

Preventing and correcting spread of misinformation about near-Earth objects, impacts, airbursts, and planetary defense: Case studies

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Abstract—The landscape of scientific publishing and communication is changing rapidly with the accelerating growth of open-access outlets that lack rigorous peer review, revenue-driven online media, inadequately trained journalists, social media, online influencers, podcasts, celebrity endorsements of pseudoscience, anti-science political movements, and the emergence of artificial intelligence. Near-Earth objects, impacts, and airbursts—particularly when related to global catastrophes or planetary defense—often attract intense public interest and the kind of media coverage that is prone to the spread of misinformation. The field of planetary defense has profound consequences, so maintaining public trust is essential to its success. Scientists cannot afford to ignore these challenges merely because they fall outside the scope of conventional scientific discourse. This paper classifies several types of misinformation, presents representative case studies in planetary defense and planetary science, and offers practical approaches for mitigation. We consider (1) rapidly evolving news events requiring timely expert response; (2) intermediate-term cases involving inadequately reviewed publications, overpromotion, and uncritical reporting; and (3) long-term, persistent, and self-perpetuating myths that can grow organically and insidiously, even within the scientific community. We also discuss how misinformation can originate and proliferate through inadequate peer review, news releases and press conferences, exploitation of limited scientific literacy, unsubstantiated claims, and amplification of false narratives by artificial intelligence. Finally, we suggest proactive strategies for preventing and correcting misinformation, with particular attention to its implications for planetary defense.

INTRODUCTION

One implicit assumption in developing planetary defense tabletop exercises that are used as practice sessions for experts and decision-makers is that, in the real world, the participants will be competent and acting in good faith. Recent history suggests that this may not always be the case.

Personal and ad hominem attacks on mainstream scientists and science journalists in the context of near-Earth objects (NEOs), impacts, airbursts, and planetary defense are already occurring on social media, podcasts, and blogs such as the “Cosmic Tusk.” Much of this animosity stems from advocates of the Younger Dryas impact hypothesis (YDIH) which postulates that a swarm of comet fragments triggered a catastrophe 12,900 years ago, and “airburst archeology” which claims that cosmic airbursts destroyed ancient settlements. According to St. George (2024), mainstream and academic scientists have been accused of forming a “scientific cabal” suffering from “groupthink” and suppressing evidence for the YDIH, refusing to talk about it because they are “becoming very wealthy.” One YDIH coauthor wrote that “the failure to properly report evidence for the Younger Dryas Impact will one day be understood as the worst intellectual crime in the history of science journalism” (ibid).

The YDIH and the unconventional and often adversarial methods of its supporters provide a cautionary case for what might occur in an actual impact crisis. While current stakes remain low in the absence of an imminent threat, the planetary defense community exists precisely to prepare for a confirmed impactor. Logically, part of our preparation should anticipate bad actors, propaganda campaigns, denial, and disinformation. Real impact scenarios and proposed mitigation efforts will likely involve winners and losers, with enormous potential consequences in terms of casualties, economic loss, and geopolitics, and will not be evenly distributed. These inherently political stakes of a possible planetary defense response are further complicated when scientific understandings are politicized with bad faith disinformation or inadvertent misinformation.

Our civilization now faces unique challenges in the information age. For most of history, communication was slow, costly, and filtered through layers of expertise that naturally moderated the spread of misinformation. That filter has disappeared. Information can now circulate instantly, cheaply, and without quality control.

Misinformation related to planetary science is already widespread, often fueled by profit-driven “clickbait” media indifferent to accuracy. Stories can originate from researchers at the fringe of science, motivated more by desire for visibility—news stories,

media sharing scores, and citation counts—than by accuracy. Such stories are often illustrated by eye-catching images that have little or nothing to do with the subject (Figure 1). In a real impact emergency, this background noise will probably intensify, potentially drowning out factual information from subject matter experts (specialists in a relevant field). Scientists should not expect immunity from personal attacks or defamation, as seen in other high-stakes fields such as climate science and public health (Mann & Hotez, 2025; Oreskes & Conway, 2010).

The present paper presents case studies of misinformation related to asteroids, comets, impacts, airbursts, and planetary defense. We analyze the origins and dissemination pathways, provide context, suggest methods to limit propagation and negative effects, and advocate institutional support for mitigation. For discussion purposes, we classify misinformation into three categories.

Short-Term Misinformation

Short-term misinformation often arises from rapidly developing events first reported on social media or unreliable sources that resemble legitimate news outlets but do not make use of standard journalistic practices such as fact checking. For example, early Russian media reports about the 2013 Chelyabinsk event included unfounded claims of a UFO, unconfirmed reports of an air-defense intercept, a fighter jet crash or missile explosion, and a speculative link to asteroid 2012 DA₁₄. Such misinformation has a typical life span of hours to days and follows the news cycle. It can be mitigated by networks of specialists that coordinate early, share accurate information, and prepare for media inquiries.

Intermediate-Term Misinformation

Intermediate-term misinformation often originates from inadequately reviewed papers amplified by press conferences and news releases. Examples include the retracted YDIH papers (The PLOS One Editors, 2026a, 2026b) and “airburst archeology” papers arguing that ancient human settlements were destroyed by cosmic airbursts (Bunch et al., 2025; Kincaid, 2025; Tankersley et al., 2023). Although inadequate peer review is common in predatory journals, even established publications such as the *Proceedings of the National Academy of Sciences* (PNAS) and *Scientific Reports* have published flawed papers due to procedural lapses. Holliday et al. (2023) noted that early PNAS YDIH papers relied on “pal review,” in which a sympathetic prearranged editor facilitated publication. Such misinformation can be



FIGURE 1. The use of an incorrect image is an example of long-term and enduring misinformation about Tunguska. Left: Tunguska epicenter in June 2008 (photo by Mark Boslough). Right: Image of ~250-m diameter clearing about 25 km northwest of the Tunguska epicenter (Tunguska Scientific Center, 2025), which includes information provided by Vitaly Romeyko (photo by Dmitry Efanov from the Romeyko & Co. expedition of July 2004). This image has been frequently used to illustrate online articles about Tunguska with the misleading implication that the quasi-circular clearing was caused by the event, which was actually an atmospheric explosion with no surface impact feature (Tunguska Scientific Center, 2025).

countered by specialists who publish critical analyses and comments (e.g., Boslough & Bruno, 2025; Jaret & Harris, 2022; Neuhäuser & Neuhäuser, 2022; Nolan et al., 2023), contribute to popular science and skeptical publications such as *Scientific American* and *Skeptical Inquirer* (e.g., Boslough, 2025a, 2025b; Chapman et al., 2025), engage in post-publication review (e.g., PubPeer, see table 2 in Holliday et al., 2024), and request retractions of papers when conclusions lack verified support (Kincaid, 2025).

Long-Term Misinformation

Long-term misinformation includes claims for which sources are difficult to trace and/or correct but that have become “factoids” through repetition. Such falsehoods are often relatively innocuous but can still distort scientific findings and undermine the credibility of the scientific community if unthinkingly repeated and allowed to creep into peer-reviewed papers and official institutional statements. These enduring factoids are difficult to neutralize because they are culturally embedded and require historical research to determine their source. Nevertheless, we believe that it is important to document such cases as myths so that scholars will not continue to repeat them. Some of these myths, such as the number of trees blown over at Tunguska and the location of impact if the timing had been different, have persisted for nearly a century (discussed in “Case Studies: Long-Term, Enduring, and Self-Perpetuating Cases” section).

WHY IT MATTERS

For more than a decade, the planetary defense community has conducted tabletop exercises to prepare

for the discovery of a dangerous NEO requiring a coordinated response. The most probable real-world scenario is another large airburst similar to the 2013 Chelyabinsk or 1908 Tunguska events because of the approximate power law size-frequency distribution. The close approach and (now eliminated) potential lunar impact of Tunguska-scale asteroid 2024 YR₄ in 2032 underscores the continuing airburst risk (Wiegert et al., 2025).

In 2014, the US Federal Emergency Management Agency (FEMA), in collaboration with the National Aeronautics and Space Administration (NASA) and National Nuclear Security Administration (NNSA) laboratory scientists, conducted an exercise to practice the response to such an event. To enhance realism, participants received an advance notification and information package, stating:

The Federal Emergency Management Agency has activated the National Response Coordination Center to prepare for an imminent and certain large scale catastrophic event which will affect Texas, neighboring states, and possibly nations bordering the Gulf of Mexico. The catastrophic event will occur at approximately noon local time on September 5, 2021 and will be caused by impact of an asteroid estimated to be about 50 meters (~160 ft.) in size. Details of what is currently known about the threat and of our past efforts to deflect the object are included in this package. This disaster will be unprecedented in recorded times and will seriously affect our nation’s oil refining and other major industries, as well as the lives and property of many of our citizens. The President has directed FEMA <Federal Emergency Management Agency> to lead the response effort and be prepared to execute with state

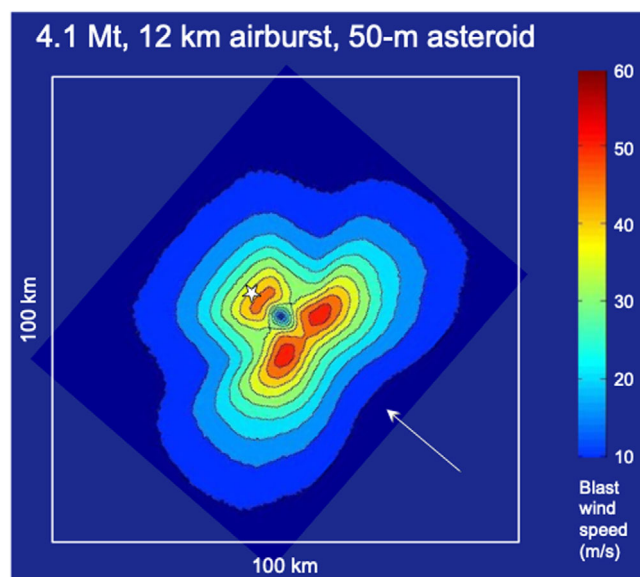


FIGURE 2. Damage map used for an emergency management tabletop exercise involving a Tunguska-sized airburst (4.1 megatons), with a similar damage footprint (modified from Boslough, 2015). The star denotes the location of impact in the absence of an atmosphere, in Pasadena, Texas.

and local officials plans to minimize/mitigate these effects. (Boslough, Jennings, et al., 2015, p. 1, para. 4).

Airburst modelers and infrastructure specialists provided damage maps (Figure 2) for various scenarios, with uncertainty quantification (Boslough, 2015; Boslough, Jennings et al., 2015; Silber et al., 2018). FEMA and other emergency managers used these maps to plan evacuation, reduce infrastructure and economic disruptions, and guide recovery. They were based on high-resolution hydrocode simulations using massively parallel computers and that were validated against experiments and tests and real-world damage data from Tunguska and Chelyabinsk. More recently, the planetary defense community has discovered that impacts and airbursts can generate global tsunamis due to atmospheric Lamb wave coupling, even for impacts on land, now validated with observations of the tsunami generated by the 2022 explosive eruption of Hunga Tonga-Hunga Ha'apai (Boslough & Titov, 2024).

Lives and livelihoods depend not only on accurate modeling, but on public trust in the results. Misunderstandings and misinformation about impact and airburst events can undermine confidence in scientific assessments and emergency response, increasing societal vulnerability. Our preparation and evacuation plans for impacts, airbursts, and the resulting blast and tsunami damage depend critically on our ability to model these events, which depends on our understanding of the

governing physics, which in turn is validated by sparse data on real events such as Tunguska. If people do not have confidence in the models on which evacuation plans are based, they could lose their lives.

TYPES OF MISINFORMATION

We present several case studies to illustrate the wide variation in the origin, motivation, propagation, duration, and potential harm of misinformation. These attributes form a continuum rather than distinct categories. Misinformation can arise unintentionally (from misunderstanding, misinterpretation, ignorance, exaggeration, or even typographical errors), or intentionally (for pranks, attention, profit, or malicious purposes). The latter is often termed *disinformation*. Many real-world cases fall between these extremes, reflecting collective human behavior in which some actors are sincere while others are not.

At the benign end of the spectrum are enduring myths, such as the claims that the Tunguska explosion felled 80 million trees and that it would have destroyed St. Petersburg if it had arrived a few hours later. These seemingly harmless statements (both wrong) illustrate the ease with which misinformation can originate, spread, and resist correction. Yet they have also appeared in peer-reviewed publications and popular accounts lacking evidential basis (including Andrews, 2025; Moskvitch, 2013; Suhir, 2023) and even an official NASA web page (Uri, 2023).¹ We are not aware of any publication that has correctly cited the original source of the “80 million trees” estimate (Astapovich, 1933) before Boslough and Bruno (2025). It might seem that identifying and correcting such trivial falsehoods is little more than a pedantic exercise, but they can also be treated as inert tracers of how misinformation is created and propagated when there is no obvious motivation to misinform on the part of those who repeat them. They can also be used to test the efficacy of our mitigation efforts by tracking their frequency of occurrence after efforts are made to arrest their growth in the absence of a coordinated disinformation campaign to maintain them. They also illustrate the importance of practicing information hygiene, such as tracing claims back to their primary source.

More consequential examples involve misunderstandings of orbital mechanics and airburst physics used to support claims that comet explosions destroyed settlements in the Middle East (Boslough & Bruno, 2025; Jaret & Harris, 2022) and North America (Neuhäuser & Neuhäuser, 2022; Nolan et al., 2023), or triggered the Younger Dryas climate shift (Holliday et al., 2023).

Other misinformation has stemmed from speculative interpretations of interstellar objects. Physicist Avi Loeb proposed that interstellar object 1I/Oumuamua might be an artificial object, and misidentified materials allegedly

linked to an interstellar bolide (Desch & Jackson, 2023). More recently, a team including Loeb posted a preprint suggesting that interstellar object 3I/Atlas could represent alien technology (Hibberd et al., 2025). Loeb also suggested on the Joe Rogan Experience podcast (Rogan, 2025) that planetary defense should address the possibility of aliens, not just rocks. He noted that NASA had not yet released HiRISE images of 3I/Atlas but did accept the official HiRISE team's explanation—that communications were suspended due to a government shutdown. However, he quoted an unfounded speculation that “NASA holds some really sensational data.” The podcast immediately fueled public confusion, politicization, and conspiracy theories.

Historically, the most lethal misinformation in this domain was the claim, promoted by radio talk show host Art Bell, that Comet Hale-Bopp was accompanied by an alien spacecraft. This rumor precipitated the ritual mass suicide of 39 members of Heaven's Gate, a religious group described as a “doomsday cult with a predilection for conspiracy theory” (Robinson, 1997), and whose members believed the UFO would carry their souls to a “Level Above Human” (Washington Post, 1997). Comet co-discoverer Alan Hale, who had warned of such a risk,² attributed the tragedy to a “combination of scientific illiteracy, willful delusions, [and] a radio talk show's deceptions about an imaginary spaceship supposedly accompanying the comet.” (Frazier, 1998). This event exemplifies the power of misinformation among audiences predisposed to distrust science and embrace alternative, unscientific, or paranormal beliefs. Indeed, misinformation related to NEOs has, to date, caused far more human fatalities than actual NEO impacts.

The persistence of misinformation spans time scales from hours to centuries. Effective countermeasures must operate on comparable time scales. The 2013 Chelyabinsk airburst demonstrated the need for rapid expert communication, as early false reports quickly filled the information vacuum. Misinformation associated with Comet Hale-Bopp emerged more slowly, on the time scale of months, and took hold despite the efforts of scientists to provide accurate information. The Tunguska event, after more than a century, continues to generate myths accepted as fact. These and other cases underscore the enduring nature and evolving mechanisms of misinformation in planetary science and are highlighted in this paper.

The rapid growth and availability of large language models and artificial intelligence (AI) have exacerbated the misinformation problem and accelerated the time scales. These tools are not always trained on authoritative information; they are amplifiers, not sources. They can replicate and distribute misinformation far beyond its origin, can be manipulated, can boost conspiracy

theories, and cannot be used reliably for fact checking. Finally, there has been a proliferation of low quality and/or predatory journals that are often used to put a gloss of legitimacy on misinformation that is, in turn, reinforced by online sources including AI.

CASE STUDIES: SHORT-TERM AND RAPIDLY DEVELOPING CASES

Rapidly evolving misinformation requires an equally rapid response. Events in 2013 and 2014 demonstrated the need for a coordinated group of scientists who are specialists capable of providing accurate information within the same news cycle, often before institutional statements can be prepared and approved. Some selected case studies include the Chelyabinsk event, the 2000 EM₂₆ “near miss,” the CNN asteroid impact hoax, the unofficial renaming of insignificant asteroids, and the Nicaragua “impact crater,” as discussed below.

Chelyabinsk Event and 2012 DA₁₄

Media interviews and press conferences were scheduled for the morning of February 15, 2013, for asteroid and planetary defense experts to provide information about the close passage of asteroid 2012 DA₁₄ (later designated “367943 Duende”), which was expected to pass within 4.3 Earth radii later that day and had become a major news story. Unexpectedly, at about 9:20 a.m. local time in Chelyabinsk, Russia (03:20 UTC), the brightest bolide in the history of recorded observations appeared. This was 10:20 p.m. EST and 4:20 CET, the time zones of Washington, DC, and Vienna, respectively, where most of the top planetary defense experts and decision makers were living or visiting.

Initial reports reaching Western media were dominated by speculation. At 04:38 UTC, the Russian news service RT published “Meteorite crash in Russia: UFO fears spark panic in the Urals,” repeating unverified claims that the meteor had been intercepted by air defenses or was related to the upcoming DA₁₄ flyby. The article's concluding statement, “It is believed that the incident may be connected to asteroid 2012 DA₁₄,” rapidly spread through social media. Although the RT article was later revised—using the same URL—to remove the speculative content, the original version persisted through reposts and cached links.³

Coauthor Mark Boslough (MB) was among the first Western scientists to see these reports. Within 90 min of the object's atmospheric entry, he identified and circulated early online sources to planetary defense colleagues. After conferring with coauthor Paul Chodas (PC), they determined from trajectory data that the

bolide entered from the direction of the Sun and therefore could not be associated with 2012 DA₁₄. At 08:00 UTC, PC concluded definitively that “this fireball cannot be associated with DA₁₄ at all,” a statement distributed to other experts for consistent communication with the media.

This experience underscored the need for a distributed communication network among planetary defense professionals across time zones, enabling prompt internal verification before speculation becomes entrenched in public discourse.

Media-Stoked Sensationalism and Misinformation in 2014

Several incidents in 2014 further demonstrated the importance of rapid, coordinated communication among experts. Media organizations increasingly recognized that stories about asteroids and “near misses” generated substantial online traffic, encouraging exaggerated or misleading coverage.

2000 EM₂₆ “Near Miss”

On February 17, 2014, to mark the first anniversary of Chelyabinsk, a commercial telescope streaming service called Slooh promoted a live stream of the supposed “near miss” of asteroid 2000 EM₂₆. Despite its limited significance, the event was widely publicized. MB participated in the broadcast,⁴ which attracted more than 1 million viewers but failed to detect the asteroid. Science reporter Joel Achenbach had just written a story in the Washington Post in which he stated, “The clicks don’t count if the story is wrong. . . the ultimate virtue in this business is getting it right.” (Achenbach, 2014a). Coauthor Alan Harris (AW) looped Achenbach into an email conversation including coauthors MB and David Morrison (DM) and brought up the 2000 EM₂₆ affair and the consistently bad reporting that accompanied it. Achenbach’s subsequent article on 2000 EM₂₆ titled “Asteroid did not nearly hit Earth, actually,” (Achenbach, 2014b) contrasted the earlier sensational coverage and emphasized that accuracy must take precedence over online engagement. This case highlighted the value of scientists working directly with journalists to ensure factual reporting.

CNN iReport Impact Hoax

On May 26, 2014, a post on CNN iReport—a platform for unvetted user submissions displayed under the CNN logo—claimed that a “giant asteroid” had a “1-in-2.04” chance of striking Earth in 2041. The story was viewed nearly 300,000 times before CNN removed it more than 24 h later, following notification from astronomer and science communicator Phil Plait.⁵ This

incident illustrated the risks posed by branded but unverified citizen journalism platforms and underscored the importance of scientists who monitor and respond through blogs and social media.

“The Beast”: 2014 HQ₁₂₄

On June 8, 2014, following the success of the EM₂₆ stream, Slooh hosted another live event for asteroid 2014 HQ₁₂₄, which promoters nicknamed “The Beast.” While the asteroid’s approach offered a valuable radar imaging opportunity at Goldstone and Arecibo radar astronomy facilities, most coverage focused on sensational headlines. The official Arecibo Radar Twitter account responded: “For the record, we do not use nicknames to refer to asteroids. Anthropomorphizing nature is confusing and misleading.” (@AreciboRadar, June 3, 2014). This case demonstrated the benefit of institutional social media channels in providing immediate, authoritative clarification.

Nicaragua “Impact Crater”

On September 8, 2014, an Associated Press article in the Guardian reported that a meteorite had “caused a mysterious boom in Nicaragua” (Associated Press, 2014), and BBC quoted an astronomer’s speculative remark that “a bit must have dropped off” asteroid 2014 RC (BBC News, 2014). Members of the planetary science community quickly refuted this claim, and later that day NASA released a statement titled “Did a Meteorite Cause a Crater in Nicaragua?” (NASA, 2014), noting that while a meteoritic origin could not be ruled out, the evidence favored another explanation. Subsequent news stories were consistent with this position. This example illustrates the importance of rapid response to questionable news stories. Further, it underscores the importance of caution when scientists comment outside their expertise and of maintaining communication with colleagues who can provide informed cross-disciplinary input.

Lessons and Continuing Challenges

Collectively, these events from 2013 to 2014 highlighted the necessity of rapid, well-informed internal communication among planetary defense experts to counter misinformation as it emerges. Over the past decade, news cycles have shortened, professional science journalism resources have declined, and incentives for sensationalism have intensified. In response, NASA has improved its communication protocols by developing preapproved public information templates that can be quickly customized and released during fast-breaking events such as the tracking of asteroid 2024 YR₄. These measures are aimed at accelerating accurate information

flow and preserving public trust during events of genuine concern to planetary defense.

Nevertheless, the changing information landscape that includes artificial intelligence as a misinformation accelerant and swarms of social media bots that are misinformation replicators creates challenges to the scientific community that did not exist in 2014, when we were able to contain misinformation before it could overwhelm us. The tragedy caused by misinformation about Hale-Bopp in 1997 was limited to a small group that was vulnerable to its influence, but modern-day misinformation about 3I/ATLAS quickly overwhelmed the news feeds that are now accessible to everyone and was far more difficult to counter.

CASE STUDIES: INTERMEDIATE-TERM AND PEER-REVIEWED CASES

Younger Dryas Impact Hypothesis (YDIH)

One of the most widely publicized claims related to planetary defense in recent decades is the YDIH, a controversial hypothesis that a comet impact or airburst caused megafauna extinctions, Paleoindian population decline, and the abrupt climate reversal known as the Younger Dryas following the last glacial episode. If the YDIH were true, it would overturn the current understanding by the planetary defense community of impact risk assessment, including the physics of airbursts, crater formation, and NEO populations. However, most of the assumptions and interpretations advanced by the proponents of the YDIH reflect a fundamental misunderstanding—or outright rejection—of the well-established principles of shock physics, impact diagnostics and signatures of shocked materials, and orbital mechanics, as well as of the scientific method and burden of evidence.

The most comprehensive recent review of the YDIH, by Holliday et al. (2023), concluded that “evidence and arguments purported to support the YDIH involve flawed methodologies, inappropriate assumptions, questionable conclusions, misstatements of fact, misleading information, unsupported claims, irreproducible observations, logical fallacies, and selected omission of contrary information.” (Holliday et al., 2023, p. 1, para. 1). That review, however, did not address the implications of such claims for planetary defense. Although the YDIH has been embraced by conspiracy theorists and those who oppose mainstream science, it is rejected by the overwhelming majority of experts across all relevant disciplines, including planetary science, archeology, paleoclimatology, paleontology, paleoecology, geochemistry, mineralogy, and geology.

The YDIH is not a single coherent hypothesis but a collection of mutually incompatible versions sharing

overlapping narratives that have evolved over time (see Holliday et al., 2023, and Daulton et al., 2017, for the history of the YDIH). The version that first gained broad attention was published in *PNAS* (Firestone et al., 2007) and misapplied the physics that governs atmospheric explosions to argue that an airburst could have devastated North America. Citing Toon et al. (1997), the authors claimed that “if airbursts explode with energy of 10^7 megatons at optimum height, they will cause blast damage over an area the size of North America that is equivalent to a ground impact of 10^9 megatons.” (Firestone et al., 2007, p. 15020, para. 9). This misunderstanding of airburst physics has been addressed:

Optimum height of burst is a concept from the nuclear weapons effects literature. It is the prescribed altitude for a point-source explosion to maximize surface damage. According to Glasstone and Dolan [1977], it is “that at which it is estimated a weapon of a specified energy yield will produce a certain desired effect over the maximum possible area.” For the YD impact hypothesis, the “desired effect” is damage due to blast waves. . .

When the optimum altitude for creating blast waves (which neglects the Earth’s curvature) is extrapolated, a 10^7 Mt explosion must be detonated at 500 km to generate continental-wide effects [Glasstone & Dolan, 1977]. Whereas nuclear weapons can be set off at any altitude, there is no physical mechanism that can cause a comet to explode in outer space (e.g., 500 km). Such an explosion would require the conversion of significant kinetic energy to internal energy for heating and vaporizing the comet. This would necessitate momentum loss through drag on the cometary mass. In the absence of air, there is no mass to which momentum can be transferred, and such an explosion would violate the laws of physics. Therefore, one cannot use the optimum height concept to constrain the mass (and explosive equivalence) of large comets. (Boslough et al., 2012, p. 16, para. 4 & 6).

David Morrison and Kevin Zahnle (who were coauthors of Toon et al., 1997) have rejected the extrapolation by Firestone et al. (2007). Zahnle (pers. comm. to MB and DM) noted, “it is nonsense to think of an airburst occurring in a near vacuum above 500 km altitude. . . how is one to imagine an impacting body—say 200 m diameter, which maps to 100 Mton—being aerobraked at 100 km or whatever it would be?” Nevertheless, the misinterpretation by Firestone et al. (2007) continues to circulate as an explanation for continent-wide destruction nearly two decades later, aided by the now-defunct *PNAS* “pal review” mechanism that allowed publication without adequate external peer scrutiny.

YDIH proponents have misunderstood or redefined some common terms such as *base surge* and *strewn field*, and have also introduced ambiguous or nonstandard terminology terms, such as *melglass*, *scoria-like objects (SLOs)*, *lonsdaleite-like grains*, *diamonoids*, *impact-related proxies*, *YDB (Younger Dryas boundary) proxies*, *carbon spherules*, *carbon elongates*, and *shock-fractured quartz*—in contrast to the kind of detailed technical definitions that have been applied by mainstream impact scientists to rigorously defined terminology long used in impact science (e.g., *diaplectic glass*, *maskelynite*, *tektites*, *lechatelierite*, *coesite*, *stishovite*, *impact diagnostics*, *shocked quartz*, *lonsdaleite*). Many of these nonstandard terms first appeared in a series of seven *PNAS* papers (2007–2013) published under the former “contributed submission” system, bypassing conventional peer review (see “[Ersatz and Inadequate Peer Review](#)” section). At least one of these nonstandard terms (diamonoid) appears to be the result of a typographical error for “diamondoid,” and the term was incorrectly described, generating misinformation that was missed during peer review of the now-retracted paper about a claimed airburst in Jordan (Bunch et al., 2025).

These conceptual errors and poorly defined evidentiary standards have inspired a number of derivative hypotheses proposing catastrophic destruction of ancient human settlements by airbursts. Two of the resulting papers have been formally retracted (Bunch et al., 2025; Tankersley et al., 2023), but the misinformation introduced by them continues to circulate.

“Airburst Archeology”: Destruction of Ancient Human Settlements

Building on the flawed framework of Firestone et al. (2007), Moore and Kennett (2013) interpreted materials from the prehistoric village of Abu Hureyra, Syria, as evidence for airburst destruction. The site, which was excavated in the 1970s and is now submerged beneath a reservoir on the Euphrates River, was claimed to have been destroyed by “a large comet or asteroid up to several kilometers in size fragmenting in the Earth’s atmosphere,” producing “multiple airbursts and small direct impacts.” (Moore & Kennett, 2013, p. 58, para. 4). This was the first of a series of papers that can be described as advocating “airburst archeology.”

The authors further asserted that “the geographic extent of the ejecta is comparable in size to the Australasian [tektite] field that is accepted as resulting from a large, fragmented comet” (Moore & Kennett, 2013, p. 58, para. 4), apparently confusing the *Australasian tektite strewn field*—formed by a single impact in Southeast Asia and associated with widespread,

intercontinental tektite distribution—with a cometary fragmentation event. They described, but did not explain, the orbital mechanics of how this could be associated with the comet explosion over North America postulated by Firestone et al. (2007).

The paper also speculated that the putative comet “passed through the northern hemisphere c. 12,900 cal BP, breaking up and causing a series of airbursts and impacts on the way... one of which destroyed Abu Hureyra” (Moore & Kennett, 2013, p. 60, para. 5). A subsequent paper (Moore et al., 2020) expanded these claims, proposing that “debris clusters” from a fragmented comet could trigger “thousands of airbursts within a span of minutes across one entire hemisphere.” The authors further asserted that such a scenario would be “thousands of times more probable” than a collision with a 10 km asteroid (Moore et al., 2020, p. 19, para. 5).

This proposition conflicts with established orbital dynamics. Small perturbations in the velocity of fragments within heliocentric orbits cause them to disperse much more rapidly along the orbital path than transversely across a hemisphere. The proposed mechanism is therefore physically implausible and inconsistent with known fragmentation behavior (e.g., Jewitt et al., 2016; Sekanina et al., 1998). Moreover, the analogy to the Australasian tektite strewnfield is inapplicable, as that field represents ejecta launched in all directions from a single terrestrial impact site, not from an interplanetary debris stream.

Subsequent publications by YDIH-affiliated authors extended the “airburst archeology” narrative to other archeological sites, including Tall el-Hammam (Jordan) and Hopewell (Ohio). Both those papers were later retracted by *Scientific Reports* (retraction notices: Bunch et al., 2025; Tankersley et al., 2023) because the evidence did not support the conclusions (Boslough & Bruno, 2025; Jaret & Harris, 2022; Neuhäuser & Neuhäuser, 2022; Nolan et al., 2023).

Lessons from Intermediate-Term Cases

These intermediate-term, peer-reviewed cases illustrate the persistence of misinformation even within scientific literature and the substantial effort required to correct it. They underscore the importance of ongoing, evidence-based engagement by specialists—through formal publications, post-publication peer review, and public communication—to counteract entrenched but erroneous claims that, if left unaddressed, could distort both scientific understanding and public perception of planetary impact risks. Misinformation associated with fringe theories like the YDIH and airburst archeology is analogous to that connected to cold fusion and climate change denial (Boslough, 2025b). Sustaining such ideas

requires a continuous flow of publications by the advocates that must be countered by replies and rebuttals in the scientific literature. Once the advocates stop publishing and promoting these ideas, as was the case for the “small comets” hypothesis of Frank and Sigwarth (1993), the false claims tend to fade from view and no longer need responses.

CASE STUDIES: LONG-TERM, ENDURING, AND SELF-PERPETUATING CASES

The 1908 Tunguska airburst has contributed greatly to our understanding of impact hazards. It has also spawned more than a century of mystery, myth, and misinformation, some of which has even taken root within the scientific community (Bruno, 2022). Many falsehoods about Tunguska have innocent origins and are simple misunderstandings that have become “factoids” through repetition. Others appear to be manufactured disinformation intended to bolster clickbait, discredit mainstream science, and/or continue to support demonstrably false conjectures. While the Tunguska myths provide well-defined case studies, inadequate peer review with insufficient oversight has also been responsible for the generation and propagation of enduring misinformation. The following are a few examples of incorrect claims, versions of which have become accepted by many scientists and journalists and are often repeated.

The Tunguska Event “Toppled or Snapped >80 Million Trees”

This is a relatively benign myth but serves as an excellent example of how misinformation can be created and propagated even when the vast majority of those who repeat it are acting in good faith but fail to cite primary sources. However, this and other Tunguska myths are not inconsequential because they either exaggerate the magnitude or downplay the effect of slight changes in circumstances. Both the number and size of trees at Tunguska figured into the earliest estimates of the magnitude of the event (Astapovich, 1933) as well as the most recent (Robertson & Mathias, 2019). Overestimates of the number and size of the trees lead to overestimates of the yield and hence impactor size of the event. Counterintuitively, this underestimates the risk because the exaggerated size implies a lower event frequency due to the approximate power-law distribution of NEO size (Boslough, Brown, et al., 2015).

Boslough and Bruno (2025) showed that this myth was boosted by Brazo and Austin (1982), which was not peer-reviewed and is not a reliable source of information about science. It appeared in the journal *Origins*, a publication of the Institute for Creation Research (ICR),

which professes young-Earth creationism. *Origins* masquerades as a scientific journal and publishes papers used to support claims by biblical catastrophists whose aim is to inflate the rate, timing, and magnitude of geological events.

The “>80 million trees” statement is an exaggeration of preexisting misinformation. Brazo and Austin (1982) wrote “[E]ighty million trees in the taiga (coniferous forest) were uprooted and blown down” (Brazo & Austin, 1982, p. 85, para. 3). They cited Whipple (1934) who in fact did not make any claims about 80 million trees. Whipple had quoted a correspondent, S. K. Banerji, who wrote, “The meteorite is said to have destroyed 80 million trees over an area of 8000 sq. km” (Whipple, 1934, p. 512, para. 2), apparently referring without citation to a just-published statement that “The overthrown trees cover an area of 8,000 square kilometers, and number about 80 million” (Crommelin, 1934, p. 243). The primary source was a Russian-language paper by Astapovich (1933). The original purpose was a “back of the envelope” estimate of the explosion’s energy, using rough estimates of the tree fall area to make an educated guess of the number of fallen trees. Astapovich wrote, “Apparently, it can be assumed that the area of the fallen forest occupies about 8000 km²” to reach his estimate, “the work of the windfall of 8×10^7 trees would be 4.4×10^{21} ergs” (Astapovich, 1933, p. 480).⁶

Unfortunately, Crommelin (1934) misrepresented Astapovich’s educated guesses as facts. Brazo and Austin (1982), writing for the Institute for Creation Research journal, exacerbated the myth by misattributing Crommelin’s numbers to Whipple (1934) and by neglecting to determine that the original source was based on a preliminary guess of the area of devastation that turned out to be about four times the actual size. The retracted paper (Bunch et al., 2025) cited Brazo and Austin (1982), but this was not the only source of the claim. We have also identified two peer-reviewed papers prior to 2006 that referred to the 80 million trees estimate, but without citing any source to support the assertion (Foschini, 2001; Taylor, 1969).

A likely nucleation event for the modern “80 million trees” figure dates to 2006, when it was published by a major fact-checked news source (BBC News, 2006) that stated, “in 1908, a massive explosion flattened 80 million trees in Tunguska, Siberia.” The article was about the BBC *Horizon* documentary *Tutankhamun’s Fireball*, made by production company TV6 that was broadcast on BBC Two on July 20, 2006, featuring two authors of this paper (MB and CK). In the program, the narrator, British actor Struan Rodger, stated, “more than 18 million trees had been destroyed.” The US National Geographic broadcast of the same documentary (21

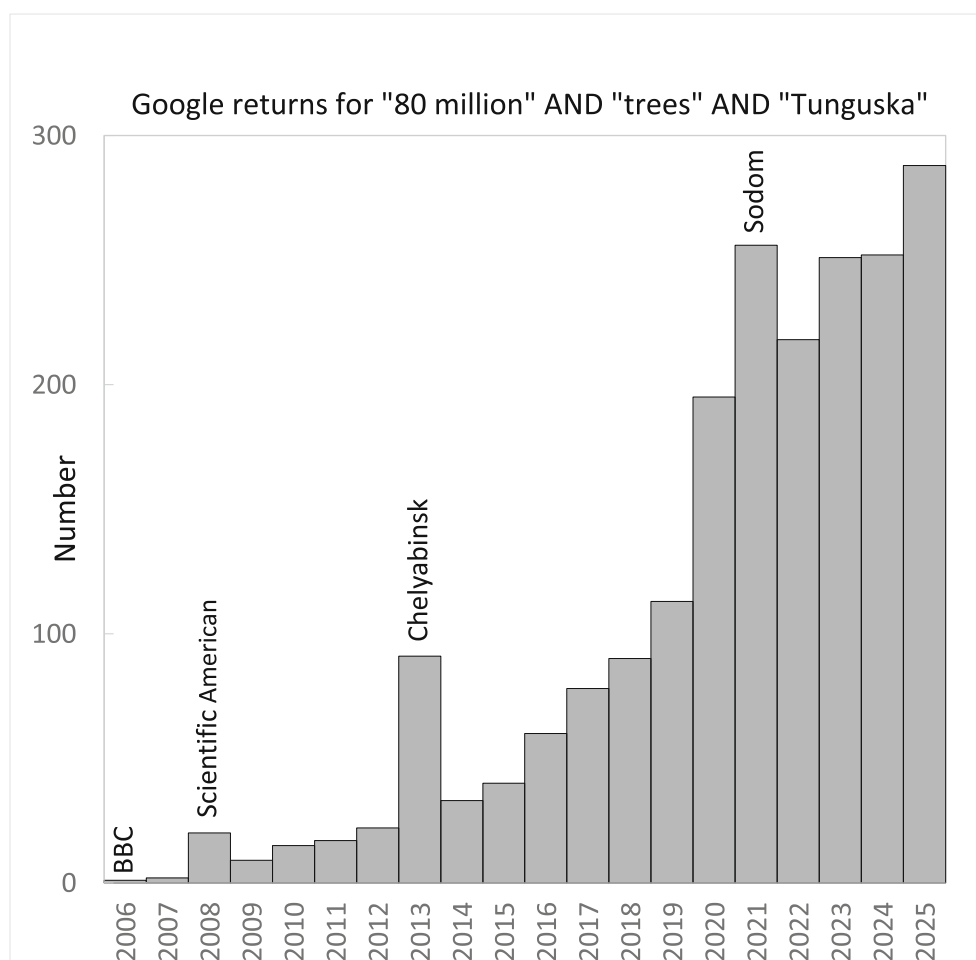


FIGURE 3. Number of documents per period that mention “80 million” AND “trees” AND “Tunguska” in Google search, by year. Prior to 2016, obvious false positives were excluded (an average of <1/year). Labels: BBC = news story (see text); Scientific American = Gasperini et al. (2008); Chelyabinsk = bolide event; Sodom = retracted paper (Bunch et al., 2025).

September 2006) instead stated, “the blast had destroyed more than 80 million trees.”

One of us (MB) contacted James Reed, the executive director of the TV6 production, who confirmed that he personally prepared the fact-checking document for the film, which would have required two sources of verification (Reed email to MB, November 4, 2024). In contrast to the two peer-reviewed sources for the “80 million trees” estimate, we have been unable to find any published source of “18 million trees” prior to 2006. If the narration mistake or typographical error⁷ in the script of the BBC version had propagated into the BBC News story, which appears to have initiated the viral “80 million trees” myth, then this estimate would likely have been “18 million trees.” Ironically, “18 million trees” is probably closer to the correct number, which had been inflated by a factor of about four (Boslough & Bruno, 2025).

Google searches on the number of documents by year that have propagated this erroneous claim (Figure 3) suggest that there was a second viral nucleation point in 2008, and it appears to have been in a *Scientific American* article published on the centennial anniversary of the Tunguska event (Gasperini et al., 2008). A sidebar stated, “The airburst flattened about 80 million trees over 2,000 square kilometers.” In contradiction, a linked slide show states, “Around Tunguska some 60 million trees over an area of 800 square miles (2,070 square kilometers) were scorched and leveled” (Hadhazy, 2008).

All three authors of the *Scientific American* article were also coauthors (with Foschini, the lead author of one of the 2 peer-reviewed papers that had quoted the 80 million trees estimate), and of a 2001 abstract which also made this estimate (Longo et al., 2001). As members of the Bologna group, which had done fieldwork at Tunguska and had extensively documented tree fall data,

they would be considered as authorities, but they never published any basis for this estimate or cited any sources. MB asked the lead author of the Scientific American article, Luca Gasperini, if he knew the source of the estimate, but he replied that he was unable to provide a clear answer (Gasperini email to MB, November 3, 2024).

Paleontologist Stephen Jay Gould described an analysis similar to that of Figure 3 in his essay, *The Case of the Creeping Fox Terrier Clone* (Gould, 1991), concluding:

Such cases provide our best evidence for thoughtless copying. When a truly important and well-known fact graces several texts in the same form, we cannot know whether it has been copied from previous sources or independently extracted from any expert's general knowledge. But when a quirky little senseless item attains the frequency of the proverbial bad penny, copying from text to text is the only reasonable interpretation. There is no other source. (Gould, 1991, p. 20, para. 5).

The Fallen Trees at Tunguska Were Up to 1 m in Diameter

Boslough and Bruno (2025) showed that this is another myth created by Brazo and Austin (1982) and exaggerated by Bunch et al. (2025). This is an example of “creeping exaggeration” by authors who have failed to get the latest information from modern, authoritative sources. The quoted size of the largest trees that were toppled by the Tunguska airburst has increased through progressive upward rounding of unit conversions, embellishments, and selective citation by authors who neglected to read the appropriate primary literature. Tree diameter is an important observation in blast analysis because the critical wind speed necessary to fell a tree is an increasing function of trunk diameter (Robertson & Mathias, 2019). Exaggeration of the tree diameter therefore inflates the inferred wind speed.

The first researcher to reach the Tunguska blast zone was Leonid Kulik who documented his first impressions, writing “десяти-двадцативершковых великанов.” This can be rendered “ten-to-twenty *vershok* giants.” A *vershok* is an obsolete unit of length that was equal to about 4.4 cm in 1927. Kulik's preliminary guess of the diameter of the largest fallen trees ranged from 44 to 88 cm. Subsequent surveys have shown that the largest trees were close to the lower end of Kulik's estimate. Fast et al. (1983) created a table of diameters for the downed trees at Tunguska, in which the largest category corresponded to those that are “over 30 cm” wide. Brazo and Austin (1982) focused only on Kulik's obsolete higher estimate but added another few cm stating, “He

[Kulik] saw an area where trees up to three feet [91.4 cm] in diameter had snapped like toothpicks...” (Brazo & Austin, 1982, p.6, para. 3). The Tall el-Hammam authors padded the upper estimate by several more cm claiming that some trees were “up to 1-m [100 cm]” across. The volume of a tree can be approximately scaled by the cube of its diameter if its growth is nearly homologous and aspect ratios do not change much. The largest tree size, in terms of mass, was therefore inflated by the Tall el-Hammam authors by an order of magnitude, in addition to their exaggeration of the number of trees by a factor of about four.

The Tunguska “Crater”

The Tunguska event was an airburst and there is no known impact crater (Morrison & Robertson, 2019). Nevertheless, online stories on Tunguska often display a photograph of a circular tree clearing, giving the impression that it is an impact crater. Similar images are used (possibly of different features), usually without identifying information. The clearing shown in Figure 1 (right panel) is about 25 km northwest of the Tunguska blast epicenter. It can be seen on satellite images at (61°02'26.2" N 101°31'15.0" E). The circumstances of this photograph were described on a website devoted to the Tunguska event, (Tunguska Scientific Center, 2025), which includes information provided by Vitaly Romeyko who had seen it and photographed it from a distance from a helicopter in the summer of 1994, but was unable to return for better photographs until 2004 (see also Rodimova et al., 2008).

Many such clearings are visible in Google Earth satellite images of the Siberian taiga. For example, a similar clearing, sometimes called “Devil's Cemetery,” is located at (58°13'53.0" N, 100°15'32.4" E), about 300 km south of Tunguska. Searches using the local name “чертово кладбище” often bring up the same Romeyko image, sometimes mirrored. This led us to misidentify it in our 2024 Geological Society of America abstract (Boslough et al., 2024), prior to discovering its true origin. The provenance of the original image (Figure 4) can be confirmed from the Tomsk archive, at Tunguska Scientific Center (2004). The first known publication of this image, but without a caption, was in a book by Romeyko and Chichmar (2004).

By contrast, Lake Cheko, which is much closer to the Tunguska epicenter, was seriously suggested to be an impact crater by Gasperini et al. (2009), but this possibility has been eliminated (Collins et al., 2008; Rogozin et al., 2017; Schmieder et al., 2015). A large hypervelocity impact crater would imply a much lower burst altitude and substantial surviving mass, and it would contradict hydrocode simulations of Tunguska



FIGURE 4. Original uncropped and un-rotated photograph of the Romeyko feature, providing confirmation of its provenance (Tunguska Scientific Center, 2004). This circular clearing, roughly 250 m in diameter and about 25 km from the Tunguska epicenter, has often been shown in stories about the airburst, giving the false impression that it was produced by the Tunguska event, despite the lack of any known impact crater.

that match the observational evidence and are consistent with an airburst in which no solid meteoritic material struck the surface at hypervelocity (Robertson & Mathias, 2019).

If the Tunguska Object Had Arrived Later It Would Have Destroyed St. Petersburg

This is incorrect because it assumes a geocentric orbit in which only Earth's rotation matters. In reality, Earth's motion around the Sun would have caused it to miss our planet by a half million kilometers. The earliest mentioning of this claim we found from citations by recent publications was the 1965 *Guinness Book of World Records*, which stated, "If the event had occurred 4 hours 47 minutes later, it would have wiped out St. Petersburg" (McWhirter & McWhirter, 1965, p. 60, para. 7). Versions of this claim have been widely repeated, including by mainstream and highly regarded scientists such as Bevan French (French, 1998) and John Lewis (Lewis, 1996).

However, we believe we have identified the original source (Astapowitsch, 1934),⁸ which stated:

It is unlikely that our generation may again be witnesses of a similar meteoric phenomenon; if it had occurred 4 hr. 47 m. later, when the city of Leningrad would have lain on the same parallel near the center of the explosion, our knowledge of it would probably have been considerably more extensive; this article would have been published earlier, and less than a quarter of a

century ago another scientist would have been its author. (Astapowitsch, 1934, p. 501, para. 4).

Figure 5 shows possible impact locations for the Tunguska object if it had been on an orbit similar to that of the Beta Taurid meteors, and if it had arrived less than a few minutes late (east of Tunguska) or a few minutes early (west of Tunguska). If it had arrived later, the airburst could have been as far to the east as Alaska, Canada, or the upper Midwest of the United States. We assumed the following impact circumstances for the 1908 Tunguska impact: latitude = 60.917° N; longitude = 101.95° E; azimuth of velocity vector radiant = 103.9° from north (slightly south of east); elevation of velocity vector radiant = 31.5° above horizon; time of impact (assuming 5 km altitude) = June 30, 1908 at 0:14:24 am UTC; impact velocity = 30 km s⁻¹; Epoch: May 11, 1908. We used the following orbital elements, consistent with these impact circumstances and a Beta Taurid-like orbit with a time of perihelion passage, T_p = 1908-May-16.26454 TDB: a = 2.0761 AU, e = 0.81978, i = 5.0846°, ω = 246.123°, and Ω = 279.191° where the parameters are eccentricity (e), inclination (i), perihelion argument (ω), and longitude of the ascending node (Ω).

These long-term cases illustrate the need for both scientists and the public to be skeptical of claims of unknown provenance, even when repeated by experts.

Younger Dryas Boundary Nanodiamonds

Long-term misinformation often arises from inadequate peer review and from reluctance by editors and publishers to correct the scientific record. Such misinformation can seriously distort scientific progress when repeatedly cited as consequential evidence.

One example involves claims of nanodiamonds from the Younger Dryas boundary (YDB) in Greenland (Kurbatov et al., 2010), a paper with indications of inadequate peer review. The samples were collected by researchers in support of a NOVA documentary on the YDIH in 2008 and broadcast in 2009 but later removed from streaming after NOVA WGBH senior management learned of irregularities and contaminated samples, reported by Dalton (2011) (see Holliday et al., 2023). Requests by independent researchers for samples or associated data files, intended to resolve discrepancies in the published work, have been consistently denied since 2010 (documented in table 2 of Holliday et al., 2024). Data files reported by Kurbatov et al. (2010) to have been uploaded to the US National Snow and Ice Data Center (NSIDC) have no such record. Results of a second Greenland expedition conducted by two coauthors of Kurbatov et al. (2010) in 2009 were never reported.



FIGURE 5. Impact corridor for an object in a Beta Taurid-like orbit, with time of impact slightly perturbed from the actual time of impact at Tunguska. Upper panel: Earlier arrivals from the presumed orbit would have been to the west, as far as the Caspian Sea. Lower panel: Later arrivals would have been to the east, as far as Michigan or Ontario (not shown).

Kinzie et al. (2014) reported a nanodiamond-bearing layer of possible impact origin across several continents, including Greenland, and are still cited as evidence supporting the YDIH. Post-publication discussion on PubPeer (DOI: [10.1086/677046](https://doi.org/10.1086/677046)) indicates that substantial methodological and interpretive concerns were raised

during peer review, many of which were not fully resolved prior to publication. Notably, the principal claim expressed in the paper's title—"A nanodiamond-rich layer across three continents"—is not demonstrably supported by the authors' described methodology or data. In the supplemental materials, the authors state:

“...for the purpose of estimating abundances, we assumed that all rounded particles were NDs [nanodiamonds]... This estimation procedure focused solely on the presence or absence of rounded particles” (Kinzie et al., 2014, Appendix A, p. 9). This approach differs fundamentally from the methodology described in the main text, indicating a significant internal inconsistency in how the data were obtained and interpreted. Such discrepancies materially affect the reliability of the reported findings and indicate deficiencies in peer-review effectiveness. The resulting publication presents a misleading account of its evidentiary basis, constituting a form of scientific misinformation arising from inconsistent or incomplete methodological reporting rather than from overt fabrication. This case illustrates how misinformation in the scientific literature can originate through inadequate methodological transparency combined with insufficient editorial and peer-review oversight.

A broader concern is that such cases persist despite publishers' public commitments to ethical best practices. The University of Chicago Press (UCP), publisher of *The Journal of Geology*, states that it supports the principles of the Committee on Publication Ethics (COPE), a commitment explicitly reaffirmed by the Director of the Journals Division. On the basis of that assurance, a formal request was submitted for publisher-level review of the editor's decision to decline retraction of the paper by Kinzie et al. (2014), grounded in COPE's retraction criteria, including methodological misrepresentation, unsupported central claims, and concerns regarding the editorial and peer-review process. The editor's primary rationale for declining action—namely the age of the article and the assertion that the underlying hypothesis remains “controversial, not falsified”—is explicitly rejected by COPE guidance. Nevertheless, the publisher declined to pursue further review (PubPeer DOI: [10.1086/677046](https://doi.org/10.1086/677046)). This outcome highlights how deficiencies in post-publication oversight can allow misinformation to persist in the literature, even when ethical frameworks intended to address such cases are publicly endorsed.

Lessons from Long-Term Cases

The misinformation associated with the numbers and sizes of trees at Tunguska, the false “crater” image, and the “what if” St. Petersburg scenario serve primarily as reminders that longevity and repetition of claims do not make them true, and that all such claims should be questioned and traced to their primary sources that might have been misinterpreted. In other cases, such as the YDB nanodiamond claims, the primary sources have been shown to be deeply flawed but nevertheless remain uncorrected. This problem underscores the need for

journal editors to adhere to COPE guidelines when such problems are brought to their attention.

MISINFORMATION GENERATION AND AMPLIFICATION

Ersatz and Inadequate Peer Review

Proponents of the YDIH frequently describe their papers as “peer-reviewed,” which might convey an impression that the results are broadly accepted and uncontroversial. However, several influential YDIH publications were handled through editorial or submission routes that differ from standard external review. More recently, proponents have established a journal to facilitate publication of their work, and it remains unclear whether these papers undergo legitimate peer review.

Early YDIH papers appeared in *PNAS* under the journal's “contributed” track, in which a National Academy of Sciences member who is an author may select reviewers (Flam, 2013; Jones, 2013). This process has been criticized for permitting greater author influence on reviewer selection and thus potentially reducing reviewer independence. Misunderstandings of impact and airburst physics, misidentification of impact diagnostics, problems with radiocarbon dating, and other methodological errors documented in subsequent critiques (Holliday et al., 2023) suggest that at least some reviewers may have lacked relevant subject-matter expertise. Consequently, many readers may have incorrectly assumed that key YDIH claims were fully vetted by experts in impact processes.

After several years of repeated rejections of papers by legitimate journals, the Comet Research Group (CRG), led by Allen West and others, created its own specialty journal in 2023, *Airbursts and Cratering Impacts (A&CI)*, using the ScienceOpen hosting platform. Like the Institute for Creation Research journal *Origins*, an early source of Tunguska misinformation (Brazo & Austin, 1982), *A&CI* promotes itself as being peer reviewed. However, it does not appear to be indexed by any established indexing service (e.g., Web of Science, Scopus, or Clarivate). The *A&CI* website (<https://www.scienceopen.com/collection/9aae92f3-66ba-4b71-a74b-51b9995c56e5>) states that it was created because “biased reviewers often act as ‘gatekeepers’ to prevent novel discoveries from being published, to the detriment of scientific progress.” Its stated purpose is to provide an alternative to standard peer review to make it easier to publish papers that have been rejected or retracted by conventional journals, are too novel, or contradict mainstream opinions (presumably on criteria that are used to identify impact craters or airburst events, and that

are governed by the known laws of physics). It purports to enable the publication of “paradigm-shifting” and “disruptive” science, according to the *A&CI* website. At least two papers, originally published and later retracted in another journal, whose coauthors are editors of *A&CI* appear to have been modified and republished in *A&CI*. The majority of the editors of this journal are members of the CRG, as are most of the senior and corresponding authors of 22 papers published between the journal’s founding and March 2026. It is unclear whether any of the reviewers have been established experts on airbursts or impact craters. By the standards established by a consensus of experts, *A&CI* is a predatory journal: “Predatory journals and publishers are entities that prioritize self-interest at the expense of scholarship and are characterized by false or misleading information, deviation from best editorial and publication practices, a lack of transparency, and/or the use of aggressive and indiscriminate solicitation practices” (Grudniewicz et al., 2019, p. 211, para. 5).

Science by Press Conference and News Release

The YDIH gained public attention in 2007 when *Nature* published a news story summarizing a press conference at the AGU Joint Assembly in Acapulco (Dalton, 2007). James Kennett, a paleoceanographer at the University of California at Santa Barbara (UCSB) and the only National Academy of Sciences member among the coauthors, was instrumental in enabling the *PNAS* “personal editor” process.

Kennett stated, “The magnitude of this discovery is so important. It explains three of the highest-debated controversies of recent decades” (Dalton, 2007). These were the Younger Dryas cooling, the “disappearance” of Clovis hunters, and the “near-simultaneous” extinction of North American megafauna. These claims created misinformation that persists nearly two decades later. In reality, a comet is not required to explain abrupt climate changes; Clovis hunters adapted their hunting tools rather than disappearing; and megafaunal extinctions did not occur simultaneously (Holliday et al., 2023).

A recording of the American Geophysical Union (AGU) press conference, available on YouTube⁹ shows four panelists who were all coauthors of Firestone et al. (2007), which was in review at that time. Panelist and coauthor Allen West, who reintroduced and updated Donnelly’s (1883) discredited ideas of a comet catastrophe while placing it at the start of the Younger Dryas, had gathered virtually all the evidence supporting it for his New Age book *Cycle of Cosmic Catastrophes* (Firestone et al., 2006). Much of what the panelists stated was inaccurate. Richard Firestone showed a map of their sampling sites, stating that “All of these sites are related

to a particular time frame either by the existence of Clovis material or a black mat.” He further elaborated, “Inside this line between the fossils and the black mat we find a layer that I would call an ejecta layer that is available at all of these sites.” However, 15 of the 26 sites on his map were Carolina Bays in which neither Clovis material nor a black mat was reported and do not date to the Younger Dryas.

Allen West compared the hypothetical YDIH airbursts to those from the 1994 impacts of comet Shoemaker-Levy 9 (SL9) fragments on Jupiter, stating, “If those fragments had hit Earth according to NASA calculations not a one of them would have left a crater. They would have exploded in the atmosphere.” The only calculations of SL9 impacts attributable to NASA were published by Zahnle and Mac Low (1994) and showed that fragments exploded well below the 1-bar level.

West also presented a 2006 National Geographic animation based on the abandoned Boslough and Crawford (1997) model of simultaneous atmospheric airbursts producing Muong-Nong tektites, which might also be the source of the belief by Moore and Kennett (2013) that the Australasian tektite strewnfield was formed by a fragmented comet (see “[Airburst Archeology](#)” section). Due to implausibility, the cluster airburst model was replaced by a Type 2 airburst mechanism by Boslough and Crawford (2008). Nevertheless, the press conference reinforced the erroneous notion that a cluster of airbursts could widely affect multiple continents, a misunderstanding of orbital mechanics and impact risk corridors.

The notion that such a cluster of airbursts can take place over an area spanning two or more continents represents an ongoing misunderstanding by the CRG of how a fragmented asteroid or comet would evolve in its orbit. The planetary defense community has known for decades that perturbations in the orbital elements of an object in a heliocentric orbit, when propagated forward in time, would intersect the Earth in a narrow “risk corridor” that could span a continent in only one direction, as illustrated by Figure 5 for perturbations in the orbit of the Tunguska object.

This misunderstanding is repeatedly reinforced by institutional news releases associated with various YDIH advocates. According to Kennett, “There is no known limit to the YDB strewnfield which currently covers more than 10 percent of the planet, indicating that the YDB event was a major cosmic impact” (Cohen, 2014). This is also a redefinition of the term “strewn field” which conventionally refers to the area covered by fragments of a single meteorite or tektites that are generated by a single impact event. Other instances of misinformation have been published in University of California at Santa

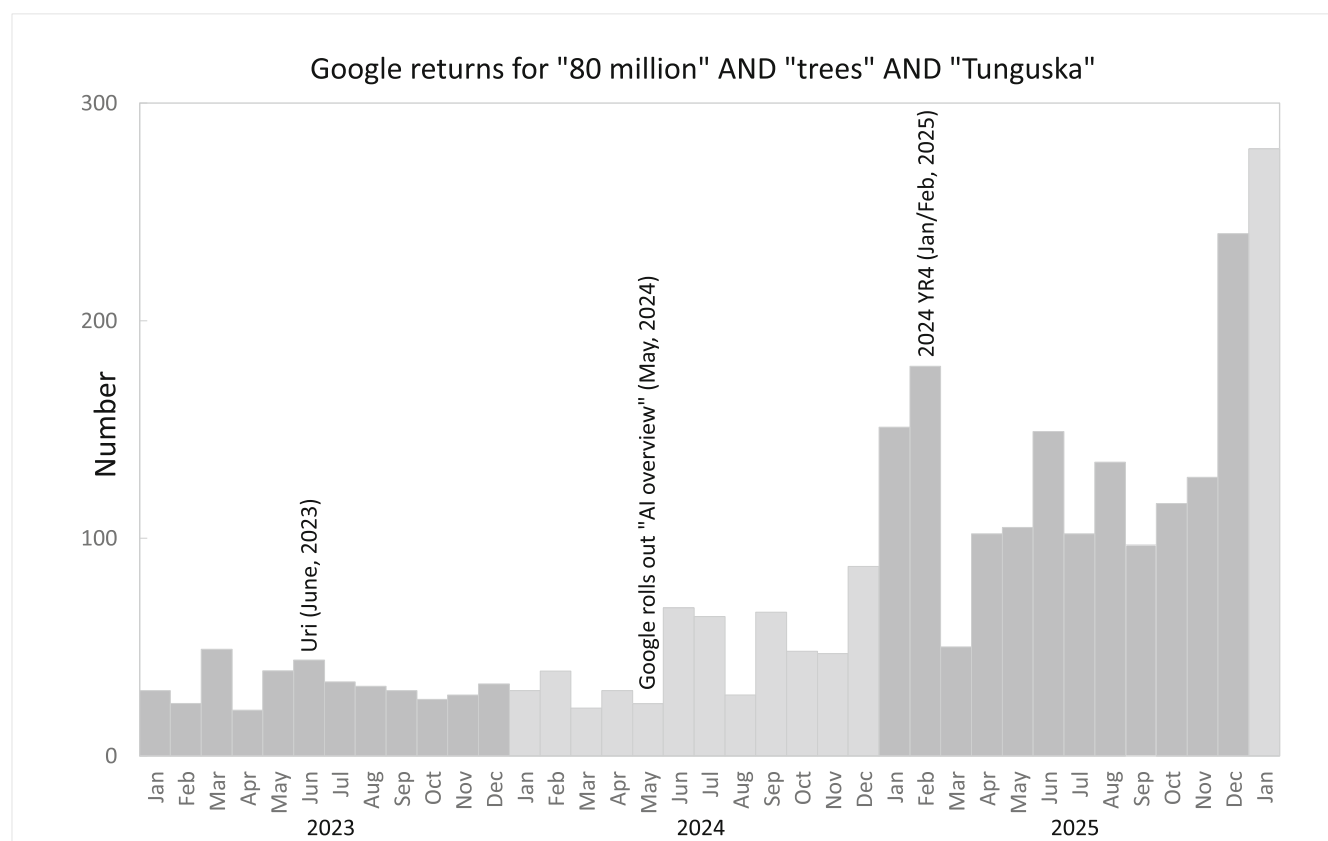


FIGURE 6. Number of documents per period that mention “80 million” AND “trees” AND “Tunguska” in Google search, by month.

Barbara news releases featuring Kennett, at least 20 of which have been posted since 2007 (<https://news.ucsb.edu/people/james-kennett>).

Excessive promotion can exacerbate misinformation, particularly when media platforms cater to audiences receptive to pseudoscience. Historical parallels include Art Bell and the Hale-Bopp/UFO conspiracy in 1997, and recently Joe Rogan amplifying Avi Loeb and the CRG (Rogan, 2025). Public fascination with unusual phenomena, combined with scientific reticence, can create fertile ground for rumor proliferation and conspiracy theories. Responsible scientists must proactively provide accurate information, even in the face of opposition or sensationalized media narratives.

Artificial Intelligence as a Misinformation Multiplier

The “80 million trees” myth was significantly amplified by the retracted paper of Bunch et al. (2025), which achieved a high Altmetric score and over 666,000 downloads shortly after its retraction in 2025. Despite image manipulation and an editorial expression of concern (Kincaid, 2023), NASA cited the study in a story

marking the 115th anniversary of the Tunguska event that June (Uri, 2023), along with the inflated tree fall estimate.

The rollout of Google’s “AI Overview” tool in May 2024 accelerated propagation (Figure 6). By November 2025, a Google search for “How much damage did Tunguska do?” returned the answer, “The 1908 Tunguska event caused catastrophic damage by flattening approximately 830 square miles of forest in Siberia, equivalent to about 80 million trees,” citing the NASA story (Uri, 2023). AI-generated summaries may have created a rapid self-reinforcing misinformation loop: repeated citations from authoritative-seeming sources encourage further repetition by users, journalists, and other scientists, providing AI with additional sources that seem to confirm it.

Gould’s (1991) summary of the article, “The Nine Lives of Discredited Data (Old Textbooks Never Die—They Just Get Paraphrased)” (Paul, 1987), may be particularly relevant to this case:

Paul analyzed the sections on heritability of IQ from twenty-eight textbooks on introductory genetics published between 1978 and 1984. She paid particular



FIGURE 7. Photomicrograph of ~150 fragments of material asserted to be typical Abu Hureyra “meltglass” and glassy microspherules, published as Figure 10a by Moore et al. (2023). These materials were not reported in any of the original excavation reports and were only discovered decades later by the proponents of the YDIH. They have not been made available for analysis by independent researchers despite numerous requests.

attention to their treatment of Sir Cyril Burt’s data on identical twins raised separately. We now know that these “studies” represent one of the most striking cases of fraud in twentieth-century science—for Burt invented both data and co-workers. His sad story had been well publicized, and all authors of texts published since 1978 surely knew that Burt’s data had been discredited and could not be used. Several texts even included discussions of the Burt scandal as a warning about caution and scrutiny in science. . . But Paul then found that nearly half these books continued to cite and use Burt’s data. (Gould, 1991, p. 16, para. 5 & 6).

The Tunguska case demonstrates the same principle: once misinformation is repeated in authoritative formats, it is likely to persist, especially when amplified by AI and media.

DEVIATION FROM SCIENTIFIC NORMS

Missing, Withheld, and Mishandled Data and Samples

Publications supporting the YDIH have repeatedly raised concerns regarding transparency and reproducibility. Most of the data and evidence published by the Comet Research Group (CRG) in legitimate journals remains unavailable for independent evaluation by subject-matter experts. The CRG appears to have a longstanding policy of rejecting or ignoring requests for data, methods, and materials. This lack of transparency became apparent shortly after the discovery that carbon spherules from the Gainey (Michigan) YDB site, presented as an impact proxy, were actually

contaminants (Boslough et al., 2012). Systematic failures to comply with publishers’ materials and data availability guidelines are documented on the post-publication review site PubPeer (Holliday et al., 2024—their table S2). In some cases, the responses to requests suggest that supplies of materials are scarce or depleted.

However, other materials, such as “meltglass” from Abu Hureyra, appear to be plentiful yet have not been made available to impact and airburst glass experts for independent evaluation. Moore et al. (2023) state “the Abu Hureyra site is now submerged beneath Lake Assad” and “no more unprocessed bulk sediment is available from the YDB layer,” but make no mention of the availability of Abu Hureyra “meltglass” (Figure 7).

A notable issue with the retracted Tall el-Hammam paper (Bunch et al., 2025) involved inappropriate manipulation of photographs, which were then used as evidence to support claimed blast directionality. One coauthor attributed the edits to the group’s graphic artist (Marcus, 2021). This raises the possibility that other CRG evidence could have also been compromised if the same personnel were involved in creating data graphs, recording data with inappropriate methods, or handling materials. These examples underscore the need for transparency and adherence to standard materials and data availability guidelines, allowing independent researchers to properly evaluate YDIH evidence.

CRG continues to withhold information critical for evaluating their results. In one *A&CI* paper, they modeled the 1945 Trinity test using a 2D hydrocode simulation, claiming that “no known studies have simultaneously modeled changes in airburst pressures, temperatures, shockwave speeds, visible materials, and

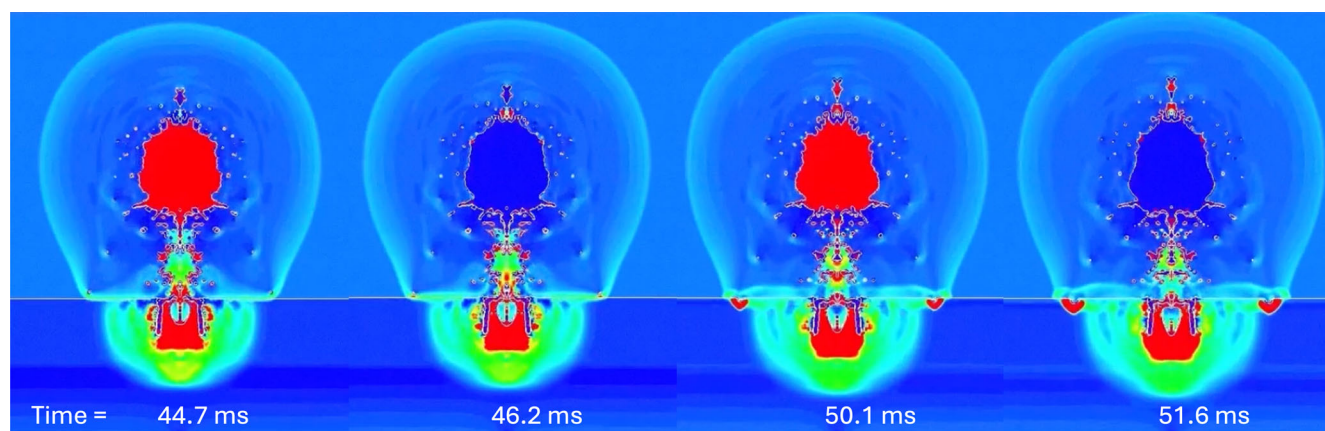


FIGURE 8. Frames from an animation of the CRG's attempt to model the Trinity test (West et al., 2024, posted supplemental video <https://vimeo.com/931733079>), exhibiting an unphysical pressure oscillation that appears to be caused by a numerical instability, as well as other phenomena that are inconsistent with observations and documentation of this event.

bulk material failure for such events.” (West et al., 2024, p. 1, para. 1). Their results deviate significantly from decades of research by Los Alamos National Laboratory and elsewhere (e.g., Bainbridge, 1976; Glasstone & Dolan, 1977).

Inspection of the authors' animations shows physically unrealistic behavior: the nuclear fireball exhibits more than 50 high-amplitude pressure oscillations spanning the full scale (from below atmospheric pressure to above 1 MPa) within the 0.25 s duration of the animation (Figure 8). This suggests that an inappropriate resolution and/or time step was used, yet the input deck remains unavailable, so it is impossible to diagnose the problem. Requests for this information on PubPeer (doi:10.14293/aci.2024.0004) were declined.

It is crucial for both scientists and the public to remain skeptical of claims based on evidence of unknown provenance. Virtually all CRG samples and raw data on which their evidence is based have been treated by the authors as confidential for unknown reasons.

Association with Fringe Science, Pseudoscience, and Conspiracy Theories

Misinformation related to meteoritics, planetary science, and planetary defense is often linked to fringe science and pseudoscience.

There is a complicated history of experts in specific fields attempting to delineate the boundaries of legitimate science with regards to cosmic catastrophes, including the acrimonious, though ultimately correct, dismissals of the fringe ideas of Immanuel Velikovsky from the 1950s through 1970s and the strident, though premature, pushback against the prospect that an NEO triggered the extinction of non-avian dinosaurs before

the discovery of the Chicxulub crater (Alvarez, 1997; Degroot, 2025; Gordin, 2012; Sepkoski, 2020). The latter instance in particular speaks to the need for caution in attributing the term “pseudoscience” to merely incorrect or unconventional hypotheses (Gordin, 2021). Yet the alliances of some of the recent groups promoting misinformation about impact risks with individuals who continue to advocate thoroughly discredited ideas justifies classifying some of this work as pseudoscientific.

The YDIH echoes themes previously advanced by 19th century fringe theorist Ignatius Donnelly (Donnelly, 1883) and recently by pseudoarcheology writer Graham Hancock. Hancock hosts a blog promoting YDIH advocates and associated books and has incorporated the hypothesis into his pseudoscientific claims that an advanced ancient civilization was destroyed by an ice-age comet swarm and global flood. These ideas were featured in the first season (2022) of the Netflix series *Ancient Apocalypse*, which included YDIH supporters Allen West and Martin Sweatman, who collaborated with James Powell on a reply to Holliday et al. (2023) (see Sweatman et al., 2024).

Allen West, a self-taught geologist whose book *Cycle of Cosmic Catastrophes* (Firestone et al., 2006) introduced the YDIH mirroring many elements of 19th century pseudoscience (Donnelly, 1883), and who was commissioned by the New Age publisher Inner Traditions that specializes in categories such as astrology, occult, UFOs, paranormal, tarot, divination, conspiracies, and ancient mysteries. Its website has pages dedicated to “ancient alien” books including one about the ancient megalithic complex at Göbekli Tepe (in modern Turkey) and “how it was built as a reaction to a global cataclysm—the Great Flood in the Bible” and

“how it served as a gateway and map to the sky-world” (<https://www.innertraditions.com>).

Despite authorship order, the book by Firestone et al. (2006) was primarily written in the first person by West, who had changed his name from Allen Whitt after he was convicted and fined in 2002 for “masquerading as a state-licensed geologist” (Dalton, 2011). Nevertheless, the introduction describes the authors as “trained researchers who have worked as government scientists.” (Firestone et al., 2006, p. 1, para. 4) and echoed Donnelly and Hancock by claiming to present tangible evidence for “the megafloods and cataclysms recorded in the Bible, Plato’s story of Atlantis, Native American lore, and the myths and literature of other cultures.” (Firestone et al., 2006, p. 2, para. 2).

Firestone et al. (2007), published in *PNAS*, removed most pseudoscientific content but retained West’s central role as the field collector and analyst of YDB sites. The paper omitted details from Firestone et al. (2006) about how West rapidly collected samples from rims of 15 Carolina Bays—including an industrial sandpit, roadsides, and a golf course—an activity completed over a few months in 2005 for the book. Misidentification of these locations as Younger Dryas boundary sites continues to be cited as evidence for the YDIH.

Martin Sweatman, a trained scientist (with a PhD in theoretical physics) and Reader at the University of Edinburgh, also appeared on *Ancient Apocalypse* to discuss an idea based on his self-published book, *Prehistory Decoded* (Sweatman, 2019). Promoting his book on Hancock’s blog, Sweatman claimed that Göbekli Tepe “opens the door to an alternate universe—one where hypotheses of writers like Graham Hancock are probably closer to the truth than those of orthodox archaeologists.” (<https://grahamhancock.com/sweatmanm1/>). Sweatman argues in his book that Göbekli Tepe commemorates the Younger Dryas comet catastrophe.

James Powell, a trained geologist, self-published *Deadly Voyager* (Powell, 2020), criticizing mainstream scientists for rejecting the YDIH and implying bias. He continues to disregard established critiques, which summarize that YDIH evidence involves flawed methodologies, unsupported claims, irreproducible observations, and selective omission of contrary data (Holliday et al., 2023).

Significantly, the CRG’s YDIH research and Avi Loeb’s alien technology research both receive funding from philanthropist Eugene Jhong, who provides support to “contrarian researchers” (Guenot, 2024).

Exploitation of Gullibility and Scientific Illiteracy

Advocates of fringe science often use media platforms that reach large audiences but are largely

ignored by scientifically literate communities. Avi Loeb, for example, told podcaster Joe Rogan (2025):

When we know that there is alien technology that is putting Earth at risk... we should allocate a significant fraction of our military budgets to have a system that protects the Earth. It’s called planetary defense... we are dealing not with rocks, we are dealing with technological gadgets. I much prefer to listen to imaginative science fiction writers... Because they’re much more interesting than second class scientists who don’t have an imagination. And they not only have a problem with discussing alien intelligence, they also have a problem with whoever discusses it. And they would try to suppress that voice. And I think it makes no sense whatsoever because the public really cares about it ... The public funds science.

This rhetoric mirrors claims by YDIH supporters that the “scientific establishment” suppresses alternative views they disagree with. Powell further misrepresents the scientific method, stating in a YouTube interview (Howard, 2025): “If it’s false then we need to know that. So, if it’s false and someone has the evidence that convinces them, let them publish that evidence in a peer-reviewed paper... if they have any evidence that it’s wrong, they’ve yet to show it. If they don’t have it, they should go get some.”

Such arguments run counter to the normal convention that the party who makes a claim is responsible for providing the evidence. They also ignore strong evidence supporting existing scientific paradigms, which successfully make predictions and design technology, underpinning everything we know about high-pressure shock waves, hydrodynamics, and nuclear physics (e.g., the Trinity test) to orbital mechanics and impact physics (e.g., as related to Shoemaker-Levy 9). Significantly, the massive quantity of evidence supporting these paradigms contradicts YDIH claims.

When Misinformation Becomes Disinformation

Promoters of YDIH have teamed with Joe Rogan and Graham Hancock in an effort to undermine mainstream scientists who are skeptical of their alleged evidence and claims. Their primary focus has been on archeologists who reject the YDIH and its related hypotheses by the CRG that purport to rewrite human history, including false claims that Clovis people mysteriously disappeared as the result of a comet shower that was also responsible for destroying the lost city of Atlantis and was recorded by an advanced race of humans at Göbekli Tepe. Hancock has promoted like-minded bloggers and YouTubers who have engaged in

disinformation campaigns and relentless personal attacks against mainstream scientists from many disciplines.

As part of this partnership, CRG leader Allen West joined Hancock on stage for a public event in Sedona, Arizona, called “The Fight for the Past” available on YouTube (Hancock, 2025). When it was his turn to speak about the impact risk, he said this:

One of our key scientists was high up in NASA... he told me that back in the 80s when they first discovered the big impact into Yucatan, the government knew that they couldn't do anything about it... They decided to just deny, deny, deny. Just say, “Don't worry. There's no problem. We've got it under control...” ... most of our critics either work for NASA or they work for government organizations that depend on NASA ... they couldn't stand the truth so don't tell them.

As of March 8, 2026, this video had been viewed 494,000 times. This statement is an example of disinformation that includes deliberate propagation of misleading narratives to delegitimize mainstream science.

CONCLUSIONS AND RECOMMENDATIONS

The rapid expansion of social media, blogs, podcasts, digital video influencers, AI tools, and other online sources continues to displace traditional news information media, accelerating the spread of clickbait and poorly fact-checked stories masquerading as news or documentaries. The rise of open-access and predatory journals, coupled with pressure on researchers to publish, has eroded the quality of scientific literature, incentivizing rapid publication of papers with inadequate peer review. These trends have increased misinformation across all fields, including planetary science and planetary defense where sensational and catastrophic events are inherently newsworthy.

Misinformation can take many forms and can emerge, propagate, and dominate on time scales that are short relative to the news cycle, which is now <1 day. It can also take place on time scales associated with the scientific publication and academic news release cycle, which is shrinking to months because of the emergence of rapid open-access publishing. It can also arise and endure on time scales of years, decades, or even a century due to careless citation and repetition of “sticky” but wrong claims. Prevention and correction of misinformation on each of these time scales requires different methods.

- Short-term (news cycle): Misinformation associated with the news cycle spreads within hours to a day. It requires immediate action by specialists around the world. Planetary defense researchers are not experts

in every subdiscipline, so when called by a journalist on a tight deadline, they are unlikely to be able to answer all the questions with authority. Nevertheless, members of this community know who can provide fast and accurate answers to those questions, so it is important to maintain a distributed network of professionals who can rapidly respond when news is breaking. Such a network should not be thought of as a replacement for official statements from organizations, but because it is a distributed and collective system, it can respond much faster than the news cycle. Official statements, while slower, serve to reinforce the same accurate information to journalists and the public.

- Medium-term (publication cycle): Misinformation can propagate over months through journals and academic news releases. Prevention and correction of misinformation on the publication time scale requires a longer, sustained effort. Countermeasures include publishing comments in journals and using post-publication review platforms such as PubPeer. Responses to YDIH-related claims have resulted in scores of PubPeer pages, numerous published rebuttals, and retractions.
- Long-term (“folk facts”): Culturally embedded misinformation can endure for years or decades. It is the most difficult type to correct and most likely to be met with resistance. Modern citation-tracking tools enable researchers to trace claims back to their original sources more efficiently than traditional libraries allowed. Correcting misinformation that has existed for decades requires persistence and repetition of factual information over commensurate time scales, including in peer-reviewed sources.

Preventing and correcting misinformation associated with planetary science and planetary defense requires diligence, patience, and cooperation among scientists, journalists, publishers, and program managers. While a time-consuming task, these efforts are essential for maintaining scientific integrity and public trust in the experts who provide accurate information for informed decision-making.

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Endnotes

- ¹ The mistakes in the original version of Uri (2023) have been corrected.
- ² It was in fact a colleague's remark with which Hale had expressed agreement (Alan Hale email to MB, March 27, 2026).
- ³ There are several surviving social media posts, for example, <https://forum.gamehacking.org/forum/misc/the-lounge/7736-250-injured-by-meteorite-shower-explosions#post7736>.
- ⁴ Link to Slooh announcement: https://images.slooh.com/files/press_release/asteroid_2000+EM26_2014.pdf, promotional material: <https://www.wired.com/2014/02/large-asteroid-close-approach/>, and broadcast: <https://www.youtube.com/watch?v=MCFWUemLzMO>.
- ⁵ Link to Phil Plait article: <https://slate.com/technology/2014/05/cnn-ireport-fake-story-about-a-killer-asteroid-impact-in-2041.html>.
- ⁶ Translated from Russian.
- ⁷ Another explanation is the misinterpretation of the British narrator's pronunciation of "eighty" as "eighteen".
- ⁸ Astapowitsch is an alternate transliteration of the Cyrillic spelling of Astapovich, who is the same author.
- ⁹ <https://www.youtube.com/watch?v=68XxMjI6zeM>.

REFERENCES

- Achenbach, J. 2014a. The Shroud of Turin, Pseudoscience, and Journalism. *The Washington Post*. <https://www.washingtonpost.com/news/achenblog/wp/2014/02/14/the-shroud-of-turin-pseudoscience-and-journalism/>. Accessed November 26, 2025.
- Achenbach, J. 2014b. Asteroid Did Not Nearly Hit Earth, Actually. *The Washington Post*. <https://www.washingtonpost.com/news/achenblog/wp/2014/02/19/asteroid-did-not-nearly-hit-earth-actually/>. Accessed November 26, 2025.
- Alvarez, W. 1997. *T. Rex and the Crater of Doom*. Princeton, NJ: Princeton University Press.
- Andrews, R. G. 2025. So about that Asteroid that Could Hit Earth *The Atlantic*. <https://www.theatlantic.com/science/archive/2025/02/earth-killer-asteroids-2024-yr4/681660/>. Accessed November 26, 2025.
- Associated Press. 2014. Meteorite 'Caused Mysterious Boom in Nicaragua'. *The Guardian*. <https://www.theguardian.com/science/2014/sep/08/meteorite-caused-mystery-boom-nicaragua>. Accessed November 26, 2025.
- Astapovich, I. S. 1933. Novye Materialy po Poletu Bol'shogo Meteorita 30 Iunia 1908 g. v Tsentral'noi Sibiri (in Russian). *Astronomicheskii Zhurnal* 10: 465–486.
- Astapowitsch, I. S. 1934. Air Waves Caused by the Fall of the Meteorite on 30th June, 1908, in Central Siberia. *Quarterly Journal of the Royal Meteorological Society* 60: 493–504.
- Bainbridge, K. T. 1976. *Trinity*. Technical Report LA-6300-H, 1–82. Los Alamos, NM: Los Alamos National Laboratory.
- BBC News. 2006. "Tut's Gem Hints at Space Impact." <http://news.bbc.co.uk/2/hi/science/nature/5196362.stm>. Accessed November 26, 2025.
- BBC News. 2014. "Meteorite that Hit Nicaragua 'Dropped off' Larger Asteroid." <https://www.bbc.com/news/av/science-environment-29106439>. Accessed November 26, 2025.
- Boslough, M. 2015. Airburst modeling. In *Handbook of Cosmic Hazards and Planetary Defense*, edited by J. N. Pelton, and F. Allahdadi, 665–692. Amsterdam: Elsevier.
- Boslough, M. 2025a. A Sodom and Gomorrah Story Shows Scientific Facts Aren't Settled by Public Opinion. *Scientific American*. <https://www.scientificamerican.com/article/a-sodom-and-gomorrah-story-shows-scientific-facts-arent-settled-by-public/>. Accessed November 26, 2025.
- Boslough, M. 2025b. The Problem with Inadequately Reviewed Fringe Science. *The Skeptical Inquirer*. <https://skepticalinquirer.org/exclusive/the-problem-with-inadequately-reviewed-fringe-science/>. Accessed November 26, 2025.
- Boslough, M., Brown, P., Bruno, A., Chodas, P., Collins, G. S., Daulton, T., Harris, A., et al. 2024. Myths and Misinformation about Tunguska and Cosmic Airbursts. *Geological Society of America Abstracts with Programs* 56. doi: 10.1130/abs/2024AM-401469.
- Boslough, M., Brown, P., and Harris, A. 2015. Updated Population and Risk Assessment for Airbursts from near-Earth Objects (NEOs). In *2015 IEEE Aerospace Conference*, 1–12, doi: 10.1109/AERO.2015.7119288.
- Boslough, M., and Bruno, A. 2025. Misunderstandings about the Tunguska Event, Shock Wave Physics, and Airbursts Have Resulted in Misinterpretations of Evidence at Tall el-Hammam. *Scientific Reports* 15: 13869.
- Boslough, M. B. E., and Crawford, D. A. 1997. Shoemaker-Levy 9 and Plume-Forming Collisions on Earth. In *Near-Earth Objects: The United Nations International Conference*, edited by J. L. Remo, vol. 822, 236–282. New York: Annals of the New York Academy of Sciences.
- Boslough, M. B. E., and Crawford, D. A. 2008. Low-Altitude Airbursts and the Impact Threat. *International Journal of Impact Engineering* 35: 1441–48.
- Boslough, M., Jennings, B., Carvey, B., and Fogleman, W. 2015. FEMA Asteroid Impact Tabletop Exercise Simulations. *Procedia Engineering* 103: 43–51.
- Boslough, M., Nicoll, K., Holliday, V. T., Daulton, T. L., Meltzer, D., Pinter, N., Scott, A. C., et al. 2012. Arguments and Evidence against a Younger Dryas Impact Event. In *Climates, Landscapes, and Civilizations*, edited by L. Giosan, D. Q. Fuller, K. Nicoll, R. K. Flad, and P. D. Clift, vol. 198, 13–26. Washington, DC: AGU Geophysical Monograph Series.

- Boslough, M., and Titov, V. 2024. Air-Coupled Tsunamis Generated from Impacts and Airbursts: Our Understanding before Hunga-Tonga Hunga-Ha'apai. *Acta Astronautica* 222: 641–46.
- Brazo, M. W., and Austin, S. A. 1982. The Tunguska Explosion of 1908. *Origins* 9: 82–93.
- Bruno, A. 2022. *Tunguska: A Siberian Mystery and its Environmental Legacy*. Cambridge: Cambridge University Press.
- Bunch, T. E., LeCompte, M. A., Adedeji, A. V., Wittke, J. H., Burleigh, T. D., Hermes, R. E., Mooney, C., et al. 2025. Retraction Note: A Tunguska Sized Airburst Destroyed Tall el-Hammam, a Middle Bronze Age City in the Jordan Valley near the Dead Sea. *Scientific Reports* 15: 14291.
- Chapman, C. R., Morrison, D., and Harris, A. W. 2025. The Younger Dryas Impact: A Failed Hypothesis. *The Skeptical Inquirer* 49: 59–62. <https://skepticalinquirer.org/2025/06/the-younger-dryas-impact-a-failed-hypothesis/>. Accessed November 26, 2025.
- Cohen, J. 2014. Nanodiamonds Are Forever. *The Current*. <https://news.ucs.edu/2014/014368/nanodiamonds-are-forever>. Accessed November 26, 2025.
- Collins, G. S., Artemieva, N., Wünnemann, K., Bland, P. A., Reimold, W. U., and Koeberl, C. 2008. Evidence that Lake Cheko Is Not an Impact Crater. *Terra Nova* 20: 165–68.
- Crommelin, A. C. D. 1934. The Great Siberian Meteor of 1908 June 30. *The Journal of the British Astronomical Association* 44: 242–43.
- Dalton, R. 2007. Archaeology: Blast in the Past? *Nature* 447: 256–58.
- Dalton, R. 2011. Comet Theory Comes Crashing to Earth. *Pacific Standard*. <https://psmag.com/environment/comet-claim-comes-crashing-to-earth-31180/>. Accessed November 26, 2025.
- Daulton, T. L., Amari, S., Scott, A. C., Hardiman, M., Pinter, N., and Anderson, R. S. 2017. Comprehensive Analysis of Nanodiamond Evidence Relating to the Younger Dryas Impact Hypothesis. *Journal of Quaternary Science* 32: 7–34.
- Degroot, D. 2025. *Ripples on the Cosmic Ocean: An Environmental History of Our Place in the Solar System*. Cambridge, MA: Harvard University Press.
- Desch, S., and Jackson, A. 2023. Critique of arXiv Submission 2308.15623, “Discovery of Spherules of Likely Extrasolar Composition in the Pacific Ocean Site of the CNEOS 2014-01-08 (IM1) Bolide,” by A. Loeb et al. *arXiv preprint arXiv:2311.07699*. <https://arxiv.org/abs/2311.07699>. Accessed November 26, 2025.
- Donnelly, I. 1883. *Ragnarok: The Age of Fire and Gravel*. New York, NY: D. Appleton and Company.
- Fast, V. G., Fast, N. P., and Golenberg, N. A. 1983. *Meteoritnyje i meteornyje issledovanija* (in Russian), 24–74. Novosibirsk: Nauka.
- Firestone, R. B., West, A., Kennett, J. P., Becker, L., Bunch, T. E., Revay, Z. S., Schultz, P. H., et al. 2007. Evidence for an Extraterrestrial Impact 12,900 Years Ago that Contributed to the Megafaunal Extinctions and the Younger Dryas Cooling. *Proceedings of the National Academy of Sciences* 104: 16016–21.
- Firestone, R., West, A., and Warwick-Smith, S. 2006. *The Cycle of Cosmic Catastrophes: How a Stone-Age Comet Changed the Course of World Culture*. Rochester, VT: Inner Traditions.
- Flam, F. 2013. Reporters Cheerlead for Claim that Asteroid Wiped Out Mammoths, Started Civilization. *Nature Notes* PNAS Paper Didn't Pass Standard Peer Review. *Knight Science Journalism*. <https://ksj.mit.edu/tracker-archive/reporters-cheerlead-claim-asteroid-wiped/>. Accessed November 26, 2025.
- Foschini, L. 2001. On the Atmospheric Fragmentation of Small Asteroids. *Astronomy & Astrophysics* 365: 612–621.
- Frank, L. A., and Sigwarth, J. B. 1993. Atmospheric Holes and Small Comets. *Reviews of Geophysics* 31: 1–28.
- Frazier, K. 1998. Science and Reason, Foibles and Fallacies, and Doomsdays. *The Skeptical Inquirer* 22: 5–8. <https://cdn.centerforinquiry.org/wp-content/uploads/sites/29/1998/11/22164910/p05.pdf>. Accessed April 9, 2026.
- French, B. M. 1998. *Traces of Catastrophe: A Handbook of Shock-Metamorphic Effects in Terrestrial Meteorite Impact Structures*. Lunar and Planetary Institute Contribution No. 954. Houston, TX: Lunar and Planetary Institute. 120.
- Gasparini, L., Bonatti, E., Albertazzi, S., Forlani, L., Accorsi, C. A., Longo, G., Ravaioli, M., Alvisi, F., Polonia, A., and Sacchetti, F. 2009. Sediments from Lake Cheko (Siberia), a Possible Impact Crater for the 1908 Tunguska Event. *Terra Nova* 21: 489–494.
- Gasparini, L., Bonatti, E., and Longo, G. 2008. The Tunguska Mystery. *Scientific American* 298: 80–86.
- Glasstone, S., and Dolan, P. 1977. *The Effects of Nuclear Weapons*, 3rd ed. Washington, DC: U.S. Department of Defense. 653.
- Gordin, M. 2012. *The Pseudoscience Wars: Immanuel Velikovsky and the Birth of the Modern Fringe*. Chicago: University of Chicago Press.
- Gordin, M. 2021. *On the Fringe: Where Science Meets Pseudoscience*. Oxford: Oxford University Press.
- Gould, S. J. 1991. The Case of the Creeping Fox Terrier Clone. In *Bully for Brontosaurus: Reflections in Natural History*, 155–167. New York: W. W. Norton & Company.
- Grudniewicz, A., Moher, D., Cobey, K. D., Bryson, G. L., Cukier, S., Allen, K., Ardern, C., et al. 2019. Predatory Journals: No Definition, no Defence. *Nature* 576: 210–12.
- Guenot, M. 2024. A Harvard Professor Is Risking his Reputation to Search for Aliens. Tech Tycoons Are Bankrolling his Quest. *Business Insider*. <https://www.businessinsider.com/billionaire-backed-harvard-prof-says-science-should-take-ufos-seriously-2024-4>. Accessed November 26, 2025.
- Hadhazy, A. 2008. Tunguska—100 Years Later. *Scientific American*. <https://www.scientificamerican.com/article/what-happened-at-tunguska/>. Accessed November 26, 2025.
- Hancock, G., host. 2025. Ancient Apocalypse: What Happened to the World 12,000 Years Ago and Why We Should Care. *The Fight for the Past*, 1 hr., 22 min., 38 sec. <https://www.youtube.com/watch?v=ja0qElhbhiw>. Accessed April 7, 2026.
- Hibberd, A., Crowl, A., and Loeb, A. 2025. Is the Interstellar Object 3I/ATLAS Alien Technology? *arXiv preprint arXiv:2507.12213v3*. <https://arxiv.org/abs/2507.12213>. Accessed November 26, 2025.
- Holliday, V. T., Daulton, T. L., Bartlein, P. J., Boslough, M. B., Breslawski, R. P., Fisher, A. E., Jorgeson, I. A., et al. 2023. Comprehensive Refutation of the Younger Dryas Impact Hypothesis (YDIH). *Earth-Science Reviews* 247: 104502.
- Holliday, V. T., Daulton, T. L., Bartlein, P. J., Boslough, M. B., Breslawski, R. P., Fisher, A. E., Jorgeson, I. A., et al. 2024. Rebuttal of Sweatman, Powell, and West's

- “Rejection of Holliday et al.’s Alleged Refutation of the Younger Dryas Impact Hypothesis”. *Earth-Science Reviews* 258: 104961.
- Howard, G., host. 2025. The Younger Dryas, Impact Craters, and the Nature of Scientific Resistance with James Powell. *The Cosmic Summit*, 1 hr., 12 min., 22 sec. <https://www.youtube.com/watch?v=n7RNr94nUG4>. Accessed April 7, 2026
- Jaret, S. J., and Harris, R. S. 2022. No Mineralogic or Geochemical Evidence of Impact at Tall el-Hammam, a Middle Bronze Age City in the Jordan Valley Near the Dead Sea. *Scientific Reports* 12: 5189.
- Jewitt, D., Mutchler, M., Weaver, H., Hui, M.-T., Agarwal, J., Ishiguro, M., Kleyna, J., et al. 2016. Fragmentation Kinematics in Comet 332P/Ikeya–Murakami. *The Astrophysical Journal Letters* 829: L8.
- Jones, N. 2013. Evidence Found for Planet-Cooling Asteroid. *Nature News*. <https://doi.org/10.1038/nature.2013.13661>. Accessed April 7, 2026.
- Kincaid, E. 2023. Journal Investigating Sodom Comet Paper for Data Problems. *Retraction Watch*. <https://retractionwatch.com/2023/02/21/journal-investigating-sodom-comet-paper-for-data-problems/>. Accessed November 26, 2025.
- Kincaid, E. 2025. Sodom Comet Paper to Be Retracted Two Years after Editor’s Note Acknowledging Concerns. *Retraction Watch*. <https://retractionwatch.com/2025/04/23/sodom-comet-paper-to-be-retracted-two-years-after-editors-note-acknowledging-concerns/>. Accessed November 26, 2025.
- Kinzie, C. R., Que Hee, S. S., Stich, A., Tague, K. A., Mercer, C., Razink, J. J., Kennett, D. J., et al. 2014. Nanodiamond-Rich Layer across Three Continents Consistent with Major Cosmic Impact at 12,800 Cal BP. *Journal of Geology* 122: 475–506.
- Kurbatov, A. V., Mayewski, P. A., Steffensen, J. P., West, A., Kennett, D. J., Kennett, J. P., Bunch, T. E., et al. 2010. Discovery of a Nanodiamond-Rich Layer in the Greenland Ice Sheet. *Journal of Glaciology* 56: 747–757.
- Lewis, J. S. 1996. *Rain of Iron and Ice: The Very Real Threat of Comet and Asteroid Bombardment*. Reading, MA: Addison-Wesley. 236.
- Longo, G., Bonatti, E., Di Martino, M., Foschini, L., and Gasperini, L. 2001. Exploring the Site of the Tunguska Impact. *Abstracts and Proceedings of the Norwegian Geological Society* 1: 48–50.
- Mann, M. E., and Hotez, P. J. 2025. *Science under Siege: How to Fight the Five Most Powerful Forces that Threaten Our World*. New York: PublicAffairs.
- Marcus, A. 2021. Criticism Engulfs Paper Claiming an Asteroid Destroyed Biblical Sodom and Gomorrah. *Retraction Watch*. <https://retractionwatch.com/2021/10/01/criticism-engulfs-paper-claiming-an-asteroid-destroyed-biblical-sodom-and-gomorrah/>. Accessed November 26, 2025.
- McWhirter, N., and McWhirter, R. 1965. *The Guinness Book of Records 1965*. London: Guinness Superlatives Ltd. 336.
- Moore, A. M. T., and Kennett, D. J. 2013. Cosmic Impact, the Younger Dryas, Abu Hureyra, and the Inception of Agriculture in Western Asia. *Eurasian Prehistory* 10: 57–66.
- Moore, A. M., Kennett, J. P., Napier, W. M., Bunch, T. E., Weaver, J. C., LeCompte, M., Adediji, A. V., et al. 2020. Evidence of Cosmic Impact at Abu Hureyra, Syria, at the Younger Dryas Onset (~12.8 Ka): High-Temperature Melting at >2200°C. *Scientific Reports* 10: 4165.
- Moore, A. M., Kennett, J. P., Napier, W. M., Bunch, T. E., Weaver, J. C., LeCompte, M. A., Adediji, A. V., et al. 2023. Abu Hureyra, Syria, Part 2: Additional Evidence Supporting the Catastrophic Destruction of this Prehistoric Village by a Cosmic Airburst ~12,800 Years Ago. *Airbursts and Cratering Impacts* 1: 20230030.
- Morrison, D., and Robertson, D. K. 2019. Introduction to Icarus Special Papers on Tunguska. *Icarus* 327: 1–3.
- Moskvitch, K. 2013. Blast from the Past: Solving the Tunguska Mystery. *New Scientist* 218: 40–43.
- NASA. 2014. Did a Meteorite Cause a Crater in Nicaragua? *NASA Watch the Skies Blog*. <https://www.nasa.gov/blogs/watch-the-skies/2014/09/08/did-a-meteorite-cause-a-crater-in-nicaragua/>. Accessed November 26, 2025.
- Neuhäuser, R., and Neuhäuser, D. L. 2022. Arguments for a Comet as Cause of the Hopewell Airburst Are Unsubstantiated. *Scientific Reports* 12: 12090.
- Nolan, K. C., Weiland, A., Lepper, B. T., Aultman, J., Murphy, L. R., Ruby, B. J., Schwarz, K., et al. 2023. Refuting the Sensational Claim of a Hopewell-Ending Cosmic Airburst. *Scientific Reports* 13: 12910.
- Oreskes, N., and Conway, E. M. 2010. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. London: Bloomsbury Press.
- Paul, D. B. 1987. The nine lives of discredited data. *The Sciences* 27: 26–30.
- Powell, J. L. 2020. *Deadly Voyager: The Ancient Comet Strike that Changed Earth and Human History* (Self-Published).
- Robertson, D. K., and Mathias, D. L. 2019. Hydrocode Simulations of Asteroid Airbursts and Constraints for Tunguska. *Icarus* 327: 36–47.
- Robinson, W. G. 1997. Heaven’s Gate: The End. *Journal of Computer-Mediated Communication* 3: JCMC334.
- Rodimova, O. B., Sapozhnikova, V., and Fazliev, A. Z. 2008. Electronic Collection of Documents Related to the Problem of the Tunguska Phenomenon. *Bulletin of Tomsk State University. Mathematics and Mechanics* 3: 103–113.
- Rogan, J., host. 2025. *The Joe Rogan Experience*. Episode 2401. Podcast, 2 hr., 14 min., 55 sec. <https://www.youtube.com/watch?v=EaAun27gftk>. Accessed April 7, 2026.
- Rogozin, D. Y., Darin, A. V., Kalugin, I. A., Melgunov, M. S., Meydus, A. V., and Degermendzhi, A. G. 2017. Sedimentation Rate in Cheko Lake (Evenkia, Siberia): New Evidence on the Problem of the 1908 Tunguska Event. *Doklady Earth Sciences* 476: 1226–28.
- Romeyko, V. A., and Chichmar, V. V. 2004. *Tunguskiy Meteorite: Searches and Finds (from the Experience of School Expeditions of Moscow)*. Moscow: Moscow Institute of Open Education (MIOO).
- Schmieder, M., Ferrière, L., Ormö, J., Buchner, E., Koeberl, C., and Reimold, W. U. 2015. Comment on: “Direct Evidence of Ancient Shock Metamorphism at the Site of the 1908 Tunguska Event”, by P. Vannucchi et al. [Earth Planet. Sci. Lett. 409 (2015) 168–174]. *Earth and Planetary Science Letters* 419: 222–23.
- Sekanina, Z., Chodas, P. W., and Yeomans, D. K. 1998. Secondary Fragmentation of Comet Shoemaker-Levy 9 and the Ramifications for the progenitor’s Breakup in July 1992. *Planetary and Space Science* 46: 21–45.
- Sepkoski, D. 2020. *Catastrophic Thinking: Extinction and the Value of Diversity from Darwin to the Anthropocene*. Chicago, IL: University of Chicago Press.
- Silber, E. A., Boslough, M., Hocking, W. K., Gritsevich, M., and Whitaker, R. W. 2018. Physics of Meteor Generated Shock Waves in the Earth’s Atmosphere—A Review. *Advances in Space Research* 62: 489–532.

- St. George, Z. 2024. The Comet Strike Theory that Just Won't Die. *The New York Times*. <https://www.nytimes.com/2024/03/05/magazine/younger-dryas-impact-hypothesis-comet.html>. Accessed November 26, 2025.
- Suhr, E. 2023. Probabilistic Fitts' Law and the Likelihood of the Tunguska-Type Event. *Journal of Space Safety Engineering* 10: 59–65.
- Sweatman, M. 2019. *Prehistory Decoded*. Leicester: Troubador Publishing Ltd.
- Sweatman, M. B., Powell, J. L., and West, A. 2024. Rejection of Holliday et al.'s Alleged Refutation of the Younger Dryas Impact Hypothesis. *Earth-Science Reviews* 258: 104960.
- Tankersley, K. B., Meyers, S. D., Meyers, S. A., Jordan, J. A., Herzner, L., Lentz, D. L., and Zedaker, D. 2023. Retraction Note: The Hopewell Airburst Event, 1699–1567 Years Ago (252–383 CE). *Scientific Reports* 13: 14201.
- Taylor, S. R. 1969. Criteria for the Source of Australites. *Chemical Geology* 4: 451–59.
- The PLOS One Editors. 2026a. Retraction: A 12,800-Year-Old Layer with Cometary Dust, Microspherules, and Platinum Anomaly Recorded in Multiple Cores from Baffin Bay. *PLOS One* 21: e0342613.
- The PLOS One Editors. 2026b. Retraction: Shocked Quartz at the Younger Dryas Onset (12.8 Ka) Supports Cosmic Airbursts/Impacts Contributing to North American Megafaunal Extinctions and Collapse of the Clovis Technocomplex. *PLOS One* 21: e0342620.
- Toon, O. B., Zahnle, K., Morrison, D., Turco, R. P., and Covey, C. 1997. Environmental Perturbations Caused by the Impacts of Asteroids and Comets. *Reviews of Geophysics* 35: 41–78.
- Tunguska Scientific Center (KSE). 2004. *Aerial Photography*. Tunguska Phenomenon Photo Archive. <https://tunguska.tsc.ru/ru/cae/photo/2000/2004/aero/>. Accessed November 26, 2025.
- Tunguska Scientific Center (KSE). 2025. *Craters (in Russian)*. <https://tunguska.tsc.ru/ru/lyrics/prose/romeiko/r2/craters/>. Accessed November 26, 2025.
- Uri, J. 2023. 115 Years Ago: The Tunguska Asteroid Impact Event. *NASA History*. <https://www.nasa.gov/history/115-years-ago-the-tunguska-asteroid-impact-event/>. Accessed November 26, 2025.
- Washington Post. 1997. *Comets, Spaceships and the 'Level Above Human'*. <https://www.washingtonpost.com/archive/politics/1997/03/28/comets-spaceships-and-the-level-above-human/38da1ef7-77ef-4cf3-a28c-8d18227fb10b/>. Accessed November 26, 2025.
- West, A., Young, M., Costa, L., Kennett, J. P., Moore, C. R., LeCompte, M. A., Kletetschka, G., et al. 2024. Modeling Airbursts by Comets, Asteroids, and Nuclear Detonations: Shock Metamorphism, Meltglass, and Microspherules. *Airbursts and Cratering Impacts* 2: e20240004.
- Whipple, F. J. W. 1934. On Phenomena Related to the Great Siberian Meteor. *Quarterly Journal of the Royal Meteorological Society* 60: 505–522.
- Wiegert, P., Brown, P., Lopes, J., and Connors, M. 2025. The Potential Danger to Satellites Due to Ejecta from a 2032 Lunar Impact by Asteroid 2024 YR4. *The Astrophysical Journal Letters* 990: L20.
- Zahnle, K., and Mac Low, M.-M. 1994. The Collision of Jupiter and Comet Shoemaker–Levy 9. *Icarus* 108: 1–17.