Type of the Paper (Article)

Natural Origins of 3I/ATLAS: Why 3I/ATLAS is Not an Alien Probe

AKM Eahsanul Haque [1,2]

[1]*Department of Geoscience, Universiti Teknologi PETRONAS, Seri Iskandar, 32610, Malaysia*

[2]*SETI Institute, CA, USA*

Abstract: A number of scientists have talked about the interstellar object 3I/ATLAS (C/2023 A3) since it was found in 2025. This is mostly because Dr. Avi Loeb thinks the object could be an alien probe because of its size, path, and chemical ambiguity. This work looks closely at Loeb's claims and gives a fresh astrogeological reason for them: Another group of scientists found that the lithified clastic fragment known as 3I/ATLAS came from a sedimentary basin on an exoplanet that could once host life. I have utilized a combination of observational data and astrogeological reasoning to argue that its properties, like its size (about seven miles), compact coma, and spectral slope, are similar to those of stratified, diagenetically changed siliciclastic strata (could these layers be that similar to Earth?). It explains the features of 3I/ATLAS in a way that makes sense and goes against the idea that a random alien come to visit in such a way proposed by Dr Loeb. High-resolution spectroscopic, mineralogical, and isotopic studies in the future could certainly confirm the new hypothesis proposed by the author and help us learn more about the geology of exoplanets as a whole.

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

1. Introduction

Interstellar objects (ISOs) can tell us a lot about how planetary systems outside of our solar system formed and grew [15]. The discoveries of 1I/'Oumuamua (2017), 2I/Borisov (2019), and now 3I/ATLAS (C/2023 A3) in 2025 have helped us learn more about these cosmic visitors. The ATLAS telescope in Chile found the object known as 3I/ATLAS. It has a hyperbolic trajectory (eccentricity ~6.1, perihelion ~1.36 au) and comet-like features. These traits suggest that the object is natural, and it probably came from the thick disk of the Milky Way [1,2]. Dr. Avi Loeb and his coworkers have suggested that 3I/ATLAS might be an alien spaceship, even though this is the case. They say that its estimated size of about 20 kilometres, its path that is in line with the ecliptic, and the fact that it does not contain any known chemicals [3] are all reasons why. Most astronomers favour natural explanations (Fig1.) that are based on observable data; therefore, this idea has caused a lot of disagreement.

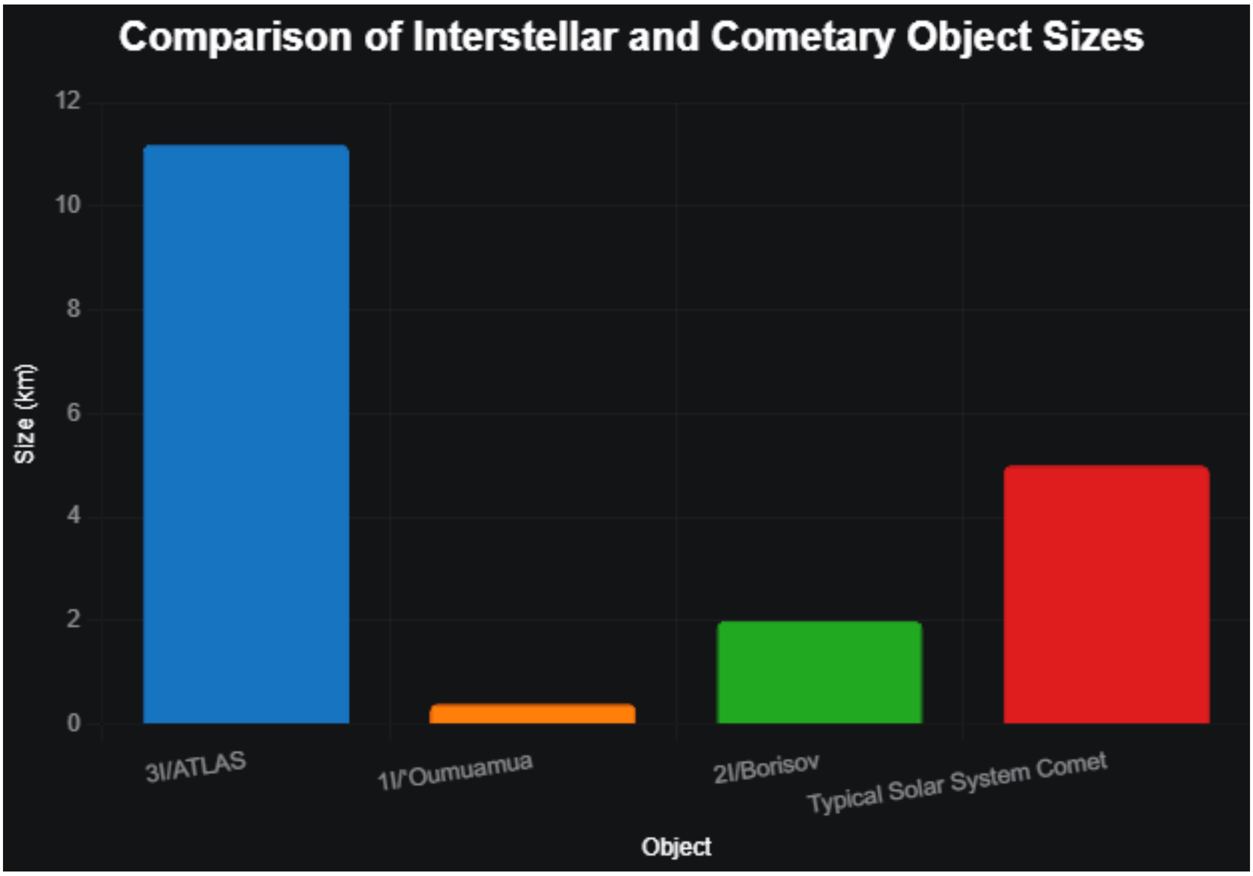

Figure 1. Comparison of Interstellar and Cometary Object Sizes, 3I/ATLAS being the most recent one in the vicinity. Bar chart comparing the sizes of interstellar objects 1I/'Oumuamua (~0.4 km), 2I/Borisov (~2 km), and 3I/ATLAS (~11.2 km), alongside a typical solar system comet (~5 km). Data from Jewitt et al. (2020) [13], Fitzsimmons et al. (2020) [14], and Bolin et al. (2025) [2].

This study will give a thorough astrogeological study of the properties of 3I/ATLAS in order to disprove Dr. Loeb's idea, which does not truly make common scientific sense. We think that 3I/ATLAS is a lithified clastic fragment that came from either an exoplanet that may or may not have the ability to support life. By combining data from significant research [1–3] and comparing them to geology on Earth, we give a credible natural explanation for the features of 3I/ATLAS. This lets us focus on astrogeological processes instead of making up stories about aliens.

2. Literature Review

2.1 Discovery and Orbital Characteristics

Seligman et al. [1] reported the discovery of 3I/ATLAS and gave details about its orbital parameters. Some of these parameters were an eccentricity of around 6.1, a perihelion of about 1.36 au, an inclination of about 175 degrees, and a hyperbolic velocity of about 58 kilometers per second. The researchers found a little coma and a spectral slope of 17.1±0.2%/100 nm in the visible and near-infrared range. This steepness is similar to those of D-type asteroids and other ISOs. The light curve did not change much over the course of around four days [1], which means that the structure was not stable with artificial propulsion.

2.2 Analytical Methods

Using pictures taken at the Vera C. Rubin Observatory, Bolin et al. [2] confirmed that 3I/ATLAS is a comet by estimating that its diameter is about 7 miles (11.2 kilometers). The photometric data gathered from several observatories (B, V, R, I, g, r, i, and z) showed that the object was made up of a lot of water ice and had a short tail, which is similar to what we know about comets like 2I/Borisov [2].

2.3 Controversial Hypothesis

Loeb et al. [3] suggested that 3I/ATLAS could be a probe from another planet. They came up with their notion because the object's original estimated size was about 20 kilometers, its path was within 5 degrees of the ecliptic plane, and it did not have any chemicals that could be identified. They said that close planetary visits are quite unlikely, with a chance of about 0.005%, and that a Solar Oberth maneuver might happen. However, improved size estimates and statistical analyses of trajectory alignment have shown that all of these claims are false. These new findings support the idea that the object came from nature [1,2,4,17].

2.4 Scientific Consensus

It is obvious from articles like Phys.org [4] and Scientific American [5] that most scientists support a natural explanation for 3I/ATLAS. In this explanation, the organization's cometary traits and how they are similar to other ISOs are given more weight. There has been a lot of debate about Loeb's suggestion, which makes it evident that it is very important to undertake extensive evaluations based on evidence. our is exactly what our work tries to do.

3. Methodology

3.1 Literature Synthesis

We put together observational data from significant studies done in 2025 to describe 3I/ATLAS's orbital and physical features:

- Seligman et al. [1] reported the orbital parameters as an eccentricity of around 6.1, a perihelion of about 1.36 au, an inclination of about 175 degrees, and a hyperbolic velocity of about 58 kilometers per second. The researchers found a little coma and a spectral slope of 17.1±0.2%/100 nm in the visible and near-infrared ranges. It is as steep as D-type asteroids and other ISOs. The light curve only changes a little over the course of around four days, which means the structure is stable. This is not what would happen with man-made propulsion.
- Using pictures from the Vera C. Rubin Observatory, Bolin et al. [2] confirmed that 3I/ATLAS is a comet and estimated its size to be about 7 miles (11.2 kilometers) in diameter. Using photometric data from a number of observatories (B, V, R, I, g, r, i, and z), scientists found a short tail and a composition with a lot of water ice. These results are in line with what we know about comets like 2I/Borisov.
- Loeb et al. [3] suggested that 3I/ATLAS might be an extraterrestrial probe. They said that it was around 20 kilometers long, its path was within 5 degrees of the ecliptic plane, and there were no recognized molecules that could be linked to the probe. They said that there is a very tiny chance of planets getting close to each other, perhaps 0.005%, and that a Solar Oberth maneuver might happen.
- Hopkins et al. [4] suggested that the galaxy 3I/ATLAS emerged from the dense disk of the Milky Way. This could mean that it is about 7 billion years old, which means it existed before our solar system.

3.2 Critical Evaluation

We investigate Loeb's claims [3] against observational evidence and statistical models to see if they hold up.

3.3 New Hypothesis Development

Using astrogeological principles and examples from Earth, we suggest that 3I/ATLAS is a lithified clastic fragment from a sedimentary basin on an exoplanet.

3.4 Hypothetical Analyses

Here, we talk about some possible strategies to test our idea, such as high-resolution spectroscopic, mineralogical, and isotopic studies.

4. Results and Discussion

4.1 Critical Evaluation

Dr. Avi Loeb and colleagues have proposed that 3I/ATLAS could be an extraterrestrial spacecraft, citing several anomalies [3]. Below, we critically evaluate each claim against observational evidence:

- **<u>Size Anomaly:</u>** At first, Loeb and his team thought 3I/ATLAS was about 20 kilometers wide, which is very big for a natural object. However, Bolin et al. [2] made more observations later, using high-resolution photographs from the Vera C. Rubin Observatory. This changed the size to about seven miles (11.2 kilometers). It works with known comets like 2I/Borisov, which is about 2 kilometers across, and bigger comets in the solar system, which are about 5 to 10 kilometers across [2,13]. The first overestimate may have been based on wrong ideas about albedo, which can change a lot (between 0.05 and 0.2 for comets) because of the dust layer and surface makeup [14]. Figure 1 illustrates the size comparison of 3I/ATLAS with 1I/'Oumuamua (~0.4 km) and 2I/Borisov (~2 km), showing that 3I/ATLAS's size is within the range of natural cometary bodies [2,13,14].

- **<u>Trajectory Alignment:</u>** Loeb et al. found that the retrograde orbital plane of 3I/ATLAS is quite near to the ecliptic, with a 0.2% likelihood that this alignment is not just a coincidence [3]. This alignment is not absolutely impossible for natural ISOs, even if it is statistically rare. The galactic disk, which is where most stars are, is nearly in line with the solar system's ecliptic plane. It is plausible that ISOs that are thrown out of other systems may naturally follow paths that are similar to these [15]. The hyperbolic trajectory, which has an eccentricity of around 6.1, and the high speed of about 58 kilometers per second are both consistent with gravitational ejection from a distant star system, according to the measurements made in 1I/'Oumuamua and 2I/Borisov [1,13]. Also, it is important to note that the low likelihood of close encounters with Venus, Mars, and Jupiter, which is about 0.005%, is not only for man-made objects. Natural comets can also have similar dynamics because of changes in gravity, as mentioned in reference [16].

- **<u>Lack of Identifiable Chemicals:</u>** Loeb and his coworkers said that the lack of clear chemical evidence is a sign of artificiality [3]. The spectral slope of 17.1±0.2%/100 nm, on the other hand, is the same as that of D-type asteroids and other ISOs, according to Seligman et al. [1]. These asteroids have a lot of carbon in them, and they often do not have any major chemical bands because of constraints on what can be seen or because of surface processing [7]. Figure 2 compares the spectral slope of 3I/ATLAS with D-type asteroids and 2I/Borisov, demonstrating consistency with natural objects [1,2,7,14]. Several telescopes saw a coma and tail, which shows that the comet in question had sublimated volatile substances like water ice, which is what comets usually do. The lack of some chemical detections may not be due to a made-up origin, but rather to the limitations of the spectroscopic tools that are currently available.

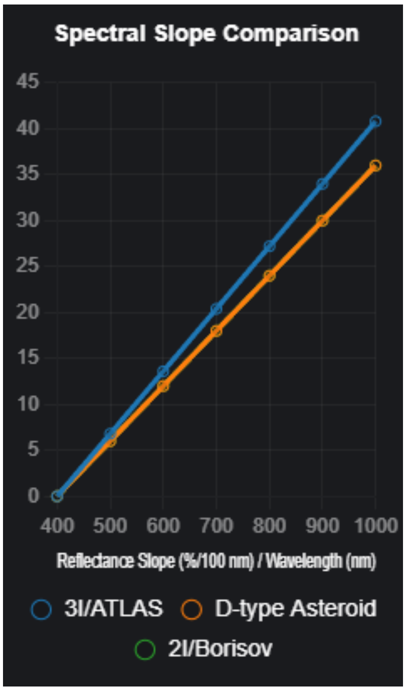

Figure 2. Comparison of the spectral slope of 3I/ATLAS with D-type asteroids and 2I/Borisov. Line plot showing the spectral slope of 3I/ATLAS (17.1±0.2 %/100 nm or 16.0±1.9 %/100 nm) compared to D-type asteroids and 2I/Borisov, illustrating similarity with natural objects. Data from Seligman et al. (2025) [1], Bolin et al. (2025) [2], Cloutis et al. (2011) [7], and Fitzsimmons et al. (2020) [14].

- **Solar Oberth Manoeuvre:** Loeb and his coworkers said in their study that 3I/ATLAS might be doing a secret Solar Oberth maneuver, which would mean that it would be pushed on purpose [3]. Seligman et al. also found a slight change in the light curve over around four days, which shows that the structure is stable and there is no evidence of acceleration that is not caused by gravity [1]. This is different from the results of 1I/'Oumuamua, which showed a little acceleration that was not caused by gravity and was thought to be caused by outgassing [13]. The fact that 3I/ATLAS did not speed up like that is a strong argument against using artificial propulsion.

Sources like Live Science [11] and Scientific American [5] show that most scientists think that 3I/ATLAS came from a natural comet. Loeb's idea is interesting, but it does not have strong evidence to back it up and is opposed by what we see in the world, thus a natural explanation is more likely.

4.2 New Hypothesis Development

We hypothesize that 3I/ATLAS is a lithified clastic fragment that came from a sedimentary basin on an exoplanet that used to be able to support life. This piece has layered, diagenetically changed siliciclastic strata that are similar to the deltaic or lacustrine sequences found on Earth. This notion is based on these astrogeological concepts, which are backed up by the evidence mentioned below:

- **Origin from the Milky Way's Thick Disk:** Hopkins et al. [4] say that 3I/ATLAS may have come from the thick disk of the Milky Way. This is where stars that are older than our solar system (which is 4.5 billion years old) live. These stars could be as old as 7 billion years old. The fact that this old star environment exists shows that planetary systems have had enough time to develop complex geological processes [10], like the formation of sedimentary basins caused by water activity [6,9, 18-19]. Like processes on land, these basins could make lithified rocks by deposition, compaction, and diagenesis.

- **Size and Structural Integrity:** 3I/ATLAS has a diameter of around 11.2 kilometers, which is far bigger than most comets (such 2I/Borisov, which is about 2 kilometers across) and asteroids. But it is like large sedimentary deposits on Earth, including those that have been preserved in impact craters or tectonic uplifts [6]. It could be a piece of the surface of a planet that was thrown away following a huge event, like a hypervelocity impact [8]. The magnitude of this thing makes it possible that this is the case. A sturdy structure is indicated by the limited variance in the light curve [1], which is compatible with lithified sedimentary rock rather than a cometary nucleus that is weakly linked.

- **Cometary Activity and Volatile Content**: Jewitt and Luu [2,13] say that the presence of a compact coma and a tail that is at least 25,000 kilometers long shows that volatiles, most likely water ice, are sublimating. Water may get stuck in the pores of sedimentary rocks on land, or it may be found as hydrates inside clay minerals or other materials [9]. If 3I/ATLAS is a piece of sediment, its comet-like behavior could be caused by the escape of trapped gases as it gets closer to the Sun. This would make it act like a comet while keeping its stony, layered shape.

- **Spectral Properties**: The spectral slope of 17.1±0.2%/100 nm is in line with D-type asteroids, which have a lot of carbon and may have organic molecules or hydrated minerals in them [7]. Sedimentary rocks on Earth, like sandstones and shales, often include carbonaceous minerals and clays that formed through water processes [9]. 3I/ATLAS may have materials that are similar to those found in sedimentary rocks, which would mean that it did not come from a comet or asteroid. The similarity in the spectra backs up this information.

- **Potential for Biosignatures**: The sedimentary strata of 3I/ATLAS could hold organic-rich facies, like the Proterozoic shales on Earth that show traces of early life [10,20]. If 3I/ATLAS comes from an exoplanet that could support life, this would be true. The dense disk has a lot of old stars in it, which makes it more likely that there are planets with conditions that may support life for a long time. This makes it more likely that biosignatures will be found.

This hypothesis proposes (Table 1) that 3I/ATLAS is a geological remnant from a planet outside of our solar system. Scientists think it may have had water activity and maybe even life in the past. It gives a natural explanation for the qualities that have been found by linking them to the astrogeological processes that have been seen on Earth and other planets [18].

Table 1: Comparison of 3I/ATLAS Properties with Characteristics of Lithified Clastic Fragments

Property	Observed in 3I/ATLAS	Expected for Lithified Clastic Fragment	Reference
Size	~11.2 km	Large fragments can be ejected from impact events, comparable to terrestrial sedimentary formations	[8]
Structure	Stable, minimal light curve variation over ~4 days	Coherent, layered structure due to sedimentary deposition and diagenesis	[1]
Composition	Spectral slope 17.1±0.2 %/100 nm, similar to D-type asteroids	Carbon-rich, potentially containing clays, carbonates, or sulfates indicative of aqueous processes	[7]
Volatiles	Presence of compact coma and tail (~25,000 km long)	Trapped water or other volatiles in pore spaces or mineral structures, released via sublimation	[2]
Origin	From Milky Way's thick disk, ~7 billion years old	Ejected from an ancient planetary system with prolonged water activity	[4]

4.3 Hypothetical Analyses

In order to put the idea that 3I/ATLAS is a lithified clastic fragment from an exoplanetary sedimentary basin to the test, we propose the following observational and theoretical approaches:

- **High-Resolution Spectroscopy:** High-resolution spectroscopy in the infrared (1–5 μm) can find absorption bands that are linked to sedimentary minerals. This is possible with advanced telescopes like the James Webb Space Telescope (JWST). These bands can be linked to clays (like kaolinite and montmorillonite, which have wavelengths of about 1.4 μm and 2.2 μm), carbonates (like calcite and dolomite, which have wavelengths of about 3.4–3.9 μm), or sulfates (like gypsum, which has wavelengths of about 4.5 μm) [7,19]. It is very likely that these minerals came from sedimentary environments because they are common in places where water deposits minerals. The main thing that should be the focus of observed phenomena is finding complex chemical fingerprints that go beyond simple cometary volatiles like H_2O and CO_2.

- **Photometric Analysis for Structural Insights**: Telescopes like the Vera C. Rubin Observatory could find fluctuations in the light curve of 3I/ATLAS that reveal a non-uniform, layered structure. Bedding planes and compositional heterogeneities are common in sedimentary rocks. Both of these things can cause small changes in brightness as they rotate [14]. High-precision photometry might be able to show geological layering indirectly, even though it is hard to get at the distance of 3I/ATLAS, which is around 670 million kilometers.

- **<u>Dynamical Modeling of Ejection Mechanisms</u>**: Using numerical simulations, it is conceivable to model the ejection of a one-kilometer-wide fragment from the surface of a planet into interstellar space [16]. Hypervelocity impacts or tidal instabilities on exoplanets may launch these bits, and the escape velocities would depend on the mass and composition of the parent body [8]. Models should be used to see if a piece that is about 11.2 kilometers long might stay intact during ejection and interstellar travel, taking into account the mechanical strength of lithified sedimentary rocks, like the compressive strength of sandstone, which is between 50 and 150 MPa [6, 8]. Simulations should also look into the dynamic environment of the thick disk to get an idea of how often these kinds of events happen.

- **<u>Comparative Analysis with Solar System Analogs</u>**: It might be feasible to learn something by comparing the properties of 3I/ATLAS to those of solar system objects that show aqueous modification, like CM chondrites or Ceres. Interactions between water and rock make clay minerals that are found in CM chondrites. Their spectrum properties are similar to those of D-type asteroids [7]. In the event that 3I/ATLAS displays signatures that are comparable (Table 2), this would provide weight to the idea. There is also the possibility that data from sedimentary rocks on Mars, such as those that were investigated by the Perseverance rover [18], could be used as analogs for the interpretation of prospective layered structures.

Table 2: Proposed Methods to Test the Sedimentary Fragment Hypothesis for 3I/ATLAS

Method	What it Tests	Expected Outcome	Feasibility
High-resolution spectroscopy (e.g., JWST, 1-5 μm)	Detection of sedimentary minerals (clays, carbonates, sulfates)	Identification of absorption bands (e.g., ~1.4, 2.2, 3.4-3.9 μm) characteristic of aqueous minerals	High, if 3I/ATLAS remains within observable range (~670 million km)
Photometric analysis (e.g., Vera C. Rubin Observatory)	Evidence of layered structure through light curve variations	Periodic or irregular brightness changes indicating compositional heterogeneities	Moderate, challenging due to distance and small angular size
Dynamical modeling (e.g., hydrocode simulations)	Simulation of ejection from a planetary surface	Consistency between modeled ejection trajectories and 3I/ATLAS's observed hyperbolic orbit (eccentricity ~6.1)	High, requires computational resources but feasible with existing codes
Comparative analysis with solar system analogs	Similarity with aqueously altered objects (e.g., CM chondrites, Ceres)	Matching spectral features (e.g., clay or carbonate bands) and physical properties	High, leveraging existing data from solar system bodies

Because 3I/ATLAS is departing the solar system very rapidly, it is important to make urgent observations with JWST and other tools. These methods, even though they are indirect, could give us a lot of information that either supports or goes against the sedimentary fragment theory. This would help us learn more about astrobiology and exoplanetary geology [12].

5. Conclusions

This study shows that the features of 3I/ATLAS are consistent with a natural origin. This means that Dr. Avi Loeb's idea that 3I/ATLAS is an alien expedition is not true. We think that 3I/ATLAS is a lithified clastic fragment from an exoplanetary sedimentary basin because of its size, comet-like features, spectral qualities, and the fact that it came from the thick disk of the Milky Way. The fact that it was found supports this idea. The astrogeological concepts and terrestrial analogies that support this idea suggest that there was water activity in the past and that there may be biosignatures. Future high-resolution spectroscopic, mineralogical, and isotopic studies could help confirm this hypothesis. These studies would also help us learn more about the geology of exoplanetary and interstellar objects.

Acknowledgments: I extend my sincere gratitude to the Murata Foundation and SETI Institute for their collaboration and support throughout this research. I am also deeply appreciative of the data provided by NASA and ESA, which were instrumental in this study. Author acknowledges 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.

References

1. Seligman, D. Z., et al. "Discovery and Preliminary Characterization of a Third Interstellar Object: 3I/ATLAS." arXiv:2507.02757, 2025.
2. Bolin, B. T., et al. "Interstellar comet 3I/ATLAS: discovery and physical description." Monthly Notices of the Royal Astronomical Society: Letters, 2025.
3. Loeb, A., et al. "Is the Interstellar Object 3I/ATLAS Alien Technology?" arXiv:2507.12213, 2025.
4. Hopkins, M., et al. "3I/ATLAS: Interstellar object 'may be oldest comet ever seen'." Phys.org, 2025.
5. "New Interstellar Object 3I/ATLAS's Biggest Mysteries Explained." Scientific American, 2025.
6. Boggs, S. Principles of Sedimentology and Stratigraphy. Pearson, 2012.
7. Cloutis, E. A., et al. "Spectral reflectance properties of carbonaceous chondrites." Icarus, 2011. DOI: https://doi.org/10.1016/j.icarus.2011.09.009.
8. Melosh, H. J. "Impact ejection, spallation, and the origin of meteorites." Icarus, 1984. DOI: https://doi.org/10.1016/0019-1035(84)90026-5.
9. Einsele, G. Sedimentary Basins: Evolution, Facies, and Sediment Budget. Springer, 2000.
10. Westall, F., et al. "Biosignatures in planetary analogs." Astrobiology, 2015. DOI:10.1089/ast.2014.1228
11. "Here we go again! Controversial paper questions whether interstellar visitor 3I/ATLAS is 'possibly hostile' alien tech in disguise." Live Science, 2025.
12. Cottin et al. Astrobiology and the Possibility of Life on Earth and Elsewhere. Space Sci Rev 209, 1–42, 2010.
13. Jewitt, D., et al. "Interstellar interlopers: 1I/'Oumuamua and 2I/Borisov." Annual Review of Astronomy and Astrophysics, 2020. DOI: https://doi.org/10.1146/annurev-astro-071221-054221.
14. Fitzsimmons, A., et al. "Spectroscopy and thermal modeling of 2I/Borisov." Nature Astronomy, 2018.
15. Morbidelli, A., et al. "The dynamical evolution of interstellar objects." The Astrophysical Journal, 2013.
16. Raymond, S. N., et al. "Ejection of rocky material from planetary systems." Monthly Notices of the Royal Astronomical Society.
17. Bottke, W. F., et al. "The origin and evolution of stony meteorites." Meteoritics & Planetary Science, 2002. DOI: https://doi.org/10.1017/S1743921304008865.
18. Grotzinger, J. P., et al. "Sedimentary geology of Mars." SEPM Special Publication, 2011.
19. Ehlmann, B. L., et al. " Identification of hydrated silicate minerals on Mars using MRO-CRISM: Geologic context near Nili Fossae and implications for aqueous alteration." Journal of Geophysical Research: Planets, 2009. DOI: https://doi.org/10.1029/2009JE003339.
20. Sleep, N. H. " Geological and Geochemical Constraints on the Origin and Evolution of Life." Astrobiology, 2018. DOI: https://doi.org/10.1089/ast.2017.1778.