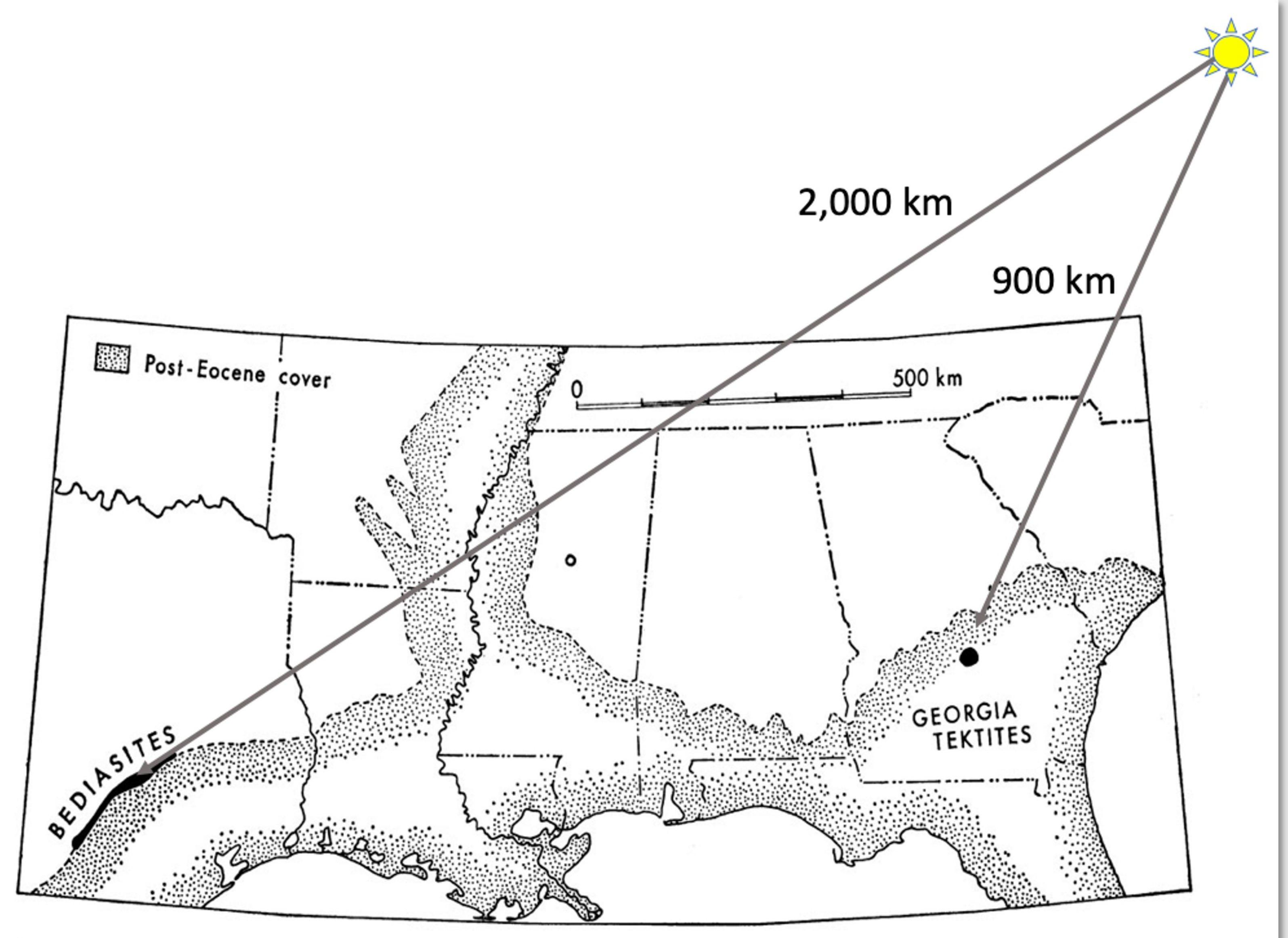
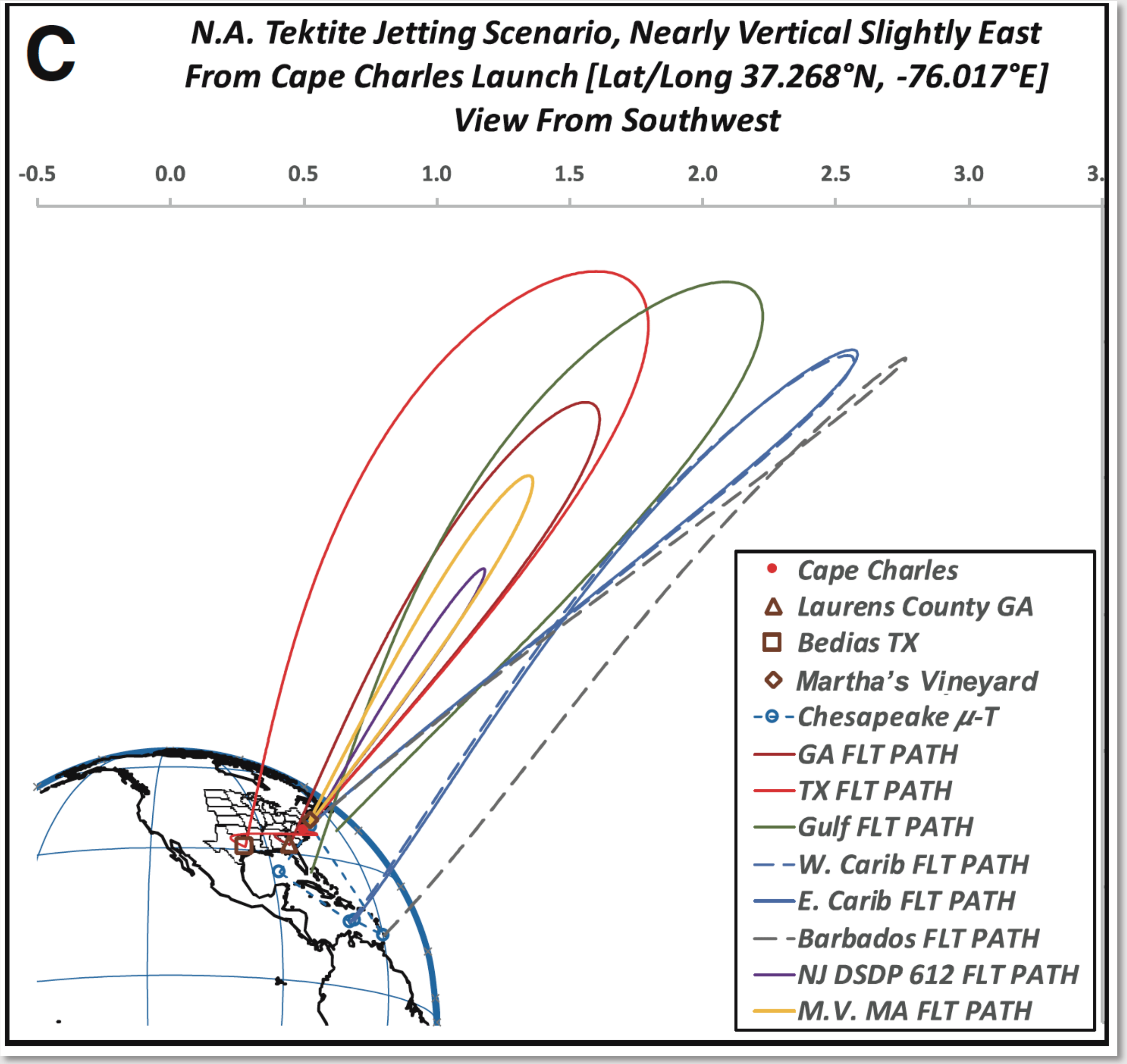


Fig. 3. (Solid areas) Regions where tektites are found in Texas and in Georgia. (Stippled areas) Regions covered by sediments deposited after the tektites fell. (Open circle) The Kilmichael crater in Mississippi.

Jetting Scenario – N. A. Tektites

It is possible that all N.A. Tektites launched at nearly identical conditions within a proposed jet

Figure 10 C, Harris, T.H.S., 2022, Terrestrial ejecta suborbital transport and the rotating frame transform, In the Footsteps of Warren B. Hamilton: New Ideas in Earth Science: GSA SP 553, p. 271–292, https://doi.org/10.1130/2021.2553(23).



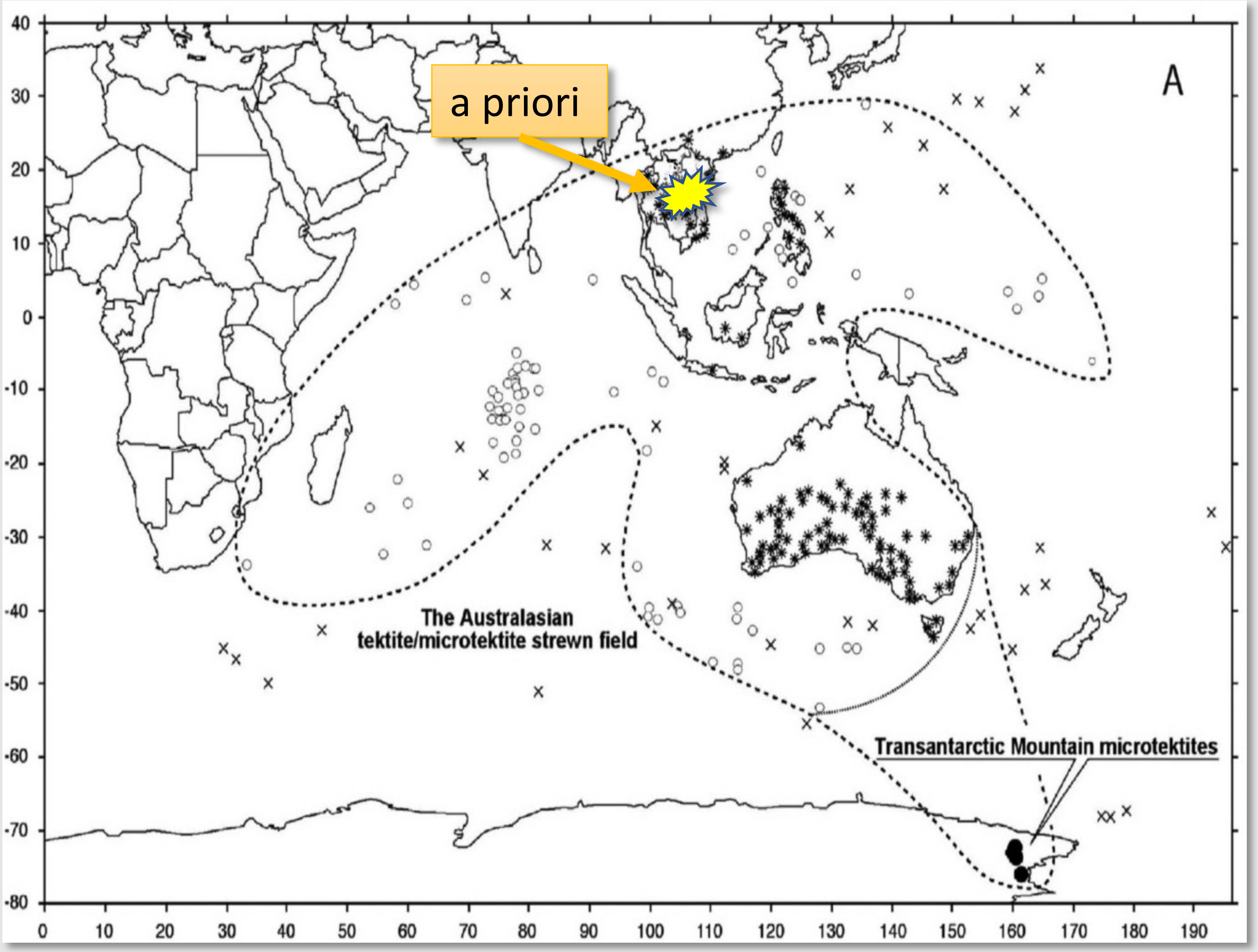
Empirical Evidence of Tektite Distribution

- Four strewn fields are corelated with impact structures
  - No tektites found within 20 crater radii those four impact structures
  - Those strewn fields display a highly asymmetric distribution of tektites
  - Those strewn fields are offset from impact, increasing with crater diameter

Some impact specialists dismiss the corelated evidence as artifacts of "serendipity"

MPT Australasian Tektite Strewn Field Enigma

- 50 years have transpired since determining the tektites were created at the MPT
  - Geologically "Yesterday"
- Distal morphology proposed originally
  - atmospheric ablation
  - devolitized (1,000 x less H_2O than obsidian)
  - high vacuum in bubbles
- Chemistry points to genesis from Average Continental Crust (non marine)
- Southeast Asia location for impact a priori



Map from L. Folco, et al, 2016, *Stretching out the Australasian microtektite strewn field in Victoria Land Transantarctic Mountains, Polar Science 10*

Seminal Paper Locating AA Crater in SE Asia

Peter H. Stauffer, 1978, *Anatomy Of The Australasian Tektite Strewnfield And The Probable Site Of Its Source Crater*

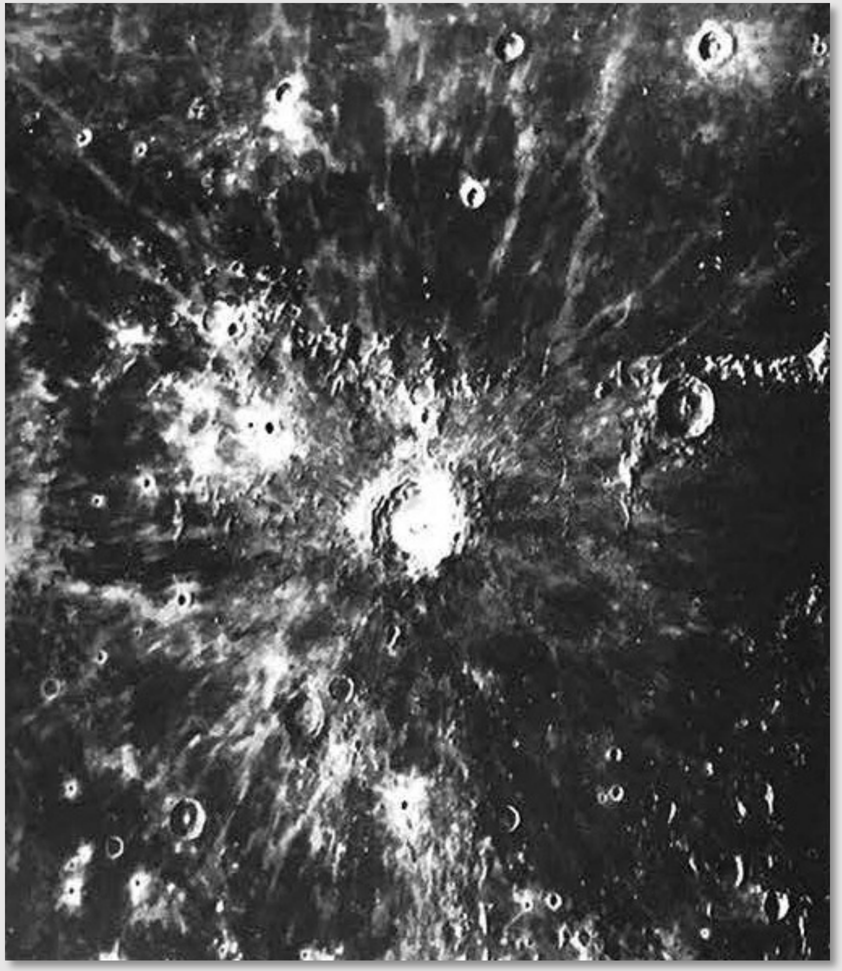
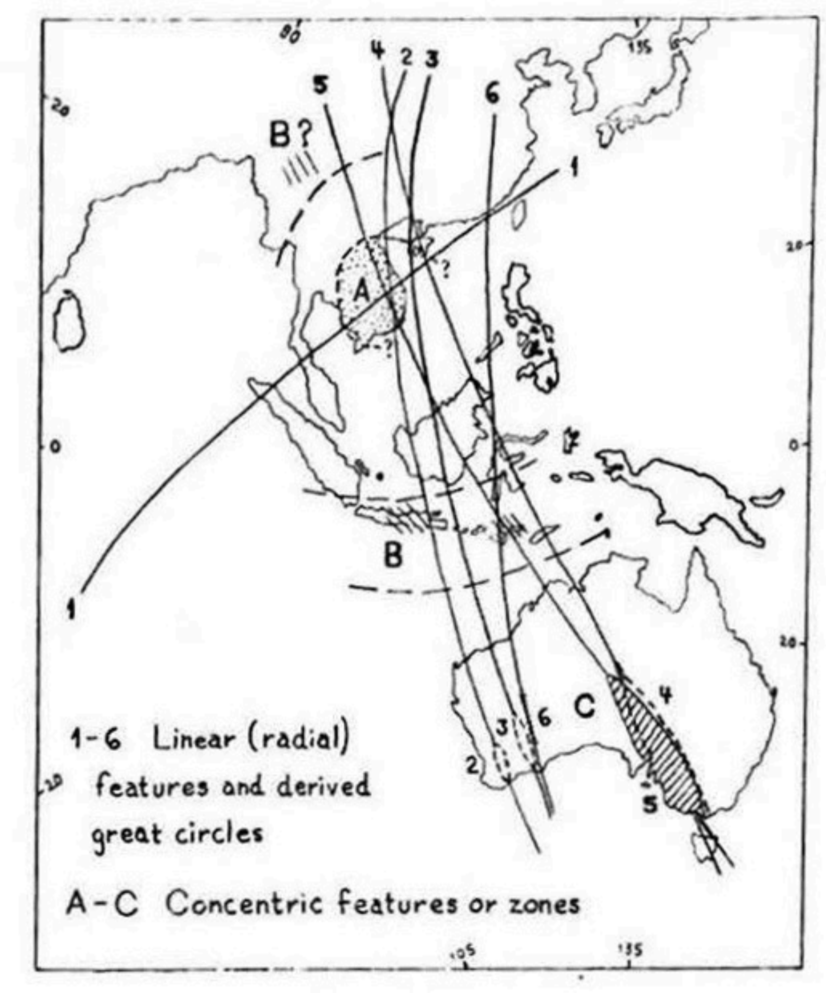


Figure 2. Photograph of the lunar crater Copernicus showing the pattern of ejecta.



Figure• 3. Radial and concentric structural elements of the Australasian tektite strewn field. Radial elements (linear features) and the great circles derived from them:...

Conference Paper: Geology and Mineral Resources of Southeast Asia, Bangkok, November 14-18, 1978, Peter H. Stauffer, Department of Geology, University of Malaya

a priori

[ey prahy-**awr**-ahy, -**ohr**-ahy, ey pree-**awr**-ee, -**ohr**-ee, ah pree-**awr**-ee, -**ohr**-ee]

SHOW IPA

EXAMPLES | WORD ORIGIN

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adjective

1 from a general law to a particular instance; valid independently of observation.: Compare a posteriori**(def 1)**.

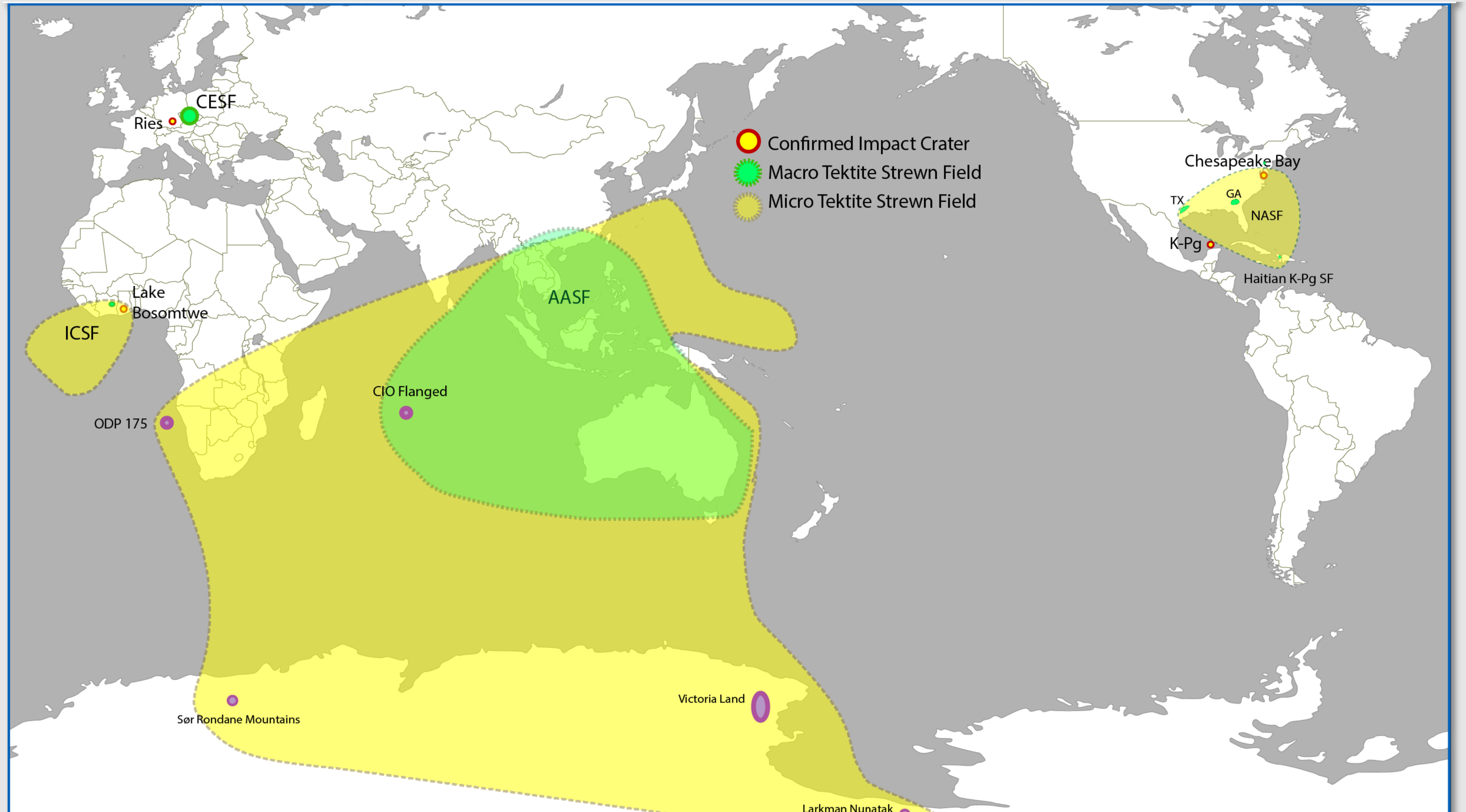
2 existing in the mind prior to and independent of experience, as a faculty or character trait.: Compare a posteriori**(def 2)**.

3 not based on prior study or examination; nonanalytic:
an a priori judgment.


I know there's a pony in here somewhere!

Tektite Strewn Fields

- The Australasian Tektites comprise the youngest of these strewn fields
- In spatial and tektite mass it is orders of magnitude larger than the others combined
- Lack of an identified impact structure suggests the event is easily the most unique



This map includes recent additions of more extensive microtektites finds in Antarctic, and a speculative addition of the ODP 175 finds.

This distribution conflicts with the established tri-lobe pattern, which is ultimately limited by the amount of ODP cores available. (Glass and Simonson, 2013)

Bounty of Data noted 50 years ago – Still no solution

Over the past 30 years ***immense progress has been made in understanding tektites but rather than providing elucidation, the large amount of research*** *on the Australasian tektite Strewn Field* ***seems to have multiplied the constraints to be surmounted.***

Joe McCall, 2001, *Tektites in the Geological Record*

distal *adjective*

dis·tal | \ ˈdi-st^{ə}l \

Definition of *distal*

1 *anatomy* **:** situated away from the point of attachment or origin or a central point especially of the body

— compare PROXIMAL

// the *distal* ends of the tibia and fibula

2 *dentistry* **:** of, relating to, or being the surface of a tooth that is next to the tooth behind it or that is farthest from the middle of the front of the jaw

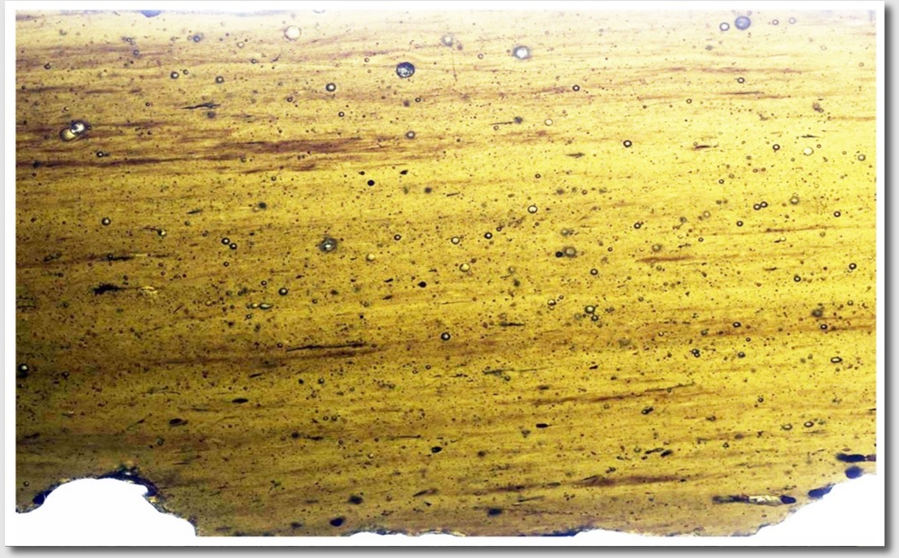
— compare MESIAL sense 2

3 *geology*: Proximal == < 5 Crater Radii

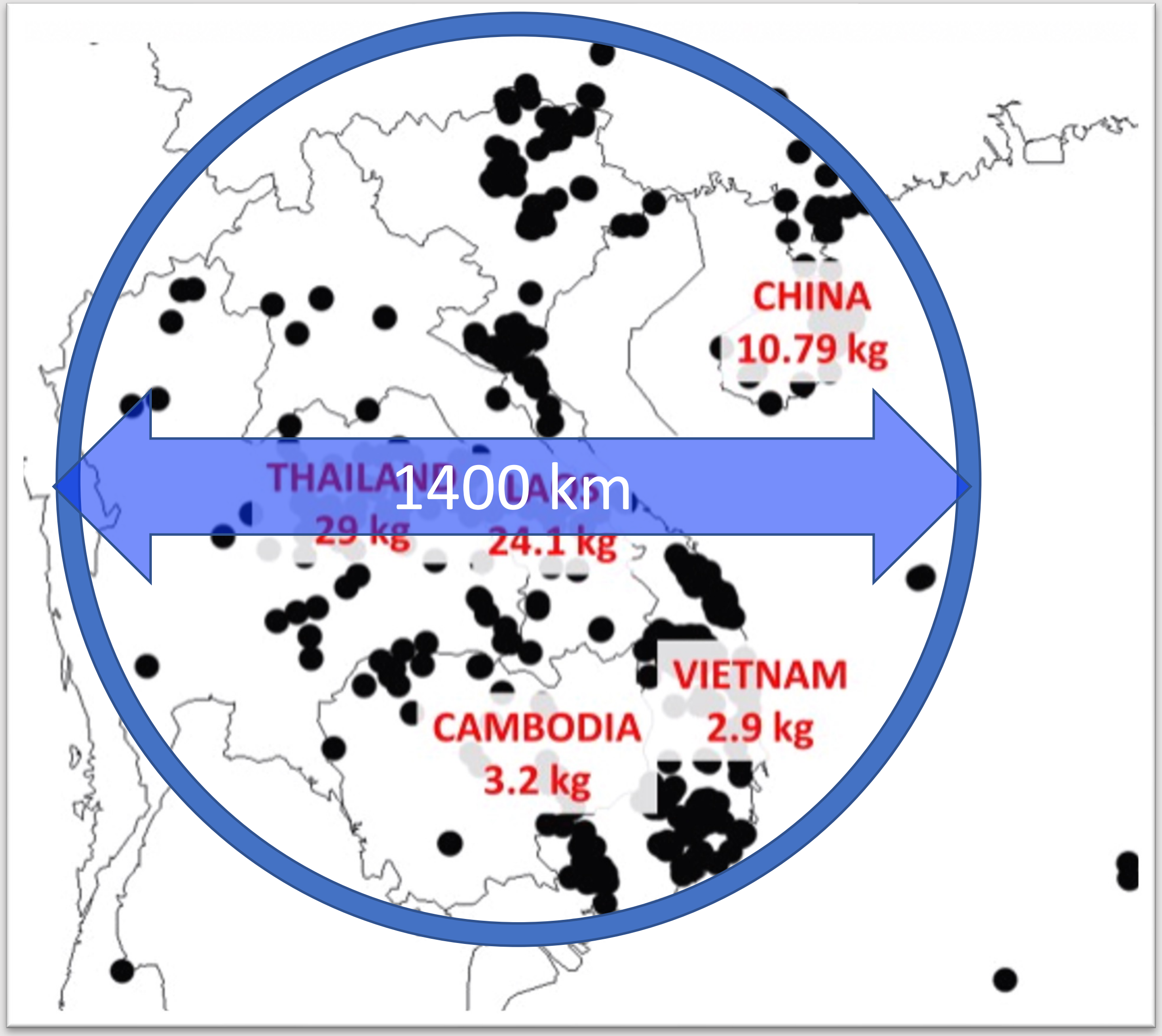
Distal == > 5 Crater Radii

Scale of Australasian Event - Unconventional

Muong Nong Layered Tektites



- Current consensus puts the layered tektites into the ”More Proximal” impact ejecta category
- Considered to have been melted “less” due to less homogeneity of chemistry
- Splash form tektites (distal) are found throughout this entire region
- A weight distribution “center” is 700 to 1000 km from other Muong Nongs



Weight distribution of largest Muong Nong tektites – credit: after A. Whymark

Irreconcilable Nature of being a Tektite

- All four strewn fields have low H_2O
- Muong Nong have more H_2O than other AA
- Muong Nong have same H_2O as Chesapeake Bay tektites
- MPT strewn field is more variable
- MPT Strewn Field estimated to have 10^5 more mass than Moldavites

A. Beran & Christian Koeberl, Meteoritics & Planetary Science 32.21 1-216 (1997)

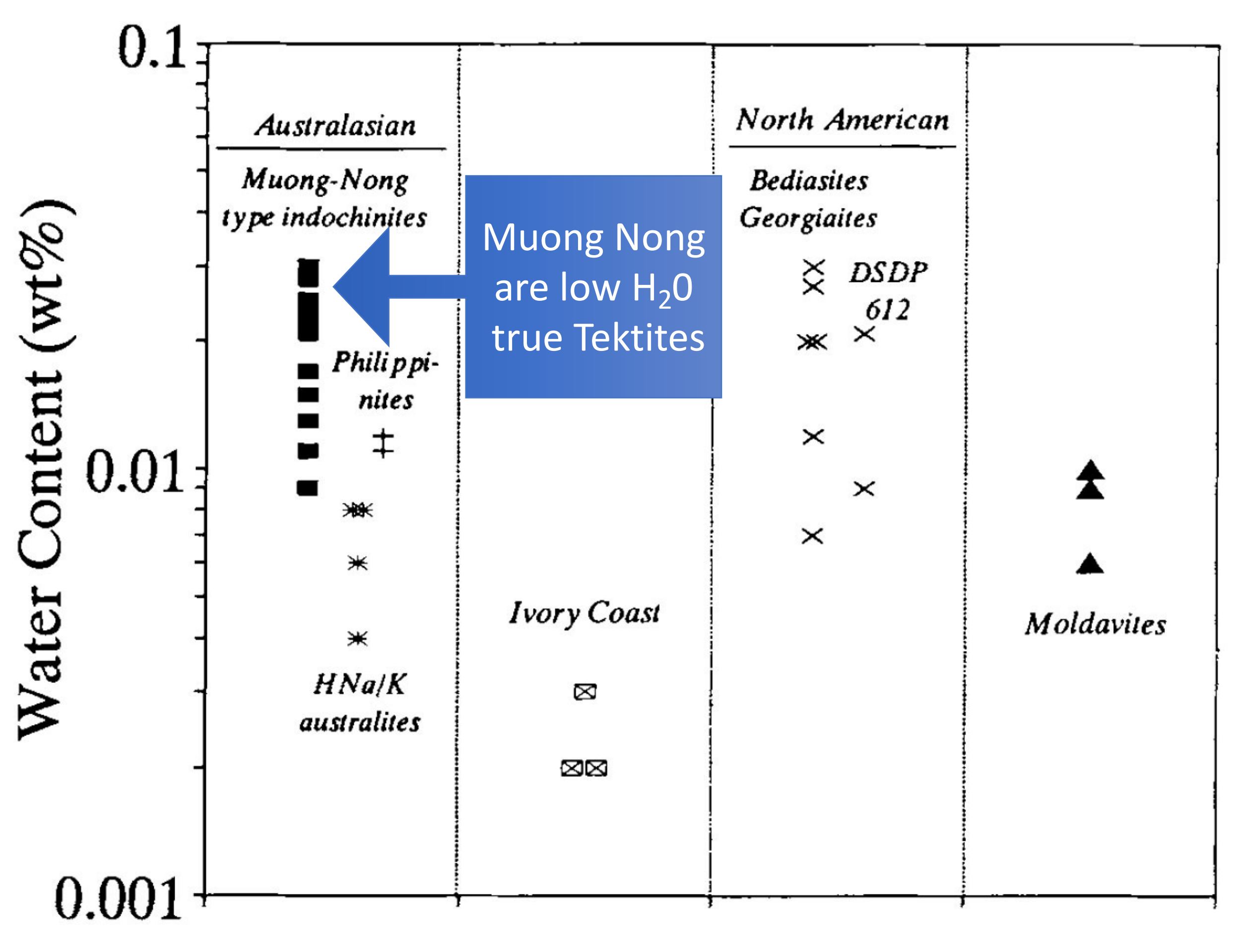
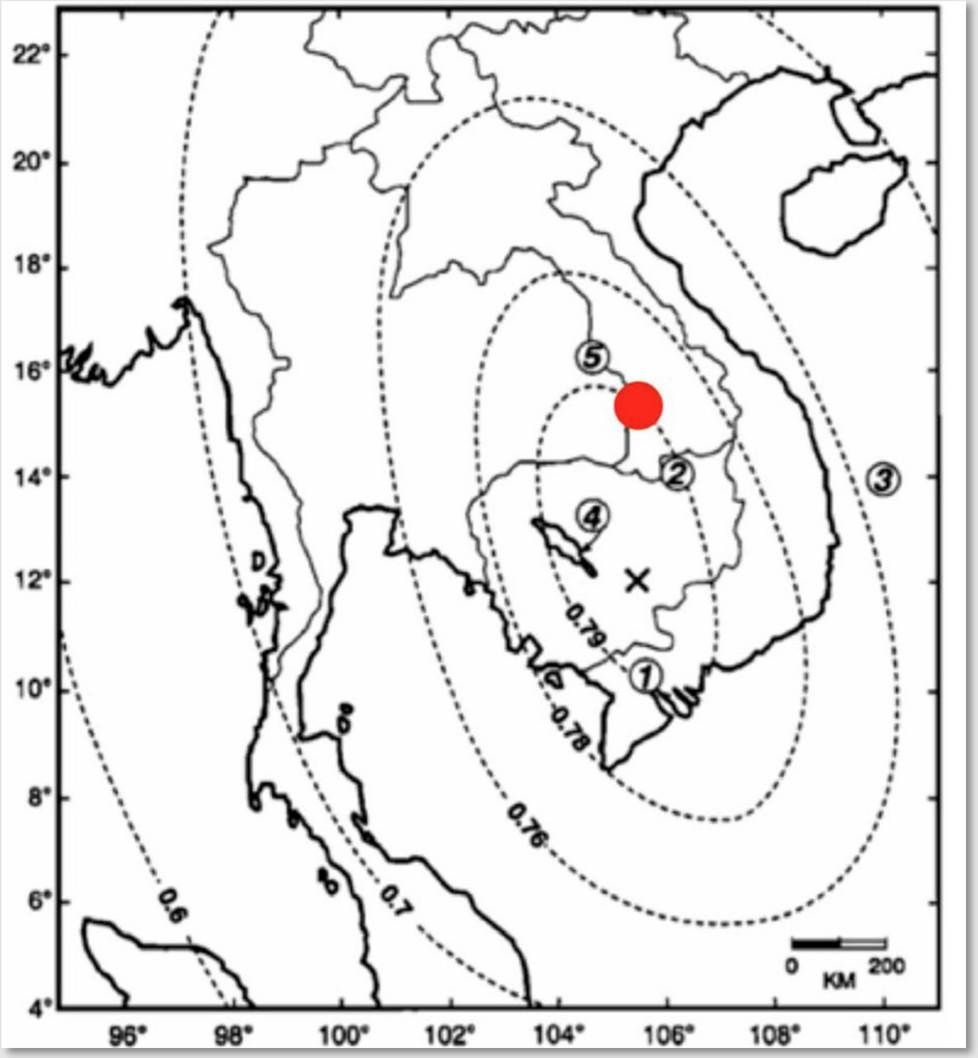


FIG. 1. Water content of tektite samples from all four Cenozoic strewn fields.

Australasian Tektite Strewn Field Crater

- Sieh et al. propose the Bolaven volcanic field in Southern Laos
- Located within a priori target area
- Footprint too small compared to 50 – 100 km expectation by others
- Current understanding of impact cratering argues strongly against impact basins initiating volcanic eruptions
- Numerous failings are elaborated on in Mizera's recent M&PS Paper 1–14 (2022)



Sieh, 2020, Fig 2.

K. Sieh et al., Australasian impact crater buried under the Bolaven volcanic field, Southern Laos. Proc. Natl. Acad. Sci. U.S.A. 117, 1346–1353 (2020).

Impact sites outside of Indochina

- Vladimir Vand suggested the Wilkes land Crater
- E.C. Chao suggested "*Scandinavia*"
- Billy Glass Suggested the Zhamanshin Crater
- Robert Dietz suggested the 18 km Siberian *Elgygytgyn* crater
- Jiri Mizera proposes loess sediments of the Alashan Desert, 2,000 km North

✓ Glass, B.P., 1979. Zhamanshin crater, a possible source of Australasian tektites. Geology 7, 351-353

✓ Dietz, R.S., 1977. Elgygytgyn crater, Siberia: probable source of Australasian tektite field (and Bediasites from Popigai). Meteoritics 12, 145-157

✓ Mizera, J., et. al, 2022. Parent crater for Australasian tektites beneath the sands of the Alashan Desert, Northwest China: Best candidate ever? GSA SPE 553, Chapter 25

Advice Offered

Lin offered:

If the explosive comet-impact model is applied to the explanation of Australasian tektites [Chapman, 1964],one may postulate ***a point of impact far removed from the Australasian region****. The evidence of* ***impact crater must then be sought on other continents****."*

Urey suggested:

"The residual crater may be very difficult to identify;
but it might well be looked for while ***keeping some flexible ideas*** *as to what its properties may be."*

Unconventional Australasian Tektite Event

Missing Crater:

As years go by (50 of them) we seems to be considering smaller structures

Tektite Mass and Distribution Area:

As years go by (all 50 of them) the total mass of tektites and their area of distribution continue to grow

Impacts themselves were Unconventional in 1940

Douglas Johnson, President of Columbia's Geology Department observed:

> sands of feet, six to eight thousand or more in some cases. The largest meteorites known to have reached the earth measure less than a score of feet in maximum diameter.

In Science In Progress, edited by G. A. Baitsell, Yale University Press, 1940 317 pp

And Hoba did not even excavate a crater!

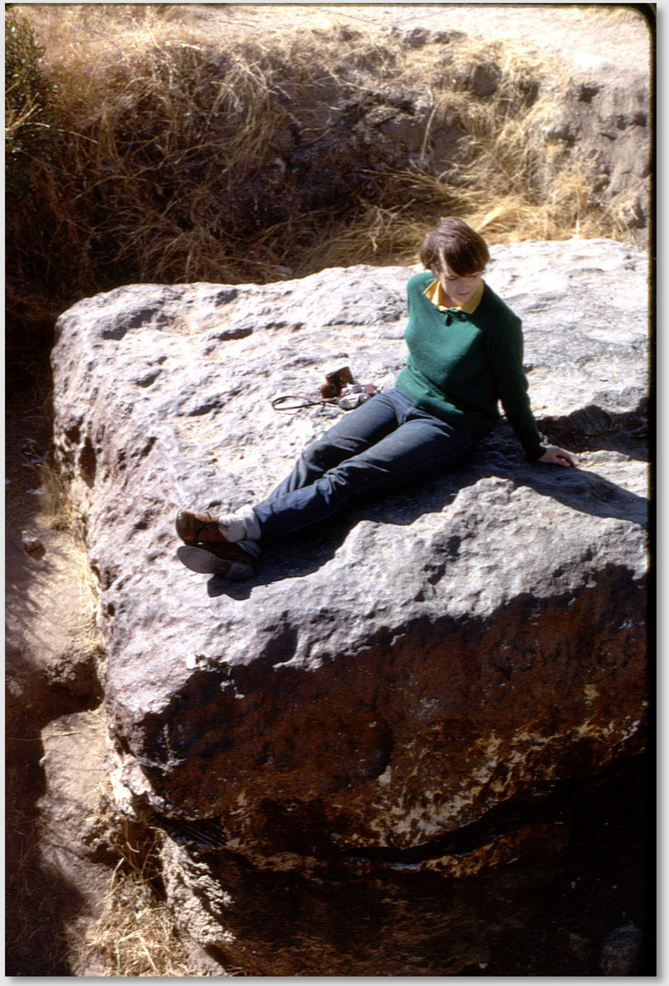


Photo by Paul Venter, Public Domain, https://commons.wikimedia.org/w/index.php?curid=4429659

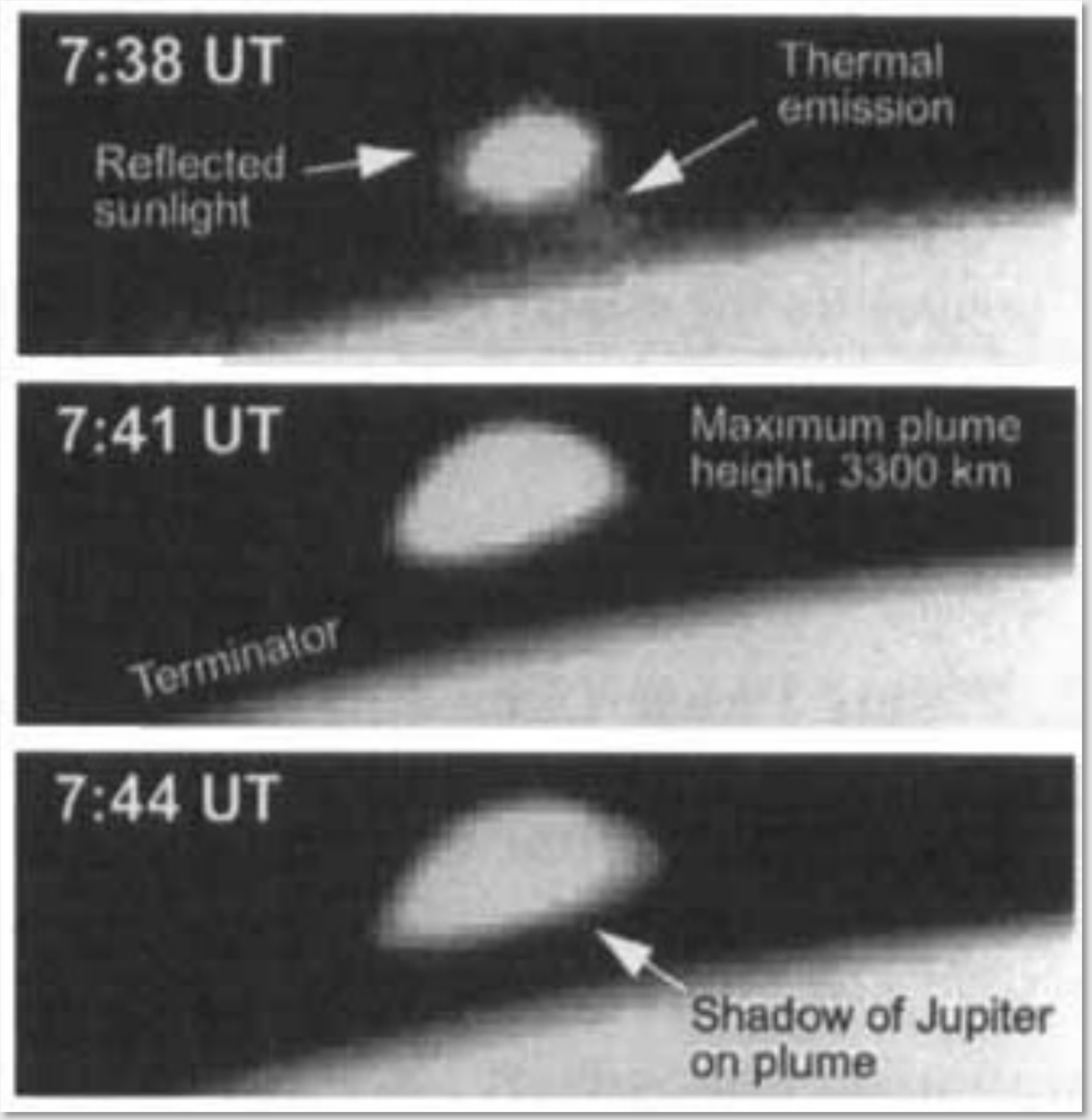
Unconventional Impact : SL-9

"Astronomers indeed observed the fireballs and plumes predicted by the models…

The actual event, however, produced a much richer array of consequences than anyone had anticipated."

- Boslough & Crawford

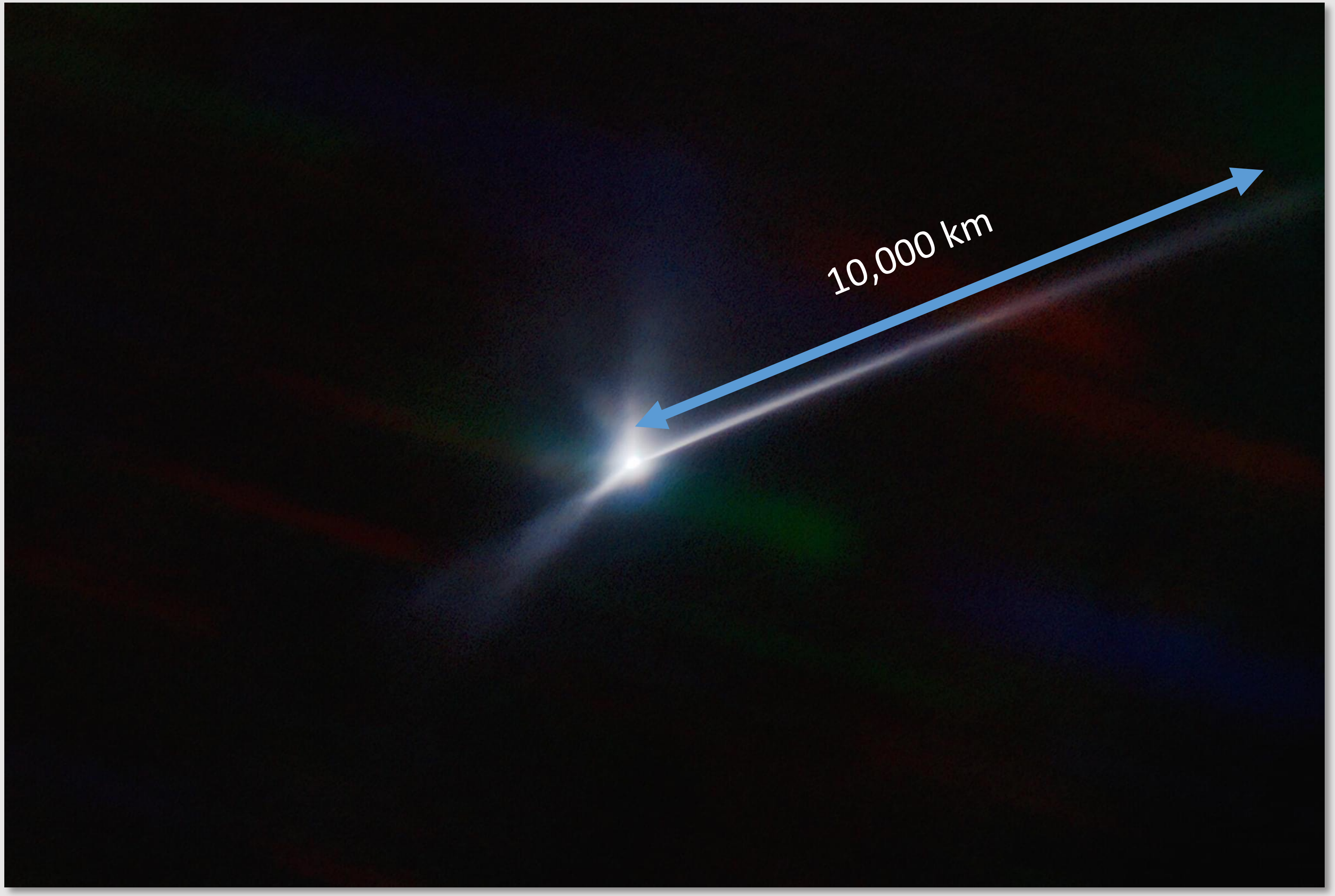
Lessons from Shoemaker-Levy 9 about Jupiter and Planetary Impacts, Joseph Harrington Chapter 8



Unconventional Blasting

Dimorphos's 10,000 tail from Southern Astrophysics Research Telescope (SOAR) – Chile. Kareta & Knight.

Two days after impact of the refrigerator-sized DART spacecraft the tail of solar-wind driven dust reaches 10,000 km



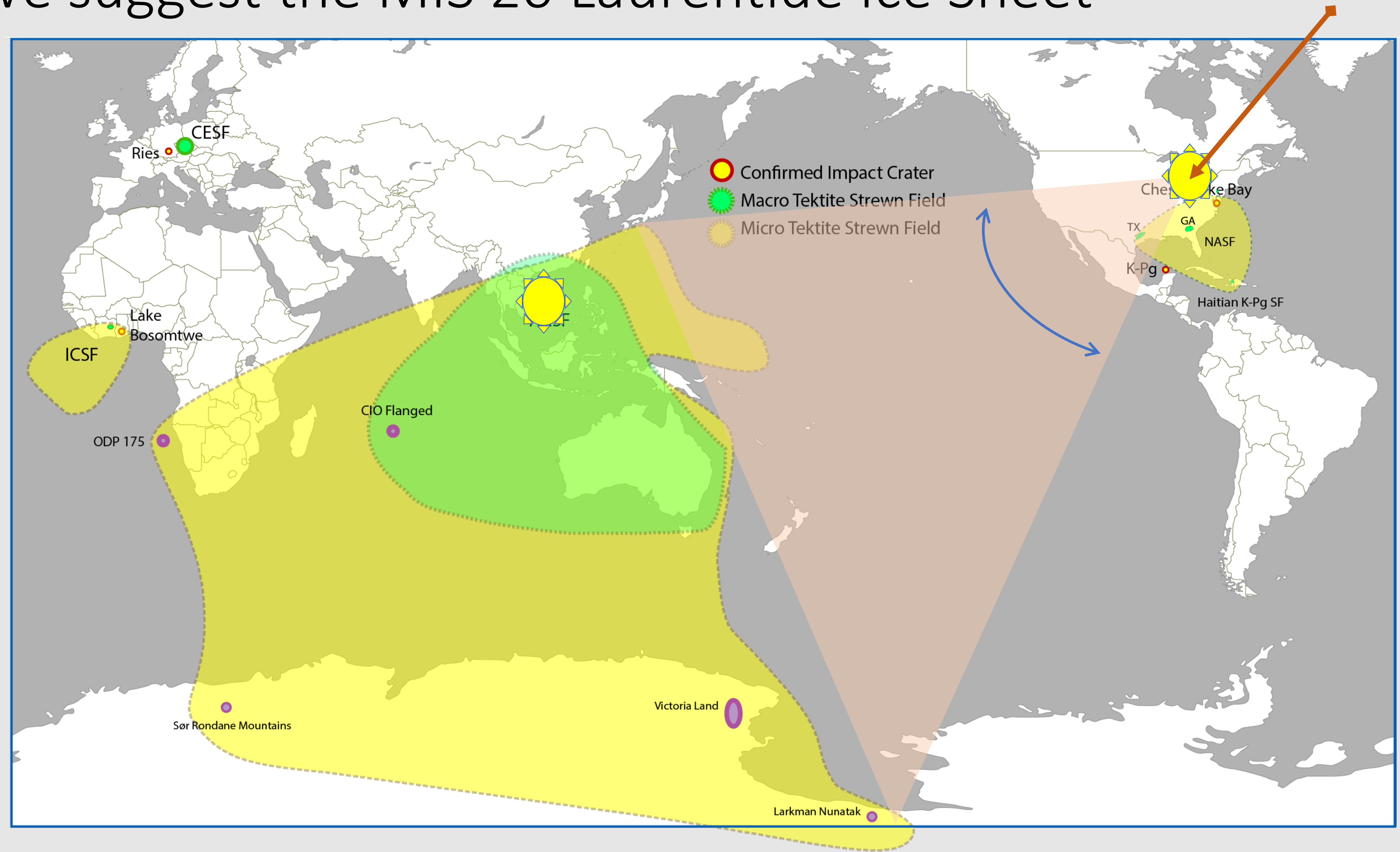
Unconventional Bounty of Data

The Davias-Harris *Mid Pleistocene Impact* framework proposes that the Australasian Tektite event

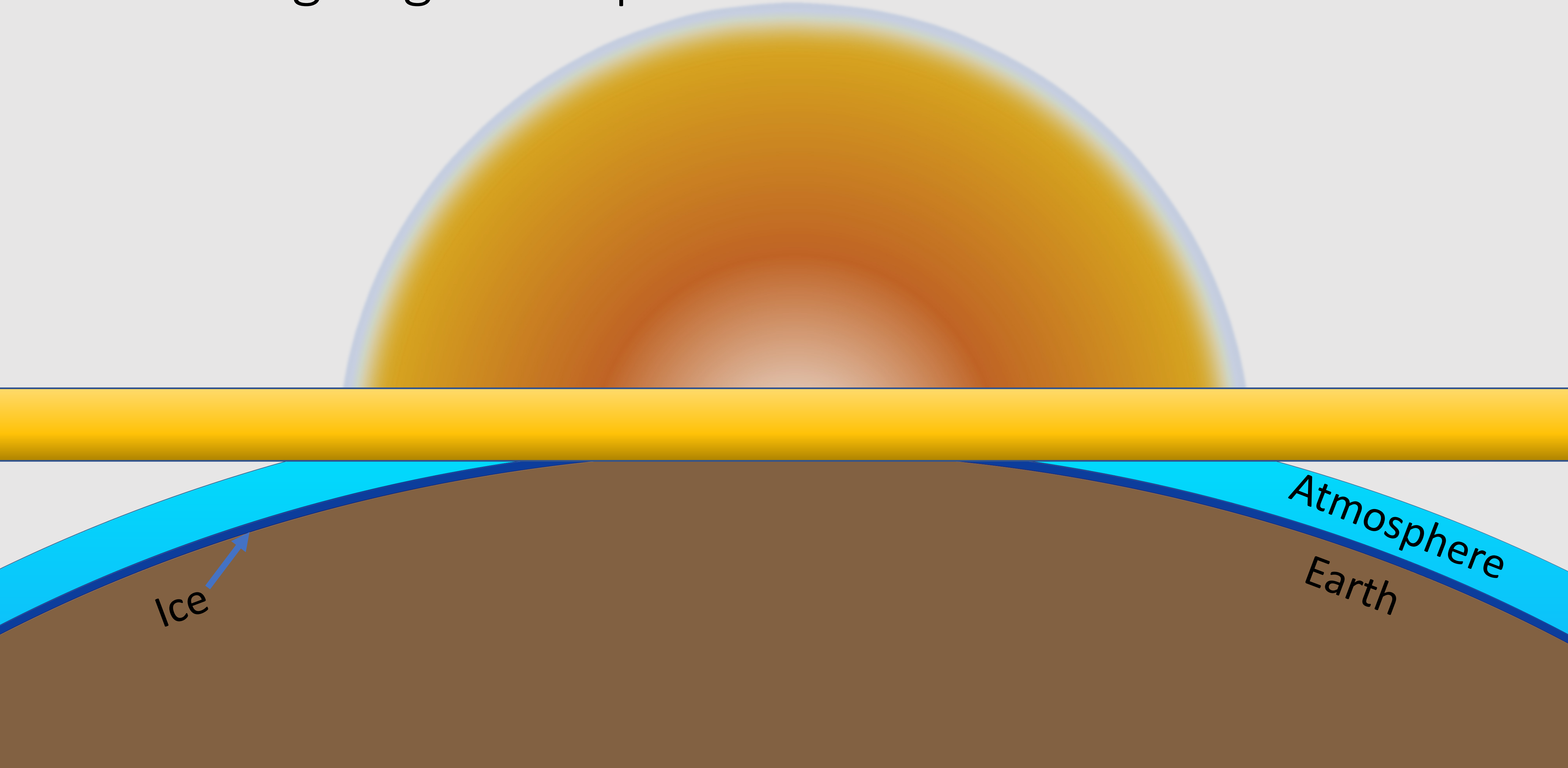
…produced a much richer array of consequences

than anyone has thus far anticipated.

We suggest the MIS 20 Laurentide Ice Sheet



Grazing Regime Impact



Summary

- This presentation offers only observations and an unconventional framework
- The *a priori* Southeast Asian designation should be retired after 50 years
- Tektite strewn fields contain DISTAL ejecta
- All tektites, including layered examples, are distal
- We challenge the term “More Proximal” for Muong Nong types
- Macro tektite strewn fields are found primarily in an asynchronous direction
- The Earth rotates 1º every 4 minutes during the suborbital transit of tektites
- The identified tektite trait groupings may be applicable to an antipodal impact site
- A North American Great Lakes antipodal impact into MIS20 ice sheet suggested
  - GSA SP553: In the Footsteps of Warren B. Hamilton: New Ideas in Earth Science
  - doi.org/10.1130/2021.2553(23)
  - doi.org/10.1130/2021.2553(24)

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- ✓ We appreciate the diligent work and critical reviews provided by the numerous reviewers of our two chapters, guiding us in improving the narratives to their current form. Thomas and I are proud of the results.
- ✓ We are honored to be a part of a body of work honoring the life and work of Warren B. Hamilton, who encouraged efforts to challenge “Geo Myths”.

The work of M. Davias and T. Harris on the MTP Impact Hypothesis has been self-funded.

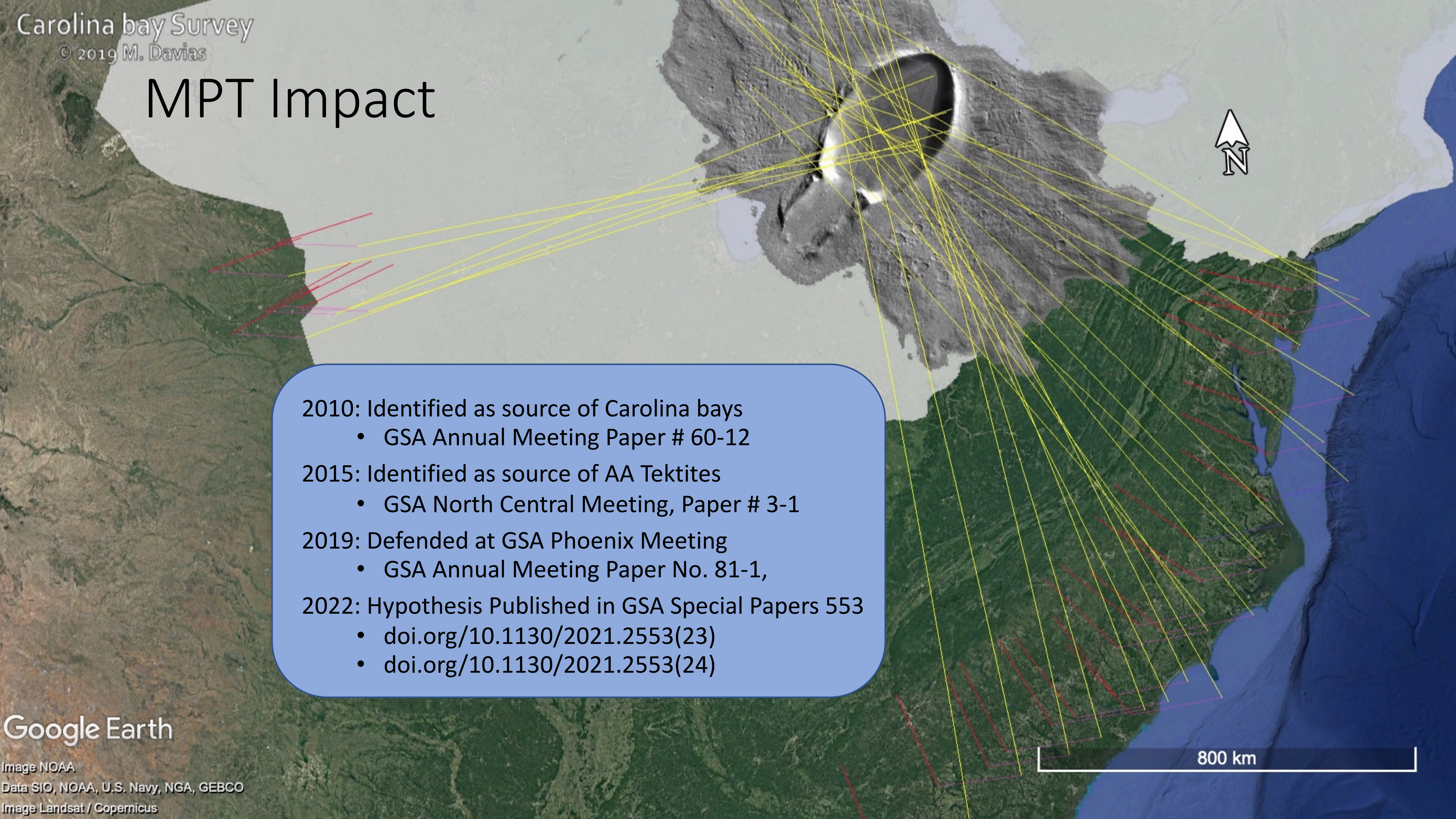
MPT Impact

2010: Identified as source of Carolina bays
- GSA Annual Meeting Paper # 60-12

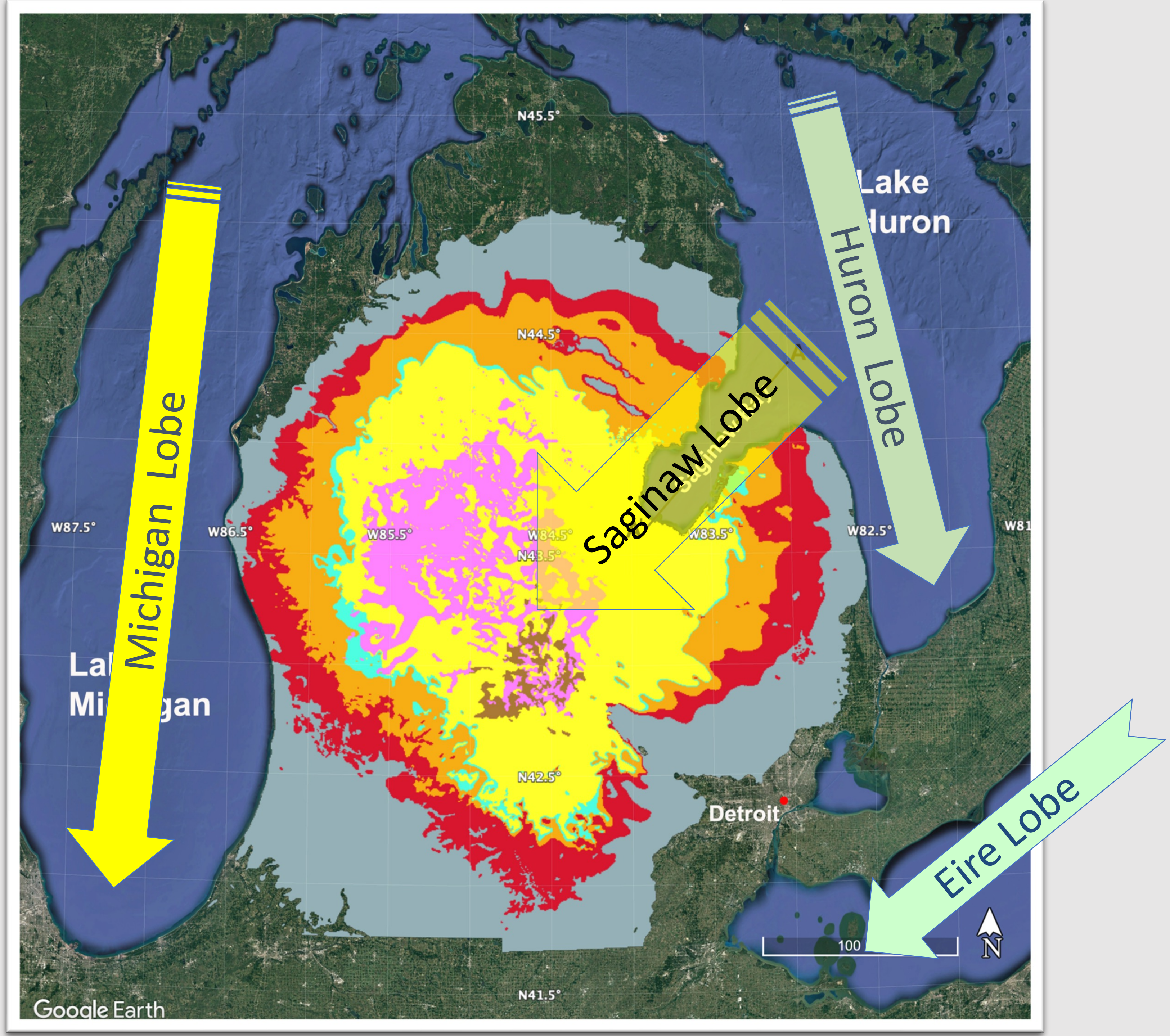
2015: Identified as source of AA Tektites
- GSA North Central Meeting, Paper # 3-1

2019: Defended at GSA Phoenix Meeting
- GSA Annual Meeting Paper No. 81-1,

2022: Hypothesis Published in GSA Special Papers 553
- doi.org/10.1130/2021.2553(23)
- doi.org/10.1130/2021.2553(24)

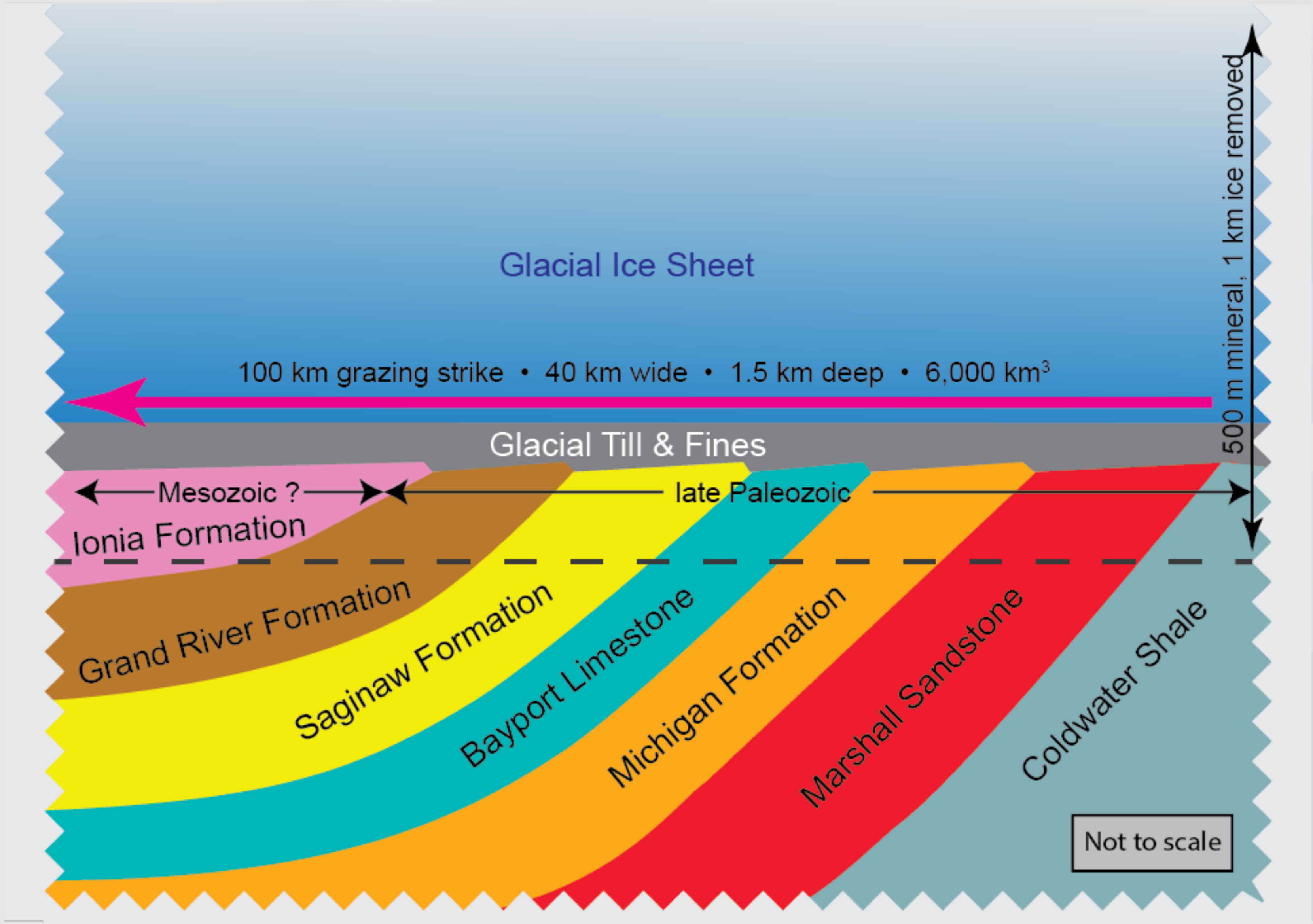


Laurentide Ice Flows



Early Mesozoic to Late Paleozoic Target

1. 1500 m ice
2. 500 m mineral
3. 300 km trench



Forensic Evidence From AA Tektites

- Barnes 1990, regarding the Origin of Australasian Tektites

  All of the tektites analyzed have rare-earth-element compositions that exactly match, within the limits of error, the rare-earth-element values in the North American Shale Composite.

- Blum, 1992, *Rb/Sr Dating*

  A correlation of Rb/Sr fractionation with Sr model ages indicates that the last major Rb/Sr fractionation event experienced by the target materials occurred 175 ± 15 Ma ago. We interpret this age as the time of deposition of sedimentary target rocks and consider the compositional layering observed in Muong Nong-type tektites to ***reflect compositional variability inherited from Jurassic sediments****. Depleted mantle Nd model ages fall within the narrow range of* ***1490-1620 Ma,*** *indicating that the source material was derived dominantly from a* ***Proterozoic crustal terrene***

Barnes, 1990, *Tektite research 1936-1990* (Barringer Award paper), Meteoritics Vol 25

Joel D. Blum, 1992, *Neodymium and strontium isotopic study of Australasian tektites: New constraints on the provenance and age of target materials*

Michigan Basin Mesozoic Sandstone Zircon Ages

Dickinson, et al, *Detrital zircons from fluvial Jurassic strata of the Michigan basin: Implications for the transcontinental Jurassic paleoriver hypothesis*, Geology 2010;38;499-502

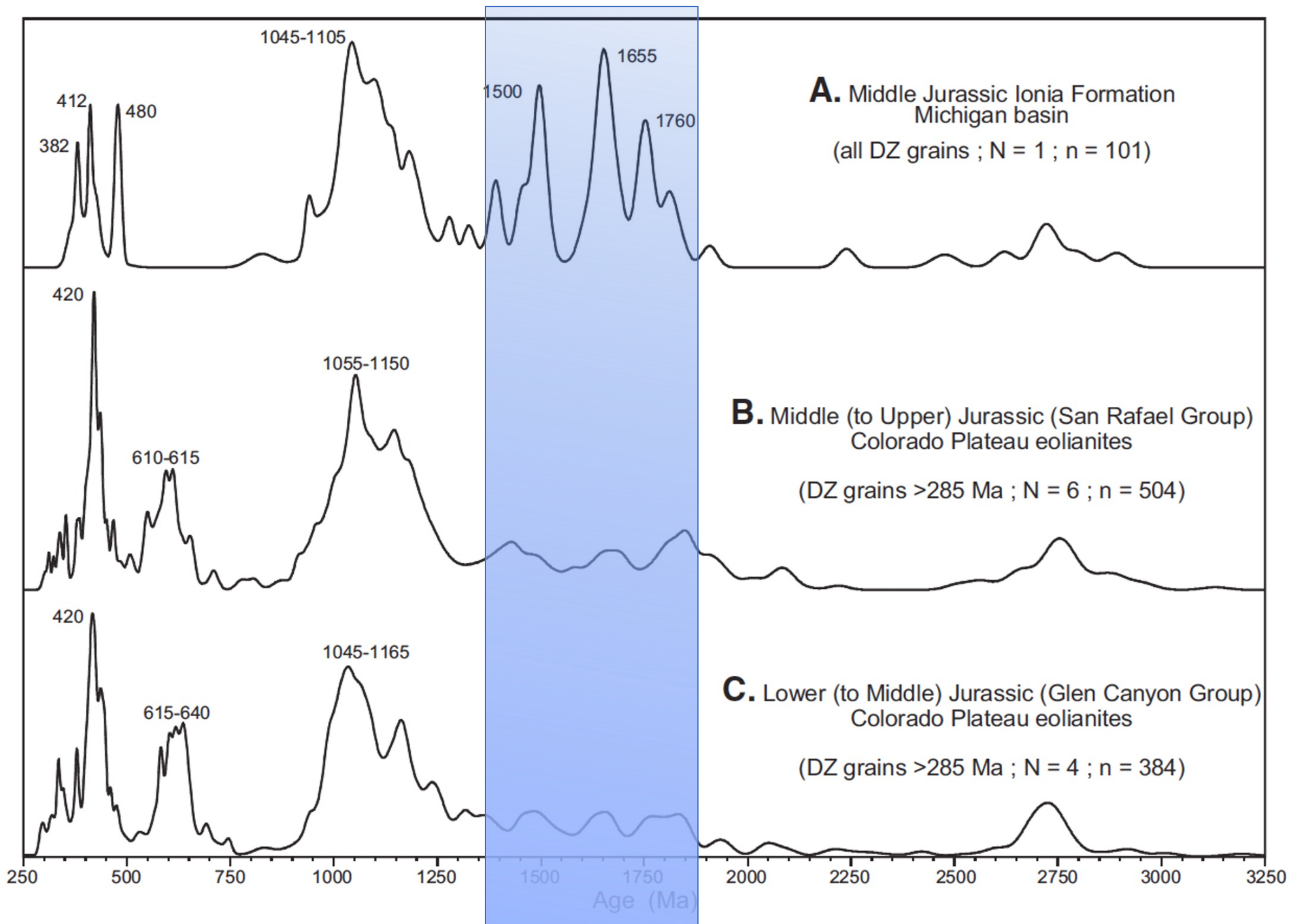
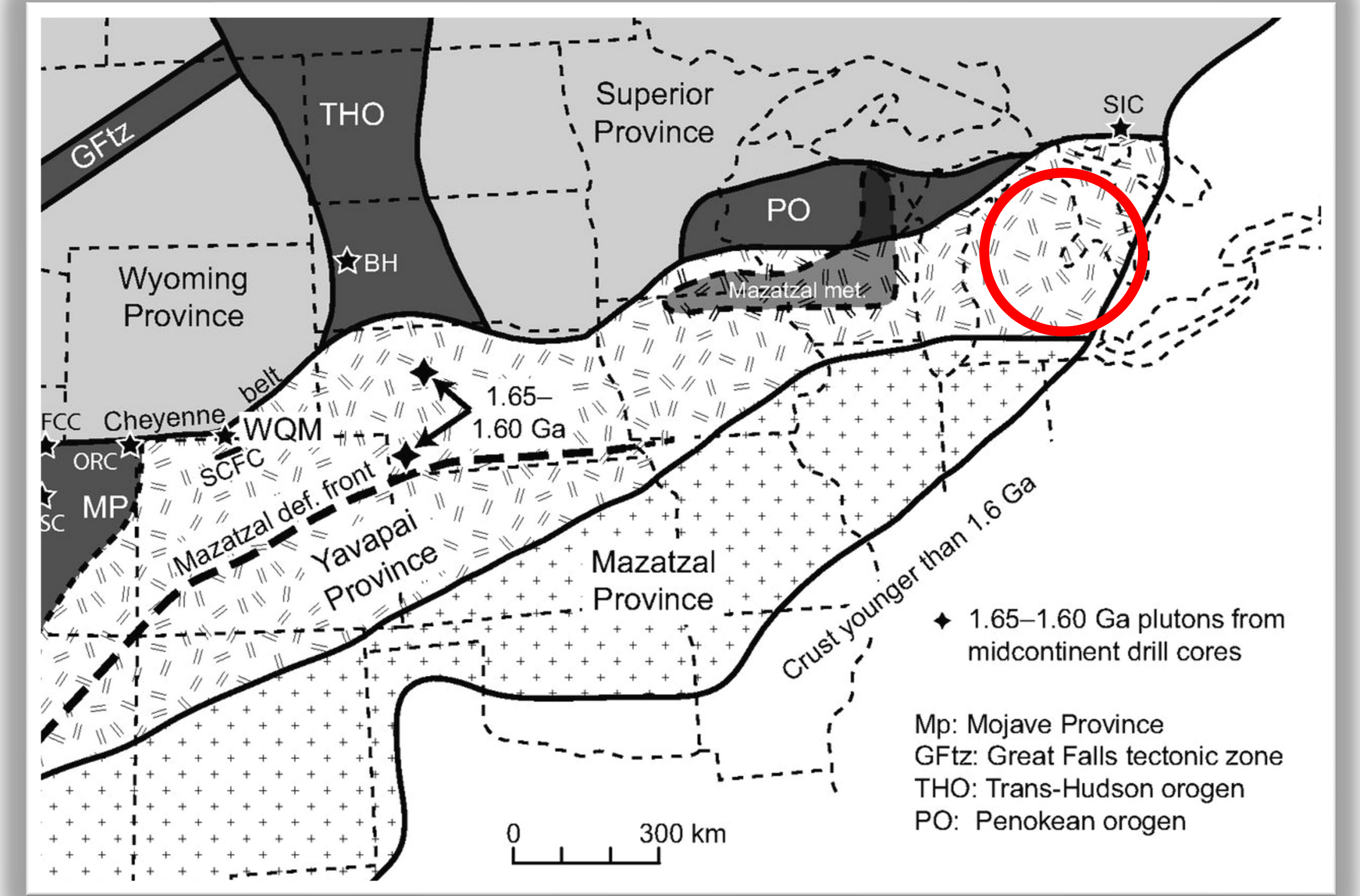


Figure 2. Age-distribution curves (normative age-probability plots) of U-Pb ages. A: Detrital zircon (DZ) grains in Ionia Formation of the Michigan basin. B, C: Detrital zircon grains older than 285 Ma in Colorado Plateau eolianites of Jurassic age. N—number of samples; n—number of grain ages.

Michigan Basin Jurassic Sandstone Zircon sources

Jones, et al, 2012, *Reactivation of the Archean-Proterozoic suture along the southern margin of Laurentia during the Mazatzal orogeny: Petrogenesis and tectonic implications of ca. 1.63 Ga granite in southeastern Wyoming, GSA Bulletin V. 125 no. 1-2*



The Great Lakes Area with θi gravity aspects

No definitive evidence of impact, *"But combed strike angles … disclose a trace of high pressure to the SE/S/SW of the Bay and may be due to an impacting body."*

Klokočník, et al, Journal of Great Lakes Research 45 (2019) 12–20

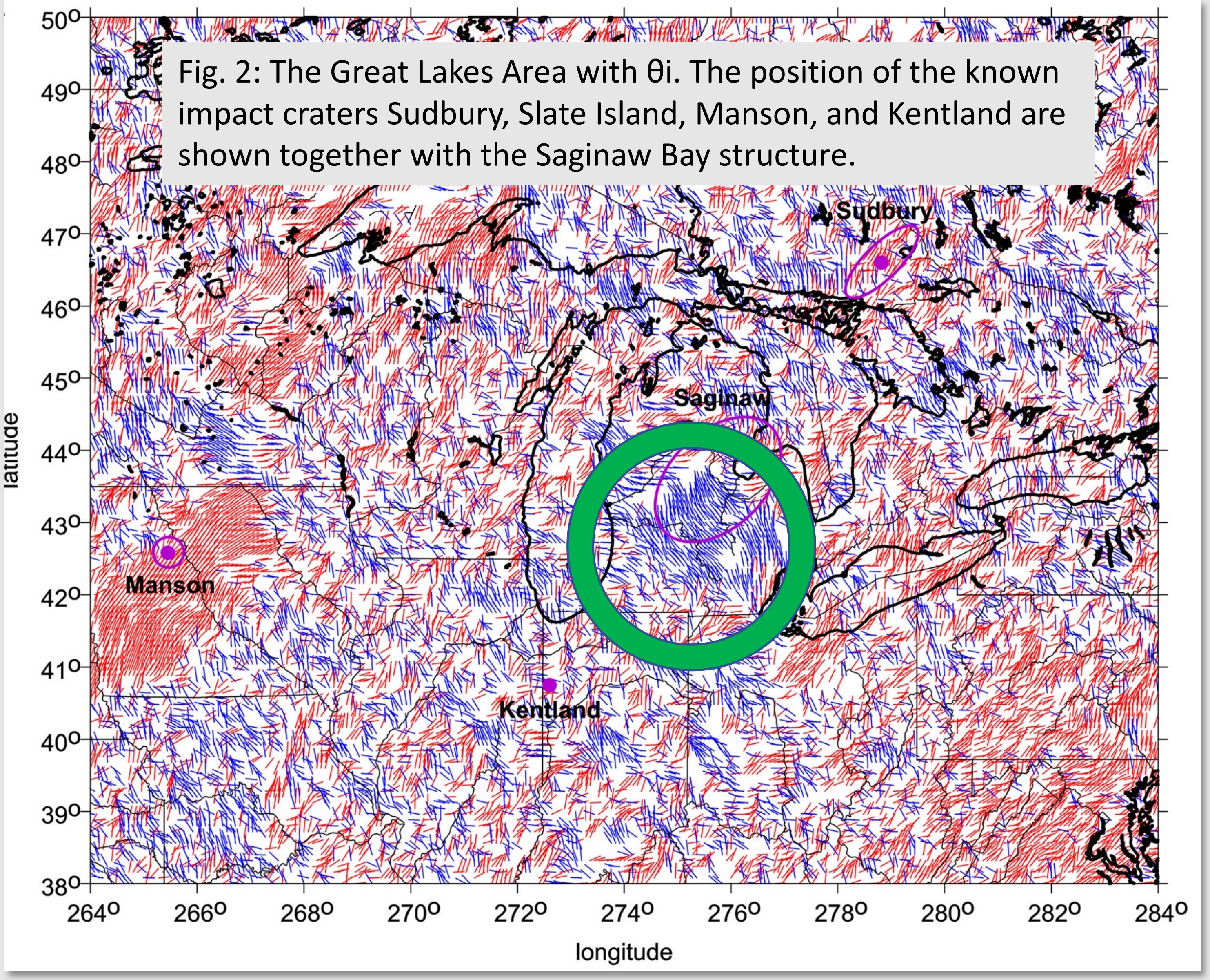
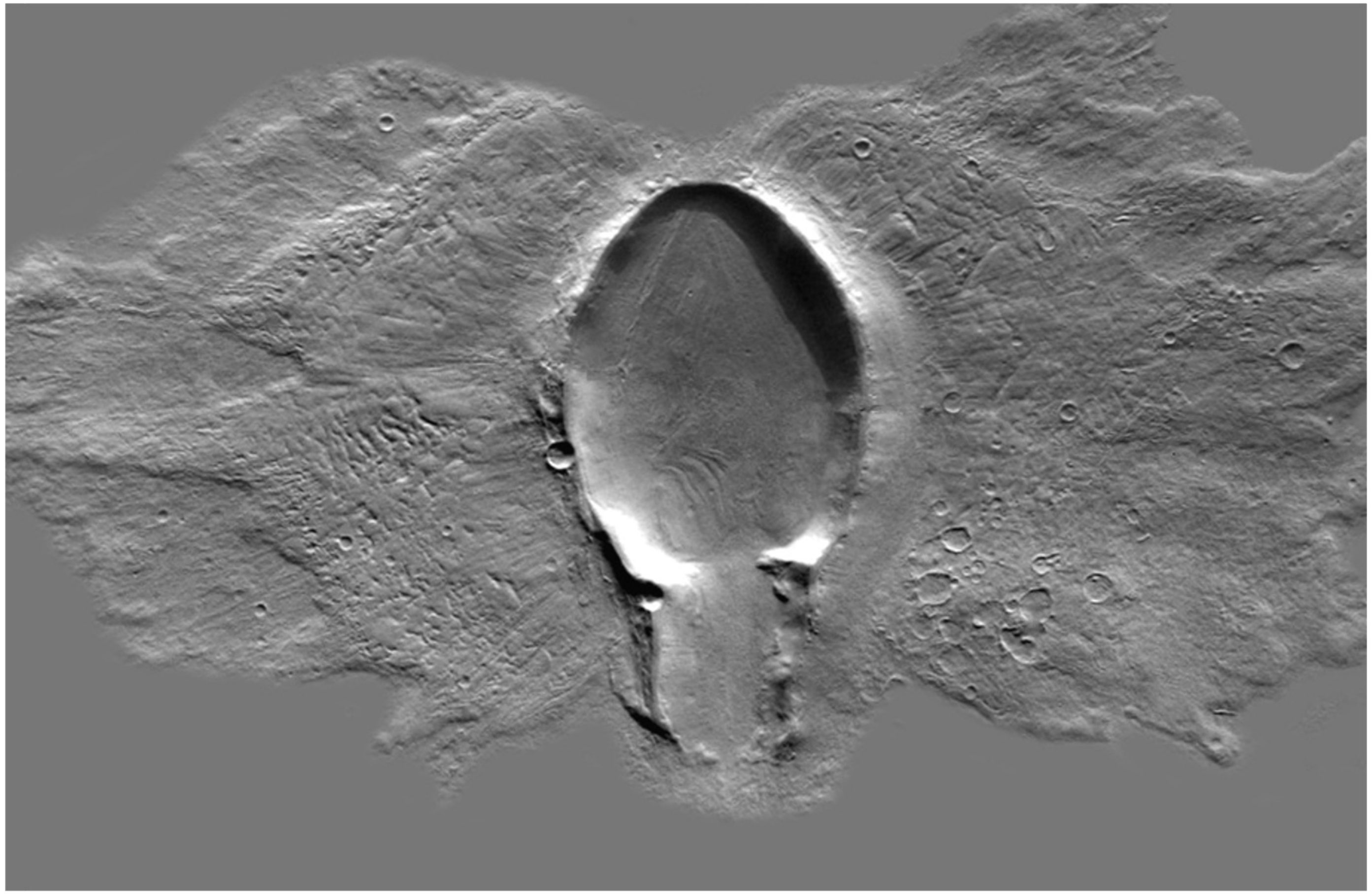


Fig. 2: The Great Lakes Area with θi. The position of the known impact craters Sudbury, Slate Island, Manson, and Kentland are shown together with the Saginaw Bay structure.

Mars Grazing Regime Examples

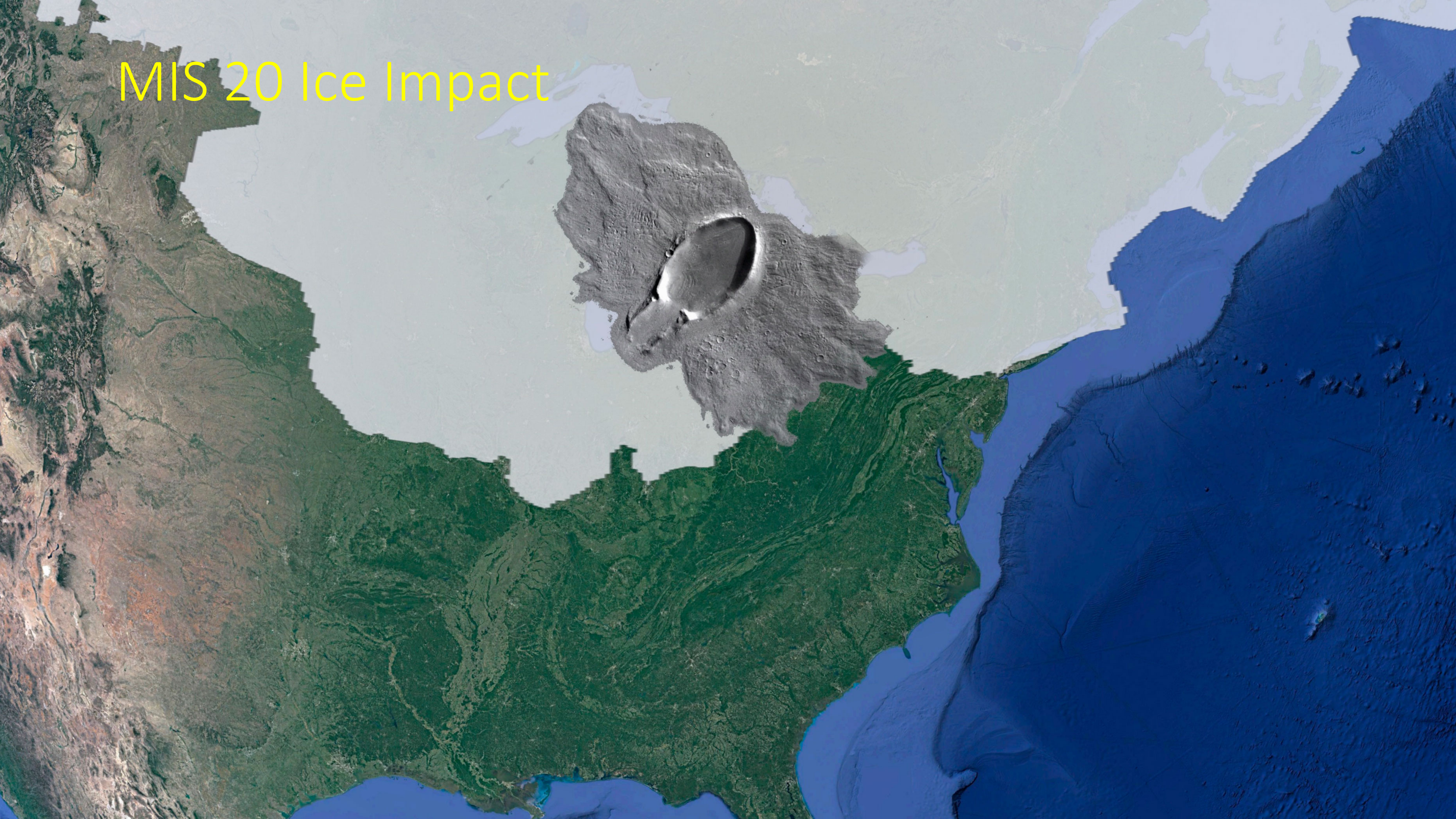


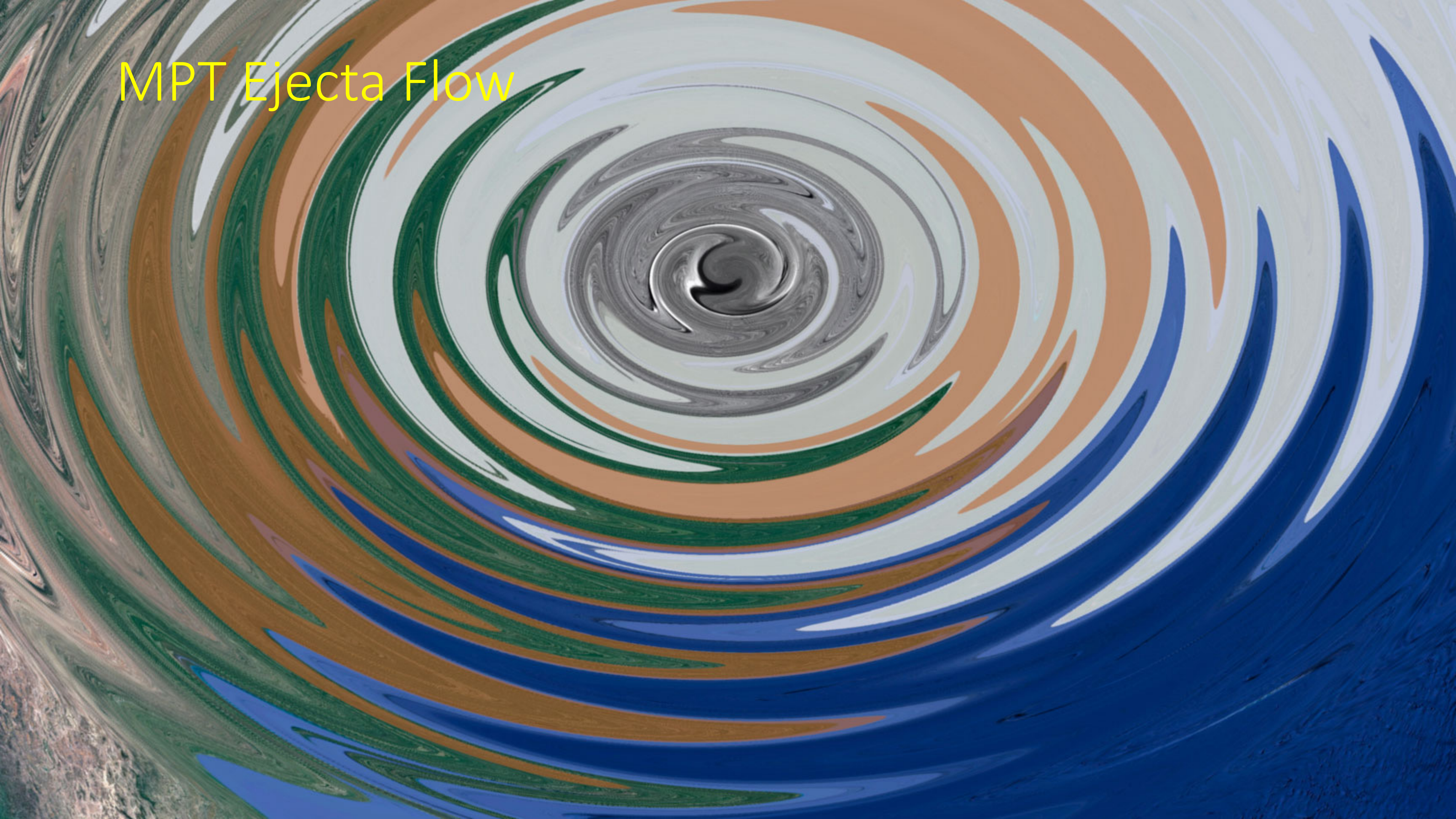
Michigan Basin Sandstone a Hydrous Target

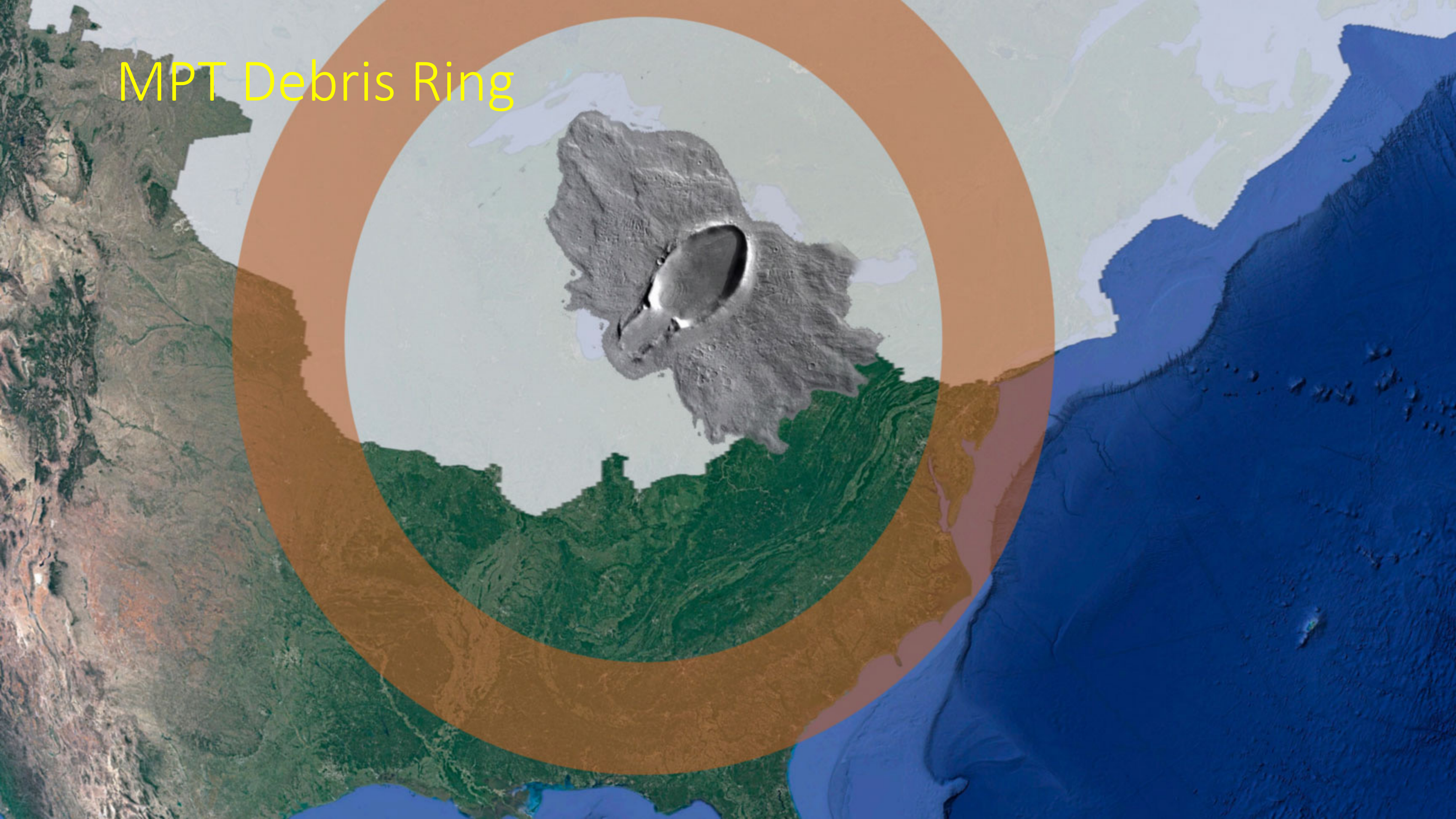
"We suggest that in addition to strength-weakening due to the presence of fluids, vaporization of water upon pressure release provides an additional ***explosive potential that superimposes the impact-induced flow field."***

"Cratering efficiency, ejection velocities, and spall volume are enhanced if the pore space of the sandstone is filled with water. In addition, the crater morphologies differ substantially from wet to dry targets, i.e., ***craters in wet targets are larger, but shallower****."*

Thomas KENKMANN, et al, 2011, *Impact cratering in sandstone: The MEMIN pilot study on the effect of pore water, Meteoritics & Planetary Science 46, Nr 6,*

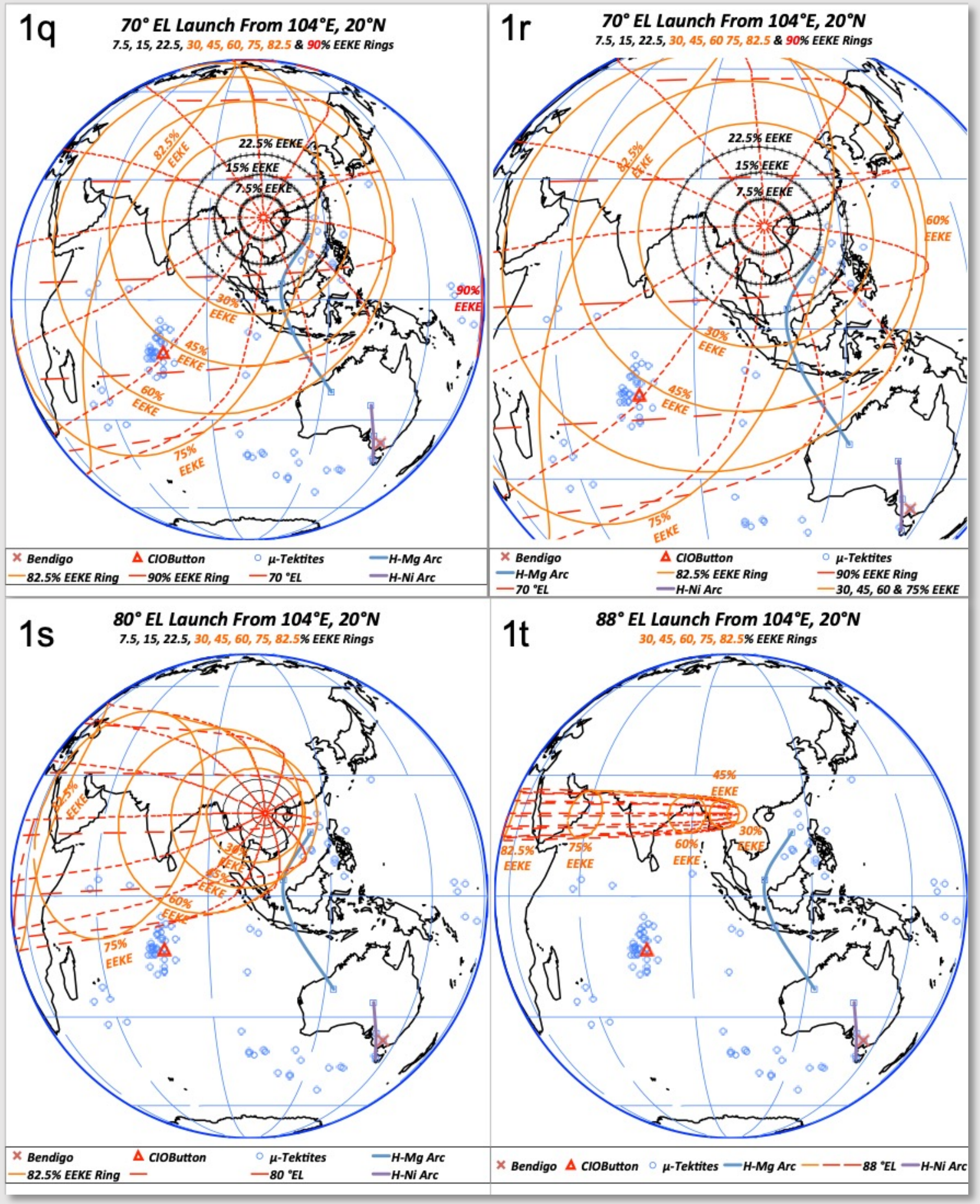

MIS 20 Ice Impact


MPT Ejecta Flow


MPT Debris Ring

Distal Ejecta – Tektites Trajectories From Indochina

- Tektites launched at 70º elevation
  - fall mostly to the west due to planetary rotation
  - Most EEKE % can reach CIO Button
  - Can’t land in Australia
- Tektites launched at >80º elevation
  - can’t reach Bendigo, Australia
  - nor the Central Indian Ocean Button location



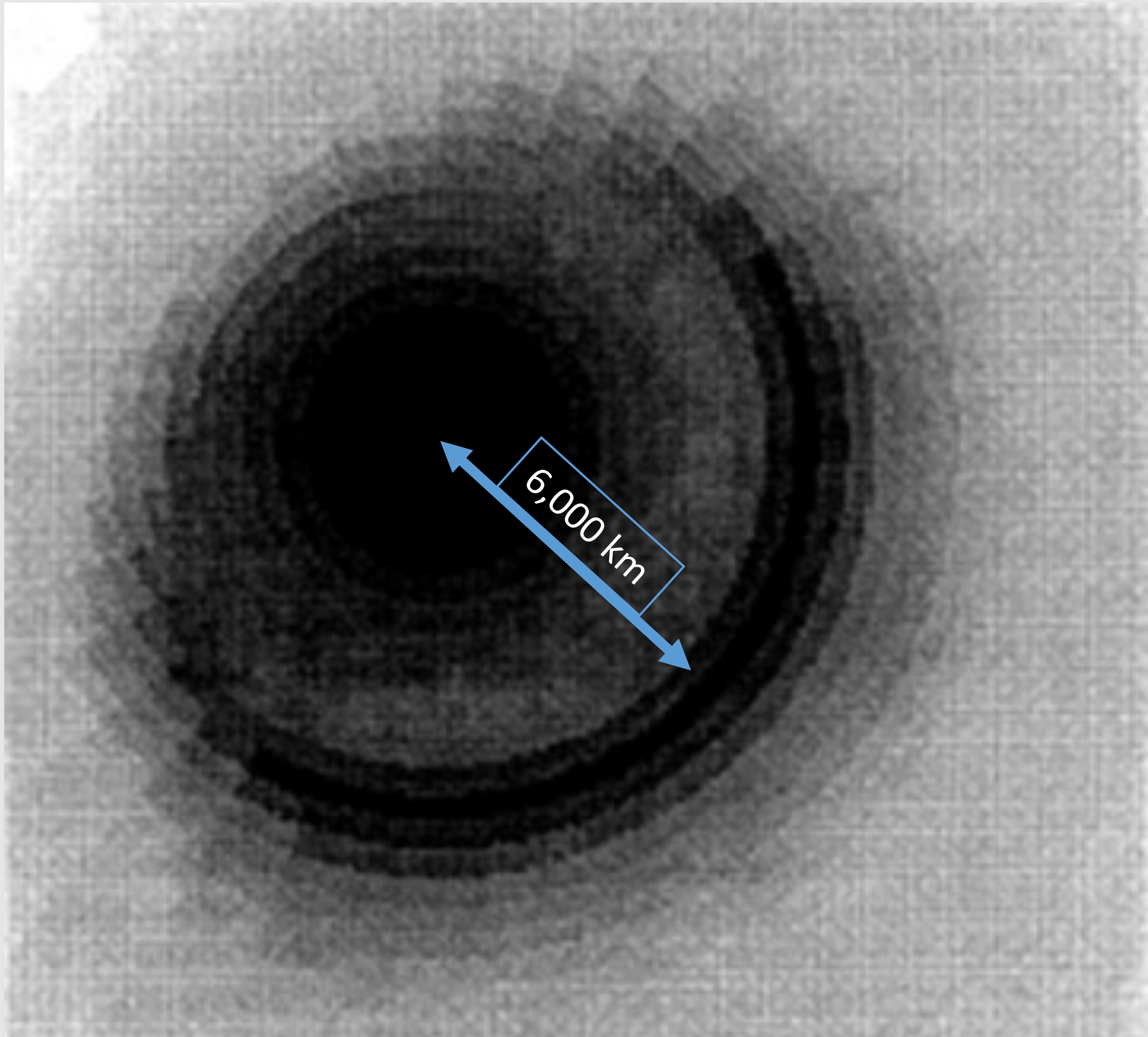
Unconventional Skidding

A ring of ejecta debris expanded for hours, while slowly rotating due to Coriolis forces.

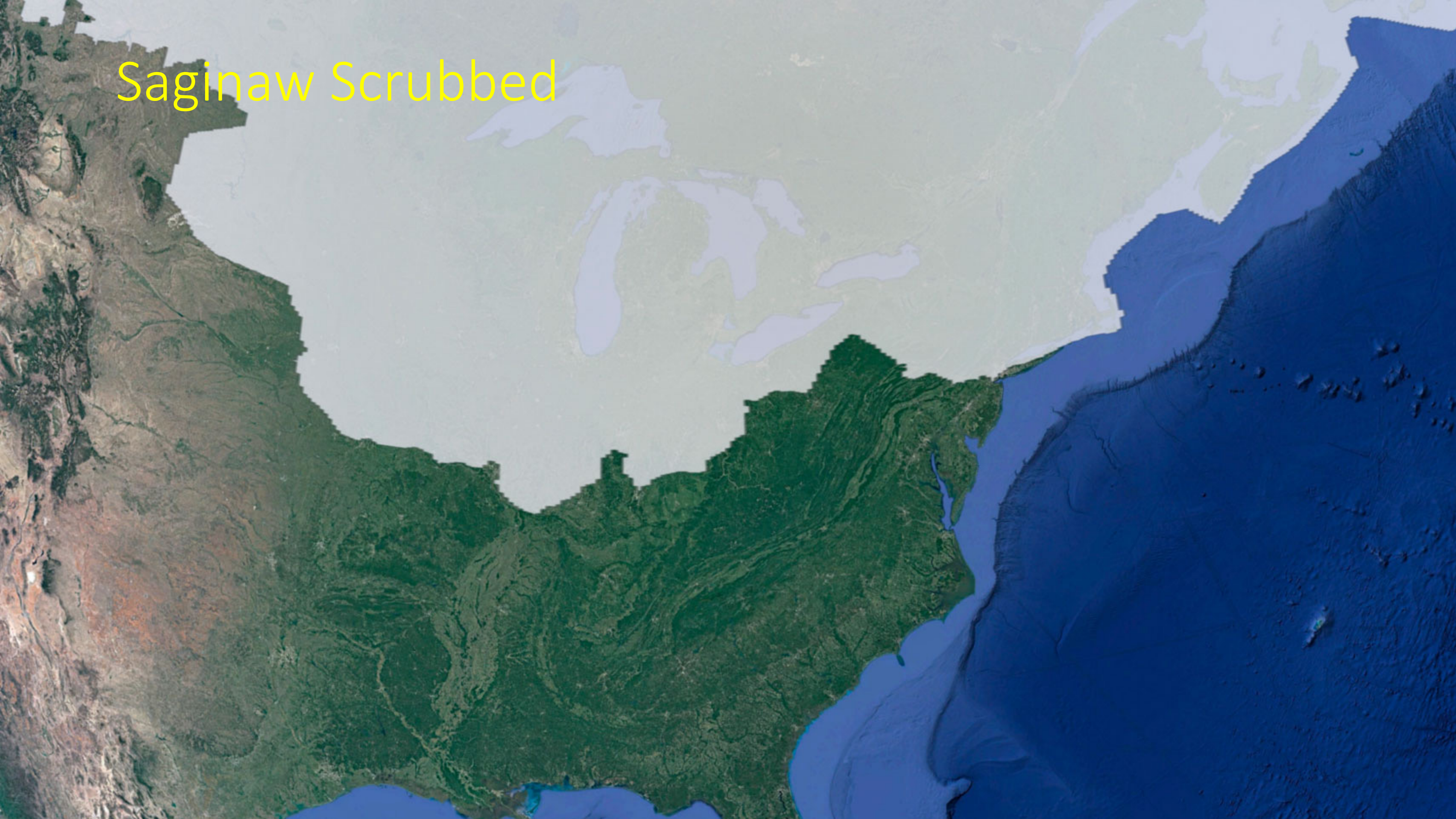
The inner crescent edge has slid 6,000 km from the impact site.

The interpretation is that the debris was *skidding* across the top of a super heated atmospheric layer.

The same dynamic has been applied to explain the transport of shocked minerals from the K-P impact all the way to New Zealand.



Nominal impact-site model of Harrington and Deming (2001). Intensity is proportional to gas mass deposited.


Saginaw Scrubbed

Button-Flange AA Tektites Ring Waves

In 1964, Dean Chapman and a team at NASA Ames demonstrated how these ringlets and flanges were created during aerodynamic ablation of a fully solidified spherical tektite, requiring velocities bracketing Earth Escape

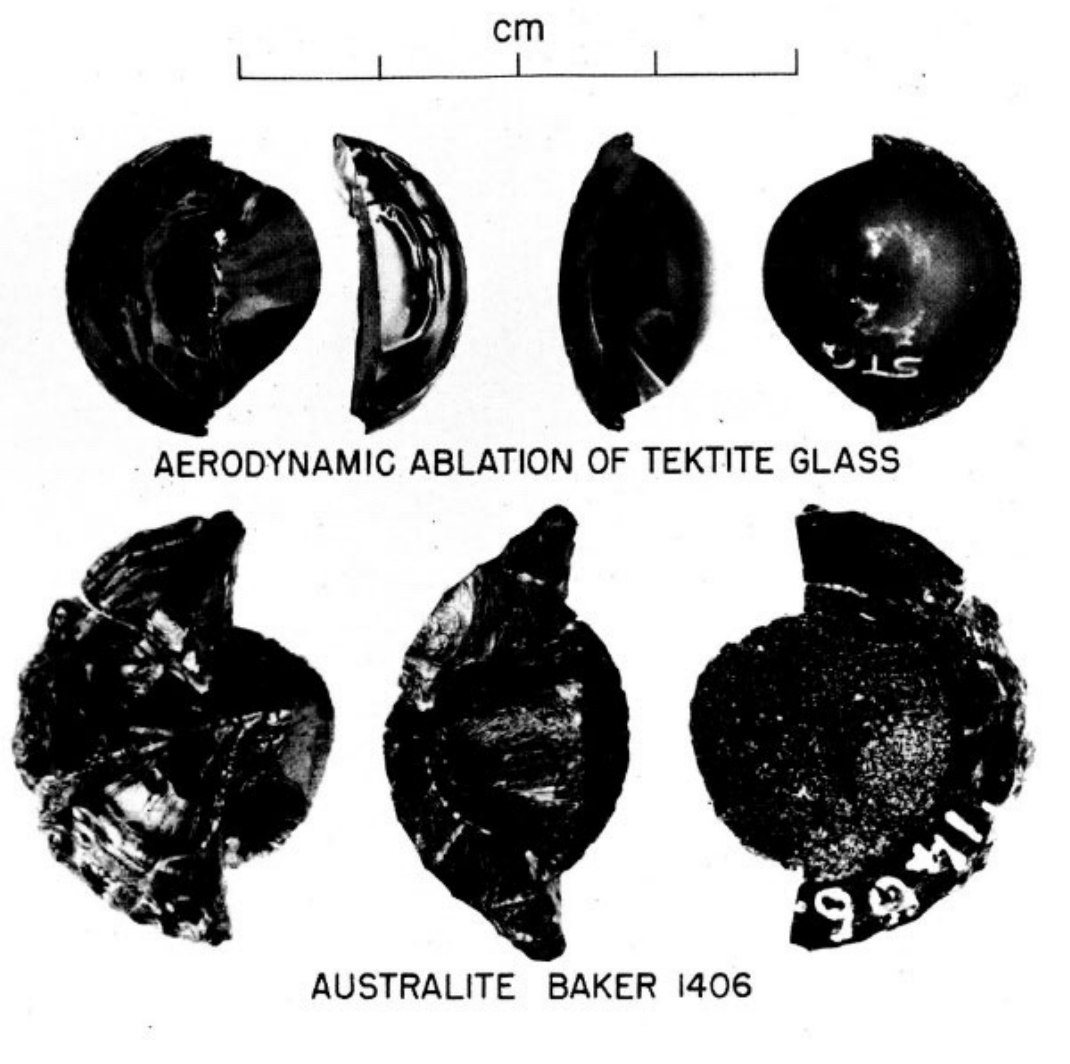


Fig. 4. Half spallation of aerothermal stress shell.

Chapman, *On the unity and origin of the Australasian tektites, Geochimica et Cosmochimica Acta* 1964, Vol. 2

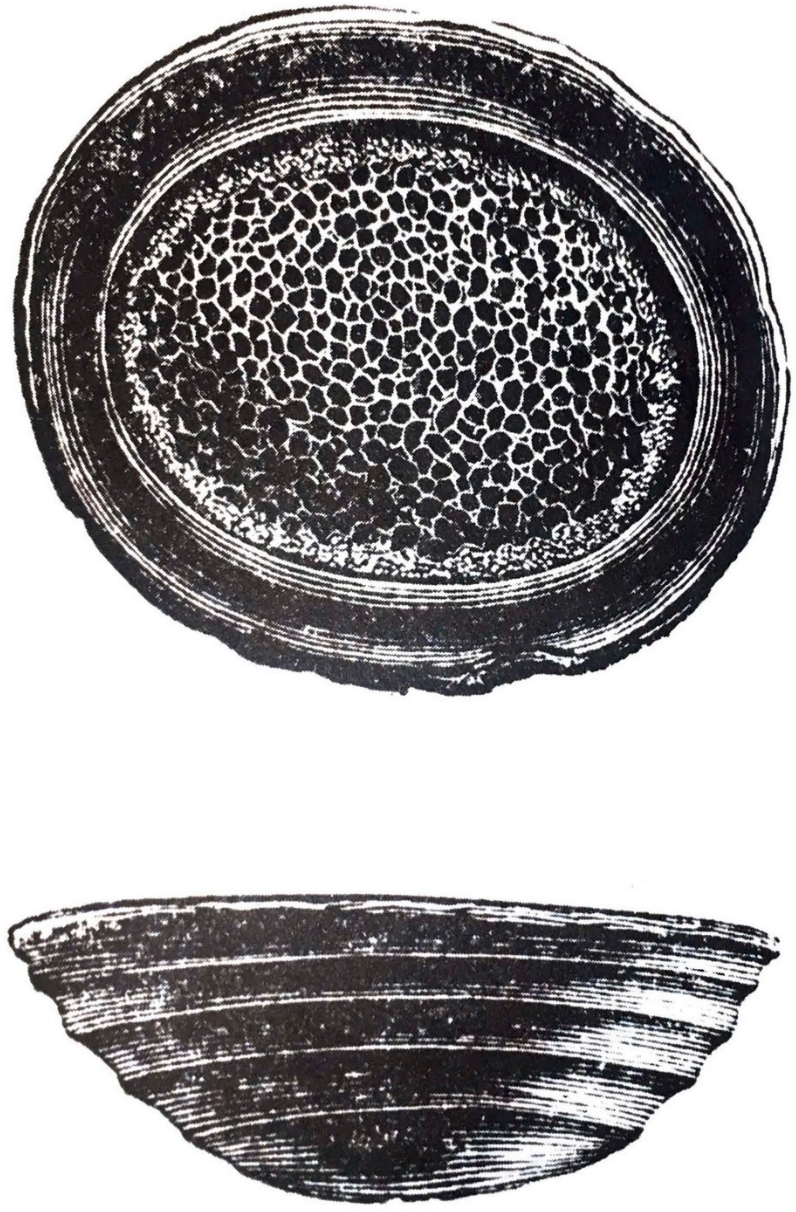


Fig. 1. First illustration known of a tektite [from *Darwin*, 1844], thought by Charles Darwin to be a volcanic bomb.

Enigmatic Button Flange

- First entered literature though Charles Darwin’s voyage on the Beagle
- Thought to be volcanic bomb
- Found across south eastern Australia
- One found in a grab core in the Central Indian Ocean, 7,000 km east of the Australian finds

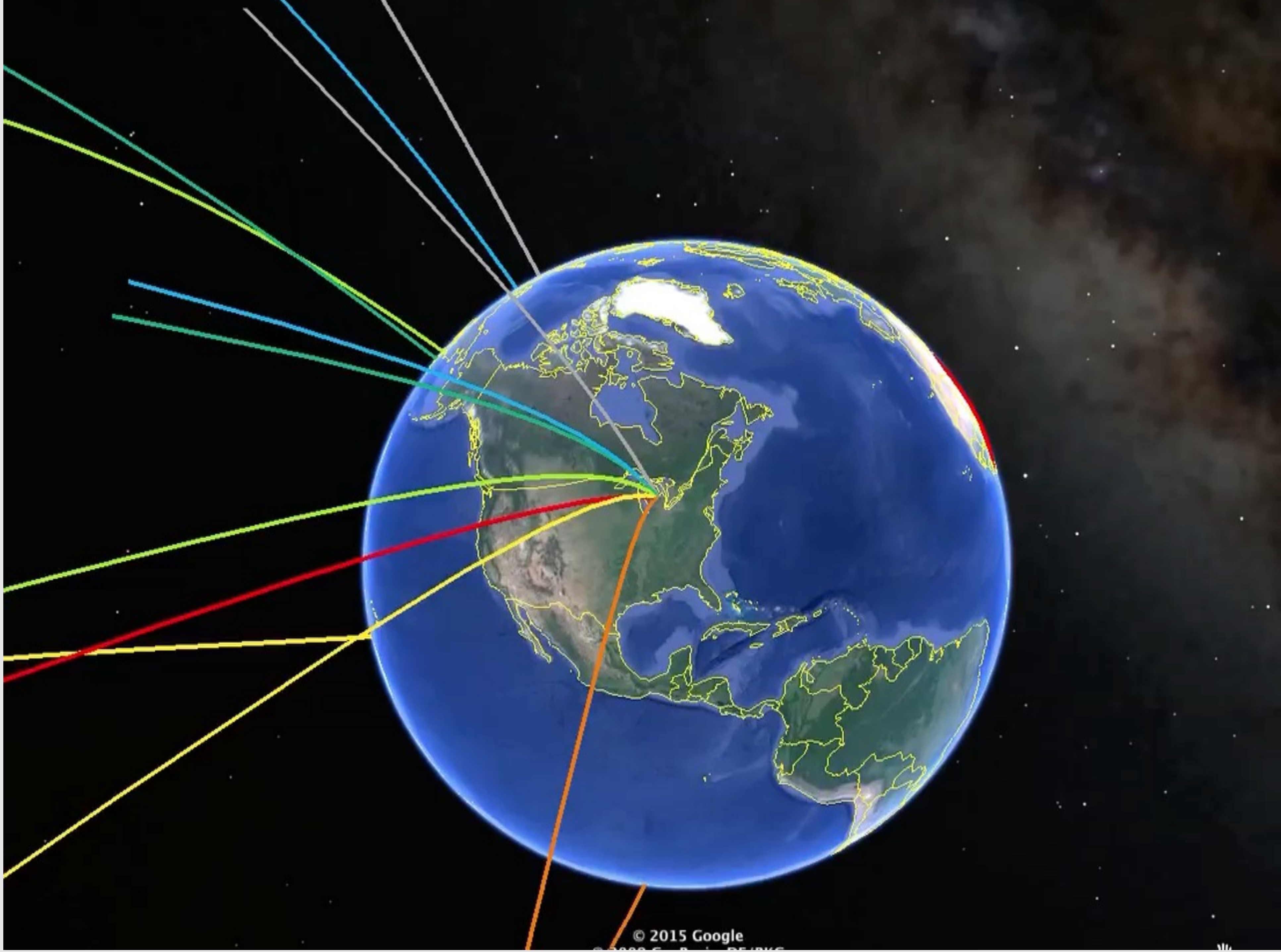
Orion Near Escape Velocity Reentry

- Dean Chapman's experiments in characterizing reentry conditions which generated button-form tektites proved the velocity straddled Earth escape.
- Re-purposed for the design of the Apollo Lunar Module heat shield, which had to handle a similar re-entry velocity
- Chapman's interpretation has been ignored, and button form Australites are accepted as reentering far slower.

Oblique impacts into ice

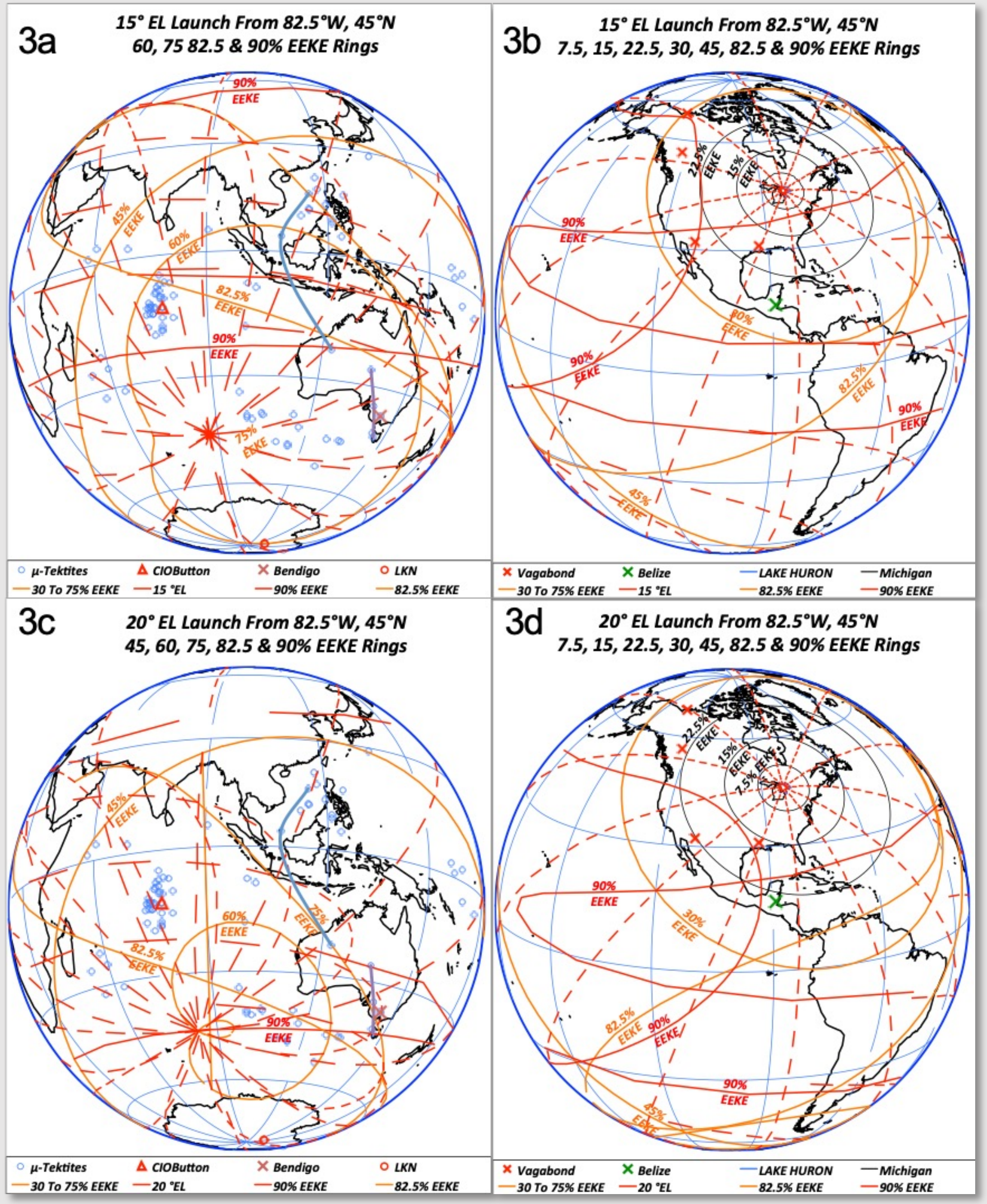
MPT Impact

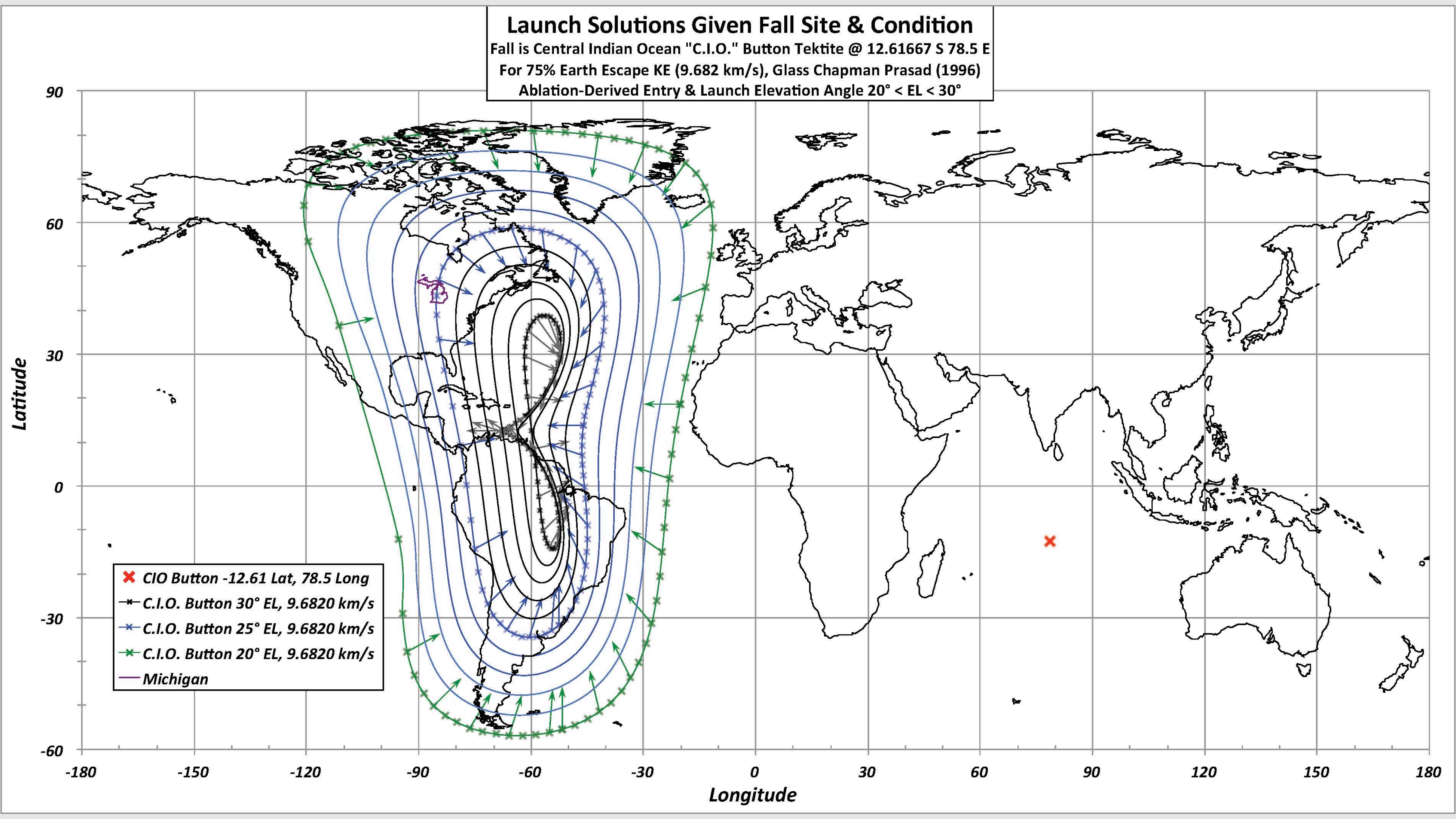
Must account for Earth's rotation, a critically important step for the very high-speed Australasian tektites and their associated long loft duration



Distal Ejecta – Tektites Trajectories From Saginaw

- Tektites launched at high EEKE from Saginaw will focus on Indian Ocean antipode
- Many viable velocities and azimuths to reach Australia




Launch Solutions Given Fall Site & Condition
Fall is Central Indian Ocean "C.I.O." Button Tektite @ 12.61667 S 78.5 E
For 75% Earth Escape KE (9.682 km/s), Glass Chapman Prasad (1996)
Ablation-Derived Entry & Launch Elevation Angle 20° < EL < 30°
Latitude
Longitude
90
60
30
0
-30
-60
-180
-150
-120
-90
-60
-30
0
30
60
90
120
150
180
CIO Button -12.61 Lat, 78.5 Long
C.I.O. Button 30° EL, 9.6820 km/s
C.I.O. Button 25° EL, 9.6820 km/s
C.I.O. Button 20° EL, 9.6820 km/s
Michigan

Closing Incomprehensible Thought

“The possibility of detachment at multilayered ice-water-rock interfaces during a low angle bolide impact highlight many of the problems encountered between laboratory experiment capability and modelling of impacts in planetary research…”

Shared Set of Spatial Relationships Observed Between Tektite Strewn Fields and Their Correlated Astroblemes;
Reliable Modus Operandi or Purely Coincidental?

Tektites are generally accepted as glassy distal ejecta comprised of fully melted terrestrial sediments high in silicon dioxide. These highly homogenous objects weight up to 15 Kg or more, suggesting they remained molten in a low dynamic pressure environment long enough to begin to solidify prior to encountering turbulent atmospheric interactions, which would otherwise shred the molten blob into fine particles. Of the over 200 astroblemes currently identified and accepted, only a handful have been convincingly corelated with having generated tektites. In four cases, empirical evidence suggests the associated tektite strewn fields are relatively small regions found a minimum of 250 km from the impact site. Additionally, the spatial relationship between astrobleme and strewn field evidences the distribution was highly asymmetric, suggesting jetting downrange from an oblique impact event. No tektite has been recovered at a proximal or medial distance from its associated crater when applying the commonly accepted crater radii counts. Given the great age of these 4 events (~1my, ~15My, ~35My and ~66My) it has been proposed that the spatial distribution record is only an artifact of the serendipity of tektite survival and discovery. Such a declaration has relevance when applying the empirical evidence from similar incidents to the protracted search for the missing astrobleme for the vast Australasian tektite strewn field (15%-30% of Earth). Being the most recent impact event on our planet to generate tektites (~778 ka), many workers dismiss the relevance of previous event's distribution patterns and instead propose a priori an impact within the strewn field, implying a 360º distribution at proximal distances. We discuss the constraints on an alternative a priori location when empirically derived spatial relationships are applied to the implied scale of the Australasian event.