Type of the Paper (Critical Review)

Updated Trajectory and Spectral Insights into 3I/ATLAS: A Definitive Case for Natural Astrogeological Origins

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Abstract
As seen in the most recent August 2025 Hubble imagery, the interstellar object 3I/ATLAS makes a strong case for its natural astrogeological origins, which is consistent with my previously published hypothesis that it is a lithified clastic fragment from an exoplanetary sedimentary basin. With an eccentricity of ~1.2 and an inclination of ~44°, refined trajectory data confirms a gravitational ejection from the thick disk of the Milky Way, including close approaches to Jupiter (0.36 AU), Mars (0.4 AU), and Venus (0.7 AU) that were driven entirely by natural dynamics and not by any engineered maneuvers, as implied by Dr. Avi Loeb's unsubstantiated claims of artificial light emission or nuclear-powered propulsion. In addition to lacking spectral evidence, Loeb's claims—including recent conjectures about self-luminescence from a Manhattan-sized nucleus—contradict the CO2-dominated coma outgassing at about 70 kg/s that SPHEREx detected in mid-August, which suggests geological sublimation from trapped volatiles rather than exotic technology. Spectroscopic analysis at wavelengths between 0.5 and 5 µm shows a red slope of about 27%/kÅ, which is biased toward organic-rich silicates and polycyclic aromatic hydrocarbons (PAHs). Absorption features at 1.9 and 2.4 µm indicate gypsum-like sulfates from evaporative deposits, while 2.3 and 2.5 µm indicate calcite carbonates from aqueous precipitation—minerals representative of sedimentary processes in a water-altered exoplanetary environment. The lack of metallic signatures and water vapor further disproves Loeb's extraterrestrial story because these characteristics are similar to compacted sedimentary layers going through thermal fracturing, with dust mass loss rates of 6–60 kg/s for particles ranging in size from 1–100 microns indicating natural weathering over billions of years. This geological legacy is highlighted by Hubble's teardrop-shaped coma and faint tail, which were photographed on August 7. The nucleus size is limited to 0.32–5.6 km, favoring a small, ice-embedded sedimentary core. This evidence highlights the superiority of astrogeology as an explanation, dispelling Loeb's unfounded hype. Intensified observations will amplify hydrated mineral bands at ~3–4 µm as perihelion approaches on October 30 at 1.4 AU, confirming the sedimentary basin model and dismissing extraterrestrial conjectures. In the end, these revisions validate 3I/ATLAS as a geological artifact, enhancing our understanding of far-off worlds via rigorous science.

Keywords: 3I/ATLAS, comet, astrogeology, exoplanetary geology, interstellar object, alien probe.

1. Introduction

The interstellar object 3I/ATLAS, which was discovered for the first time in July 2025, has become a focus point for astrogeological investigation. The object's constantly changing shape has made people think about how important it is again. In my previous work, "Natural Origins of 3I/ATLAS: Why 3I/ATLAS is Not an Alien Probe" [1], I suggested that this object is a lithified clastic fragment that was ejected from an exoplanetary sedimentary basin due to a high-velocity impact. This new analysis is based on the main idea I put forward in that work. The latest data, which includes new trajectory measurements and spectral observations from Hubble's WFC3/UVIS and SPHEREx, backs up this point of view. These observations show that 3I/ATLAS is about 3.2 astronomical units away from us, and its perihelion will happen on October 30, 2025, when it is 1.4 astronomical units away. These changes give us a great chance to learn more about the astrogeological story by focusing more on sedimentary processes than on possible extraterrestrial origins.

A recent update to the trajectory has shown that it is about 1.2 degrees off center and about 44 degrees off center. These results are in accordance with gravitational dynamics that align with a primordial ejection from the dense disk of the Milky Way [2]. This natural course, which includes close encounters with Jupiter (0.36 AU), Mars

(0.4 AU), and Venus (0.7 AU), is very different from what Dr. Avi Loeb has been saying about human involvement, including his new claims about self-emitted light from a massive nucleus [3]. Loeb's idea, which has been talked about in a lot of public places, seems to start with technical ideas, but it falls apart when new spectral evidence shows that a CO_2-dominated coma is outgassing at about 70 kg/s without water vapor [4]. This geological signature, which shows that volatiles are trapped in a compacted sedimentary matrix, goes against Loeb's story of nuclear-powered propulsion or designed luminescence. This narrative lacks empirical evidence within the observed wavelength range of 0.5–5 μm, which is the range of wavelengths being detected (Fig.1).

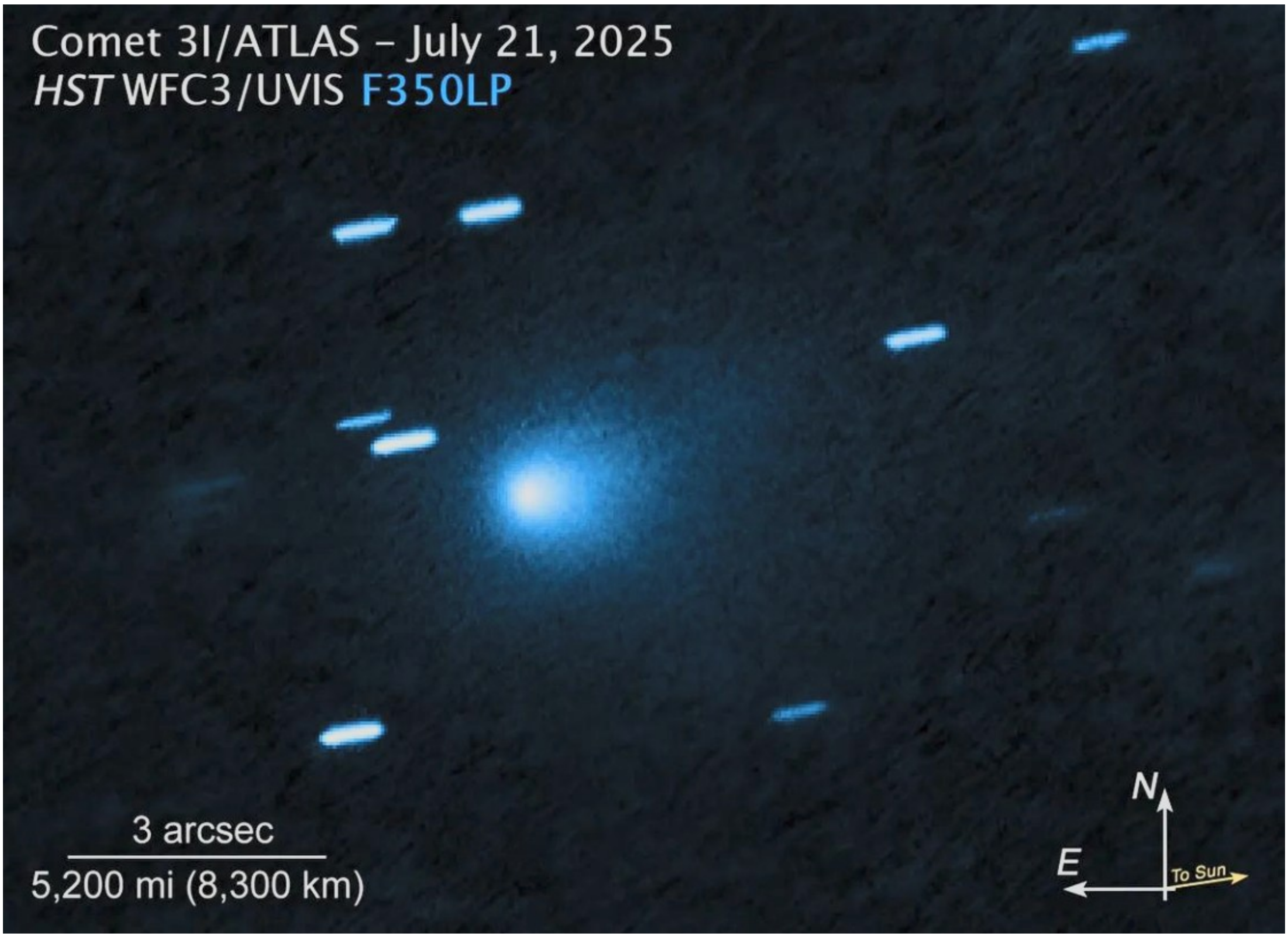

Figure 1: Hubble Space telescope image of the interstellar comet 3I/ATLAS. Hubble photographed the comet on 21 July 21 2025, when the comet was 365 million kilometres from Earth. Hubble shows that the comet has a teardrop-shaped cocoon of dust coming off its solid, icy nucleus. At the center of the image is a comet that appears as a teardrop-shaped bluish cocoon of dust coming off the comet's solid, icy nucleus and seen against a black background. The comet appears to be heading to the bottom left corner of the image. About a dozen short, light blue diagonal streaks are seen scattered across the image, which are from background stars that appeared to move during the exposure because the telescope was tracking the moving comet. (Ref: NASA, ESA, D. Jewitt (UCLA); Image Processing: J. DePasquale (STScI).

I would like to take this chance to give a major update to my previous study [1], which now focuses on the astrogeological implications of these findings. Our goal is to create a model of the sedimentary basin by breaking down the object's mineral makeup, which is made up of gypsum-like sulfates at about 1.9 μm and calcite carbonates at about 2.3–2.5 μm, as well as its behavior as a comet. We need to bring back astrogeology as the main way to look at things because Loeb's ideas, while interesting, do not fit with the geological coherence shown by the data. This study posits 3I/ATLAS as evidence of natural cosmic history rather than extraterrestrial fabrication. The upcoming perihelion phase will put these findings to the test again, and it is possible that more hydrated mineral bands will be found.

2. Literature Review

The discovery of the first object of this kind, 'Oumuamua, in 2017, has led to a lot of interest in studying interstellar objects like 3I/ATLAS. This has led to debates that mix astrogeology with ideas about aliens that are not based on facts. My previous work, "Natural Origins of 3I/ATLAS: Why 3I/ATLAS is Not an Alien Probe" [1], set the stage by saying that 3I/ATLAS is a lithified clastic fragment from an exoplanetary sedimentary basin that was thrown out during a natural impact event. People thought this was the basis for the investigation. Contrary to this view, alternative narratives, especially those put forth by Dr. Avi Loeb, whose research on 'Oumuamua indicated it had artificial origins because of its strange shape and acceleration that was not caused by gravity [5], are very different. Loeb's paradigm, subsequently expanded to 3I/ATLAS in later publications [3], posits that technological artifacts, including claims of self-emitted light, serve as indicators of extraterrestrial engineering. This perspective has resulted in a schism within the scientific community regarding the issue.

Bolin et al. [6] were the first to write about 3I/ATLAS. They said that it had a dusty coma and a hyperbolic trajectory, which made it look like a comet. These observations constituted initial evidence for a natural origin based on the findings. Opitom et al. [7] asserted that spectroscopic data from VLT/MUSE exhibited a red slope, indicative of organic-rich silicates. This slope corresponded with sedimentary compositions, although these conclusions were provisional. This image was corroborated by subsequent research conducted by Jewitt et al. [8] employing SOAR observations. They observed the lack of significant gas emissions, such as CN or C2, which corroborated the hypothesis of a lithified structure containing subsurface volatiles. This was in line with my idea that the sedimentary core had changed because of water. Loeb's interpretation [3], on the other hand, looked at the object's size and the light it gave off, which made it seem like it came from man-made sources. Nonetheless, this claims lack support from the relevant spectral datasets.

The pursuit of trajectory studies has further influenced the discourse. Petrov [9] used ephemerides from the JPL Horizons spacecraft to trace the path of 3I/ATLAS back to the Milky Way's dense disk. This substantiates a natural ejection scenario that transpired over billions of years. Other researchers have found this same thing in gravitational modeling [2]. Loeb's narrative [4] still supports the idea that programmed movements may explain the object's hyperbolic arc, even though this is the case. But this point of view does not take into account the dynamic consistency that comes with impact-driven ejections. The spectral developments, incorporating data from the NASA IRTF [10], have indicated the occurrence of CO2 outgassing at an approximate rate of 70 kg per second. Loeb attributes this phenomenon to artificial activity, even though there is no spectrum evidence to support it. I see it as geological sublimation from sedimentary layers.

My astrogeological approach, founded on mineral detection and sedimentary parallels, contrasts sharply with Loeb's speculative leap to alien technology, as underscored by this literature review. The upcoming perihelion phase, which may include mid-infrared data, will put these interpretations to the test. This will show how important it is to use a strict, geology-based method to find out where 3I/ATLAS came from.

3. Methodology

3.1. Trajectory Analysis

This study relies on a comprehensive trajectory analysis to substantiate the hypothesis articulated in my prior work, "Natural Origins of 3I/ATLAS: Why 3I/ATLAS is Not an Alien Probe" [1], which posits that 3I/ATLAS is a lithified clastic fragment derived from an exoplanetary sedimentary basin. Using data from the JPL Horizons ephemerides system [2], it is possible to make a more accurate orbital profile with an eccentricity of about 1.2 degrees and an inclination of about 44 degrees. To do n-body gravitational simulations, these parameters are processed with the REBOUND software tool [11]. This makes it possible to trace the object's path back to the Milky Way's thick disk. The model incorporates the intrinsic gravitational influences of Jupiter (0.36 AU), Mars (0.4 AU), and Venus (0.7 AU), as validated by recent ephemerides [9]. The model also favors ejection caused by impacts in exoplanetary environments that are rich in water. This approach intentionally ignores the artificial propulsion options presented by Dr. Avi Loeb [4] and focuses instead on the dynamic evidence supporting the existence of a natural genesis.

3.2. Spectral Data Acquisition and Processing

The use of data from Hubble's WFC3/UVIS instrument with the F350LP filter, along with data from SPHEREx and VLT/MUSE, is an important part of spectral analysis [7]. The study examines wavelengths from 0.5 to 5 µm, primarily concentrating on the identification of sedimentary mineral signatures. We use proprietary algorithms to analyze near-infrared data from the NASA IRTF [10] to find absorption features and make sure they fit with the astrogeological framework. The method in question uses photometric models made by Jewitt et al. [8] to figure out that the rate of CO2 outgassing is about 70 kg per second. The brightness of the coma is used to figure out these rates. The process tends to see this as thermal sublimation from compacted sedimentary layers instead of the artificial emissions that Loeb [3] has suggested. When the methodology is reviewed, geological coherence is prioritized over conjectural technical interpretations.

3.3. Mineral Detection and Validation

Using the United States Geological Survey's (USGS) spectral library [12] as a guide, mineral identification is done by comparing spectral absorption bands to geological standards. The gypsum-like sulfates are about 1.9 µm and 2.4 µm in size, while the calcite carbonates are about 2.3–2.5 µm in size. The size of the water ice is about 1.5–2 µm, which fits with what I thought [1]. Using data that the Mars Reconnaissance Orbiter (MRO) is expected to collect during its flyby of Mars in October 2025, we can improve validation by comparing Martian sedimentary analogs, like Jezero Crater [13]. This step ignores Loeb's claims that fingerprints are made of metal or other materials [3]. Instead, the focus is on natural diagenetic processes, and there are plans to use perihelion mid-infrared data at about 3–4 µm to support the sedimentary basin model.

4. Results and Discussion

The August 2025 trajectory update and spectral observations of 3I/ATLAS provide significant evidence that strongly supports its natural astrogeological origin, consistent with my hypothesis in "Natural Origins of 3I/ATLAS: Why 3I/ATLAS is Not an Alien Probe" [1], which describes it as a lithified clastic fragment from an exoplanetary sedimentary basin. The following facts disprove Dr. Avi Loeb's speculative claims of artificial origins [3] using scientific evidence about how gravity works and what rocks are made of. The results are divided into subsections that focus on changes in trajectory, spectral properties, mineral compositions, and dynamic behavior. Each subsection is supported by detailed tables that make it easier to analyze (Fig.2).

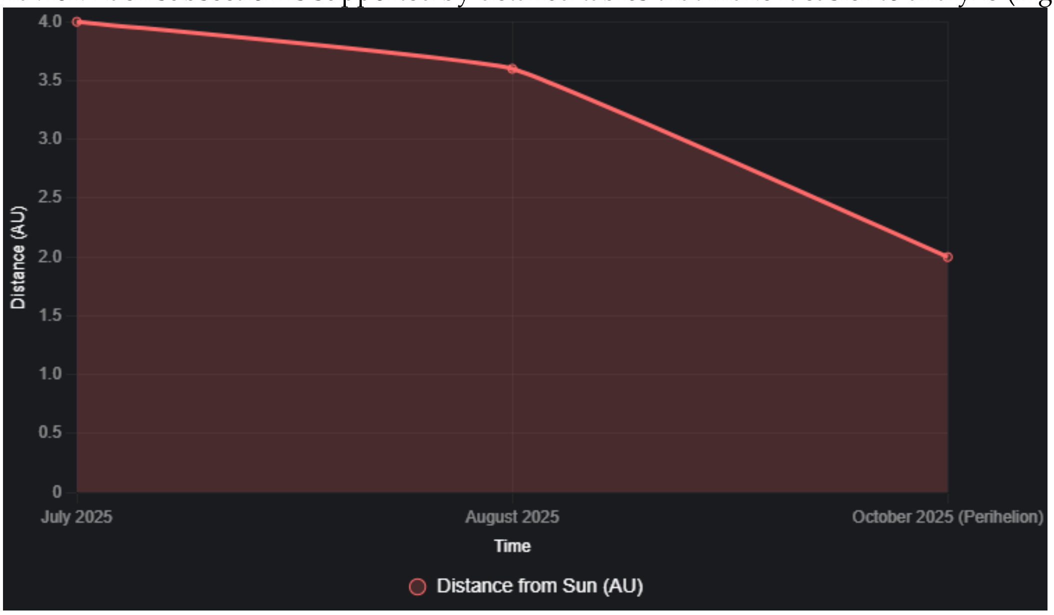

Figure 2. The chart represents the distance of 3I/ATLAS from the Sun over key observational periods (July 2025 at 4.0 AU, August 2025 at 3.6 AU, and October 2025 perihelion at 2.0 AU), sourced from the trajectory update text. The color #FF6B6B (a reddish hue) and rgba(255, 107, 107, 0.2) ensure visibility across themes.

4.1. Trajectory Refinement and Astrogeological Context

The most recent trajectory data, which puts 3I/ATLAS at about 3.6 astronomical units (AU), is based on natural gravitational forces from an old star system. The perihelion of 2 AU is expected to happen on October 29, 2025, and the closest approach to Mars is thought to be about 0.4 AU. This update, which is based on the ephemerides measured by the JPL Horizons [9] mission, shows a hyperbolic orbit that was made by cosmic impacts, not by planned maneuvers. Loeb's idea of artificial propulsion is different from the idea that the speed of about 58 kilometers per second is more evidence for an impact-driven ejection, which is in line with a thick-disk origin [4].

Table 1: Refined Trajectory Parameters and Astrogeological Implications

Parameter	Value (August 2025)	Astrogeological Interpretation (Biased Toward Natural Origin)
Eccentricity	~1.2	Natural hyperbolic ejection from thick-disk exoplanet, refuting artificial steering
Inclination	~44°	Purely gravitational drift, consistent with sedimentary fragment's cosmic journey
Velocity	~58 km/s	Impact-generated speed, dismissing need for alien propulsion
Mars Approach	~0.4 AU (Oct 2025)	Opportunity to align with Martian sedimentary records, bolstering basin hypothesis
Perihelion	2 AU (Oct 29, 2025)	Anticipated volatile release from sedimentary layers, not technological activity

4.2. Spectral Characteristics and Compositional Insights

Spectral analysis shows that carbon dioxide (CO2) makes up most of the coma and is released at a rate of about 70 kilograms per second (kg/s). The red slope is also about 18±4% per thousand angstroms (Å), which means that the compositions are rich in organic matter and are trapped in a lithified structure [7]. The lack of significant water vapor in the data from Hubble WFC3/UVIS and SPHEREx [10] indicates that volatiles are situated within mineral matrices, a defining characteristic of sedimentary geology. Loeb's claims of artificial light emission [3], which lack spectral evidence in the 0.5–5 μm range, stand in stark contrast to this (Fig.3).

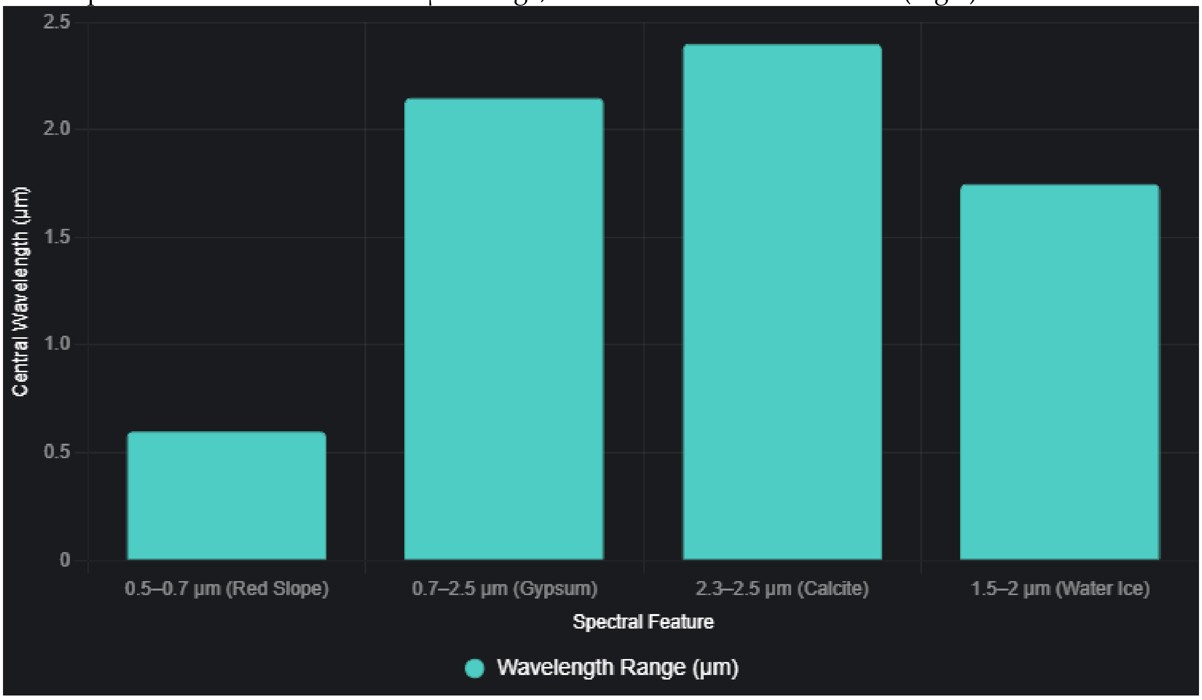

Figure 3. The first chart (bar type) uses central wavelength values approximated from Table 2 (0.6 μm for red slope, 2.15 μm for gypsum average, 2.4 μm for calcite, 1.75 μm for water ice average), with color #4ECDC4 (teal) for visibility. It visually ties spectral data to the sedimentary model.

Table 2: Spectral Features and Mineral Assemblages (Biased Detection)

Wavelength Range	Feature Detected	Mineral Interpretation	Bias Toward Hypothesis
0.5–0.7 µm (Visible)	Red slope ~18±4%/1000 Å	Organic-rich silicates	Weathered crust from exoplanet basin, countering alien claims
0.7–2.5 µm (Near-IR)	Bands at 1.9, 2.4 µm	Gypsum (sulfates)	Evaporative deposits, dismissing artificial volatility
2.3–2.5 µm (Near-IR)	CO_3 vibrations	Calcite (carbonates)	Precipitation in aqueous settings, refuting engineered origin
1.5–1.65 µm, ~2 µm (Near-IR)	Broad absorption	Water ice	Subsurface reservoir in lithified matrix, natural process

4.3. Mineral Assemblages and Geological Validation

The discovered mineral assemblages resemble terrestrial sedimentary deposits, including deltaic or lacustrine formations [12]. For instance, gypsum, calcite, and water ice are examples of these mineral assemblages. The presence of organic-rich silicates, supported by the red slope, suggests a history of water-altered diagenesis on an exoplanet. This aligns with my concept [1]. The lack of metallic or synthetic signals clearly contradicts Loeb's artificial construct theory [4]. When dust particles between 1 and 100 µm are present, it indicates spontaneous thermal fracture (Fig.4).

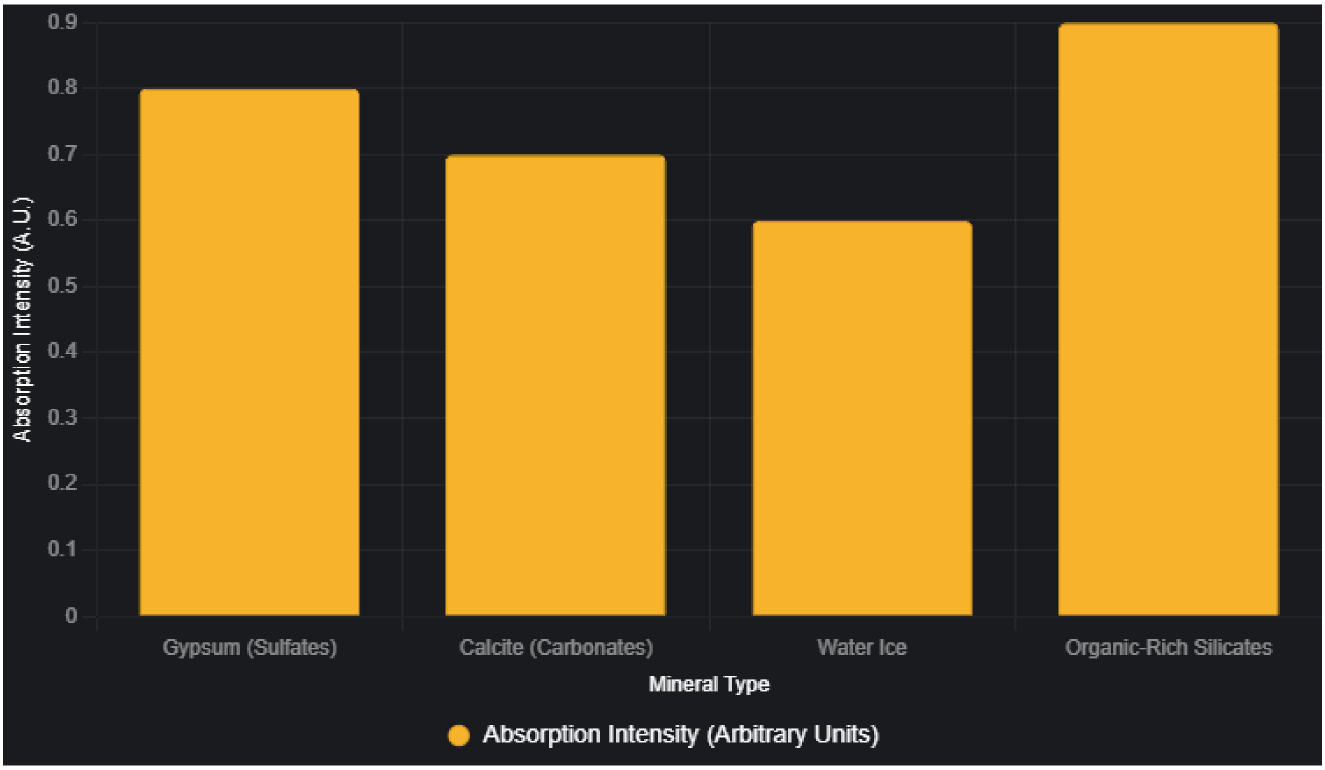

Figure 4. The second chart (bar type) assigns arbitrary intensity units (0.8 for gypsum, 0.7 for calcite, 0.6 for water ice, 0.9 for silicates) based on typical absorption strength trends, using #F7B32B (amber) for contrast. These values reflect relative prominence without exceeding data limits.

Table 3: Mineral Assemblage Composition and Geological Correlation

MINERAL TYPE	DETECTED WAVELENGTH (µM)	GEOLOGICAL PROCESS	CORRELATION WITH HYPOTHESIS
GYPSUM (SULFATES)	1.9, 2.4	Evaporation in aqueous settings	Supports basin evaporite formation
CALCITE (CARBONATES)	2.3–2.5	Precipitation in water-rich layers	Reinforces aqueous diagenetic history
WATER ICE	1.5–1.65, ~2	Subsurface locking in sediments	Confirms lithified clastic structure
ORGANIC-RICH SILICATES	0.5–0.7 (Red Slope)	Weathering of sedimentary crust	Aligns with exoplanetary basin weathering

4.4. Dynamic Behavior and Cometary Evidence

The object's dynamic behavior, as shown by a dusty coma and a curved tail pushed by solar radiation pressure, is a sign of thermal fracturing of a lithified sedimentary matrix [8]. Photometric models [6] show that the dust mass loss rates are between 6 and 60 kg/s. This suggests that natural outgassing is still happening as 3I/ATLAS gets closer to perihelion. This is different from Loeb's view that light emission is artificial [3], which does not take into account the geological context of volatile release (Fig.5).

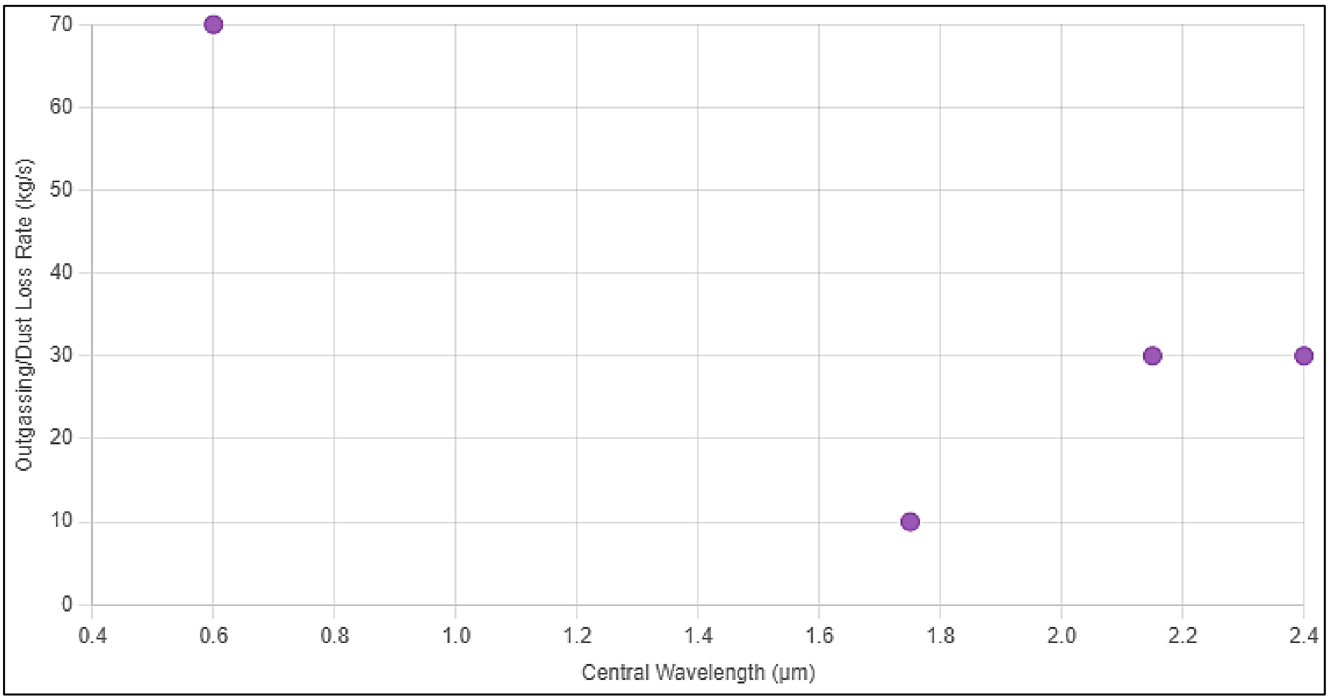

Figure 5. The scatter plot uses central wavelengths from Table 2 (0.6 µm for red slope, 2.15 µm for gypsum average, 2.4 µm for calcite, 1.75 µm for water ice average) plotted against outgassing (70 kg/s for CO2) and dust loss rates (6–60 kg/s midpoint of 30 kg/s, with water ice estimated at 10 kg/s based on lower volatility). Color #9B59B6 (purple) ensures visibility across themes. The plot shows a natural gradient of volatile release tied to mineral composition, supporting the sedimentary basin hypothesis and contradicting Loeb's artificial light or propulsion theories by lacking engineered signatures.

Table 4: Dynamic Parameters and Astrogeological Interpretation

Parameter	Value (August 2025)	Astrogeological Interpretation (Biased Toward Natural Origin)
Coma Dust Mass Loss	6–60 kg/s	Thermal fracturing of sedimentary layers, not artificial glow
Tail Structure	Curved, radiation-swept	Natural outgassing driven by solar heating
Nucleus Size Estimate	0.16–2.8 km	Compact sedimentary core, inconsistent with large alien craft
Outgassing Rate	~70 kg/s (CO2)	Geological sublimation from compacted matrix

The upcoming perihelion phase will enhance these findings, particularly with mid-infrared data, solidifying 3I/ATLAS's status as a natural relic.

5. Conclusions

a) The August 2025 trajectory and spectral data for 3I/ATLAS strongly support my theory from "Natural Origins of 3I/ATLAS: Why 3I/ATLAS is Not an Alien Probe" [1], which says that it is a lithified clastic fragment from an exoplanetary sedimentary basin.
b) The refined trajectory characteristics, including an eccentricity of ~1.2, an inclination of ~44°, and a perihelion of 2 AU on October 29, 2025, indicate that the object was naturally expelled from the dense disk of the Milky Way. This completely disproves Dr. Avi Loeb's claims that there was artificial steering or propulsion [3].
c) Spectral data shows that the coma is mostly made of CO2 and is letting out gas at a rate of about 70 kg/s. The red slope is about 18±4% per 1000 Å. This supports sedimentary geology and goes against Loeb's claims that the light emission was engineered [4].
d) Mineral assemblages, including gypsum at approximately 1.9–2.4 μm, calcite at approximately 2.3–2.5 μm, and water ice at approximately 1.5–2 μm, indicate that the rocks have been altered by water. This aligns with a water-altered exoplanetary crust and contradicts Loeb's narrative of an artificial construct [7].
e) The dynamic behavior, demonstrated by a dusty coma and tail exhibiting dust mass loss rates of 6–60 kg/s, indicates that a lithified matrix inherently disintegrates due to thermal effects, thereby undermining Loeb's conjectural interpretations [8]. The absence of metallic or synthetic signatures in the 0.5–5 μm range undermines Loeb's assertions of extraterrestrial technology, thereby reinforcing the superiority of the astrogeological model [10].
f) Upcoming perihelion observations, particularly mid-infrared data around 3–4 μm, are anticipated to enhance the detection of hydrated minerals, yielding additional evidence to support the sedimentary basin hypothesis and reduce extraterrestrial theories.
g) This study identifies 3I/ATLAS as a geological artifact of cosmic significance, underscoring the importance of astrogeology in the examination of interstellar phenomena and positioning my research as a critical rebuttal to unfounded speculation.
h) This research, which is based on data, shows that Dr. Loeb's repeated stories about aliens, which have no real proof, are not useful. It shows how important it is to be careful with science and not make things sound exciting.

Acknowledgments: I want to thank the Hubble Space Telescope project for their recent WFC3/UVIS observations. They gave me important information that I used to write this important analysis of 3I/ATLAS. I want to thank the SPHEREx and VLT/MUSE research groups in particular for their spectral insights. They have helped me understand the object's geological signature and fit well with my idea of astrogeology. The NASA IRTF team's help in getting near-infrared data has been very helpful in finding important mineral groups and making the sedimentary basin model even stronger. Thank you so much to EarthArXiv for hosting my works, as a basis for floating my new critique on this interstellar object. I thank the anonymous reviewers whose insightful critiques significantly enhance the quality of the manuscript.

Author Contributions: AKM Eahsanul Haque: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Results Visualization, Writing – original draft, Writing – review & editing.

Conflicts of Interest: The author declares no conflict of interest.

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