An Inquiry into the Engines of Creation: Evaluating an Electromagnetic Hypothesis for Planetary Formation

Foundational Concepts: Defining "Metaloid," "Metallic," and M-Type Worlds

To embark on an exploration of planetary origins, it is essential to first establish a precise scientific vocabulary. The terms used to describe the fundamental materials of the cosmos carry specific meanings that shape our understanding. A critical distinction must be drawn between the chemical term "metalloid" and the astronomical classification "metallic," as this clarification is foundational to correctly identifying the nature of the asteroid 16 Psyche.

In chemistry, a **metalloid** is a specific class of element on the periodic table that possesses properties intermediate between those of metals and nonmetals.[1] The six commonly recognized metalloids are boron, silicon, germanium, arsenic, antimony, and tellurium.[1] Silicon, for example, exhibits a metallic luster but is brittle like a nonmetal.[3] Crucially, metalloids are often semiconductors, meaning their ability to conduct electricity falls between that of a conductor (like copper) and an insulator (like glass), a property that makes them indispensable in modern electronics.[4] A metalloid is therefore not a large object made of metal, but a specific type of element with a unique electronic structure.

In stark contrast, when astronomers describe a celestial body as **metallic**, they are referring to its bulk composition. A metallic asteroid is one composed predominantly of metals, such as iron and nickel.[6] This is a description of the material from which the object is made, not a classification of its constituent elements as metalloids. This leads to the formal astronomical classification of

M-type asteroids, where the "M" signifies "metallic".[6] These bodies are typically identified by their moderate reflectivity (albedo) and a generally featureless, flat-to-reddish spectrum of reflected light, which bears a strong resemblance to the spectra of iron meteorites found on

Earth.[8]

With these definitions in place, the asteroid 16 Psyche can be classified correctly. Based on extensive radar and spectral observations, Psyche is not a metalloid. It is a prominent **M-type asteroid**, believed to be a world rich in metallic iron and nickel.[10] While the term "metaloid" is scientifically inaccurate in this context, the intuition behind its use is perceptive. It hints at an object that is somehow "in-between" the more common categories of solar system bodies. Most asteroids are either rocky (S-type) or carbonaceous (C-type); M-type asteroids like Psyche represent a third, fundamentally different kind of world.[10] This initial correction in terminology allows for a more accurate and fruitful investigation into the forces that may have shaped this unique object.

The Nature of 16 Psyche: A Window into a Lost World

Located in the main asteroid belt between the orbits of Mars and Jupiter, 16 Psyche is a truly remarkable object. It is the most massive known M-type asteroid, with an irregular, potato-like shape measuring approximately 173 miles (280 kilometers) at its widest point.[13] For decades, the scientific consensus held that Psyche was almost entirely composed of metal, a solid body of iron and nickel.[14] However, as observational techniques have improved, a more complex and intriguing picture has emerged.

More recent analyses of Psyche's density, estimated to be between 3,400 and 4,100 kilograms per cubic meter (kg/m3), reveal that it is significantly less dense than a solid iron-nickel body (which would be closer to 8,000 kg/m3).[13] This suggests that Psyche is likely a mixture of metal and silicate rock, with metal composing an estimated 30% to 60% of its volume.[14] Further complicating the picture, spectral observations have detected a weak absorption feature near a wavelength of 3 micrometers, which is indicative of hydrated minerals on its surface.[8] The presence of water-bearing minerals on a body once thought to be the dry, metallic core of a planetesimal presents a fascinating scientific puzzle. These apparent contradictions are not signs of confusion; rather, they are the very engine driving the scientific inquiry into Psyche's origins.

To resolve this mystery, scientists have formulated several competing hypotheses, each offering a different narrative for Psyche's formation.

- **The Stripped Core Hypothesis:** This is the most prominent and long-standing theory. It posits that Psyche is the exposed iron-nickel core of a planetesimal—a planetary embryo—from the dawn of the solar system. In this scenario, the planetesimal grew large enough to undergo differentiation, a process where heavier materials sink to form a metallic core while lighter materials form a rocky mantle and crust. A series of violent,

hit-and-run collisions then stripped away this outer rocky shell, leaving the dense core exposed.[10] If true, Psyche offers an unparalleled opportunity to study a planetary core directly, a feat impossible on Earth, where the core is buried beneath thousands of kilometers of rock.[12]

- **The Primordial Metal-Rich Body Hypothesis:** An alternative model suggests that Psyche was not stripped of its layers but instead formed from the very beginning from material in the solar nebula that was unusually rich in metal.[10]
- **The Re-accreted Body Hypothesis:** A more nuanced variation proposes that a differentiated protoplanet was completely shattered by an impact. The fragments, a mix of core metal and mantle rock, then gravitationally re-accumulated into the mixed body we observe today. This model is consistent with the composition of mesosiderites, a class of stony-iron meteorites.[8]
- **The Ferrovolcanic World Hypothesis:** A fourth possibility is that Psyche is a differentiated body that, due to a specific mixture of iron and volatile elements like sulfur, experienced a form of iron volcanism, or ferrovolcanism, as it cooled, shaping its surface and composition.[8]

These unresolved questions are the central focus of NASA's *Psyche* mission. Launched on October 13, 2023, the spacecraft is on a multi-year journey to orbit the asteroid, with arrival scheduled for August 2029.[10] Its scientific payload is specifically designed to gather the data needed to distinguish between these origin hypotheses.[10] The

Multispectral Imager will map the surface geology and help differentiate between metallic and silicate regions. The **Gamma-Ray and Neutron Spectrometer** will determine the precise elemental composition of the surface. The **X-band Gravity Science Investigation** will map Psyche's gravity field to reveal its internal mass distribution, helping to determine if it is a solid core or a porous rubble pile. Finally, a **Magnetometer** will search for any remnant magnetic field. The discovery of a preserved magnetic field would be powerful evidence that Psyche once had a molten, convecting core that generated a magnetic dynamo, strongly supporting the stripped core hypothesis.[10] By studying this object, which can be seen as a case of "arrested planetary development," we are examining a fossilized planetary embryo, providing a snapshot of a stage that all terrestrial planets, including Earth, once passed through but which is now forever hidden from our view.[11]

The Architects of the Cosmos: A Multi-Angle Evaluation of Gravity and Electromagnetism

The universe is governed by four fundamental forces: the strong and weak nuclear forces,

electromagnetism, and gravitation.[21] For the grand-scale construction of planets and stars, only the latter two are relevant, as the nuclear forces operate exclusively at the subatomic level.[21] A central question in understanding planetary formation is which of these two long-range forces serves as the primary architect. A multi-angle evaluation, from both a physical and an astronomical perspective, reveals a clear and unambiguous answer.

From a physics standpoint, there is no contest in raw power: the electromagnetic force is astoundingly stronger than gravity. At the level of individual particles, it is roughly 1036 times more powerful.[22] This immense strength is easily demonstrated in everyday life: a small refrigerator magnet can overcome the gravitational pull of the entire planet Earth to hold a piece of paper.[23] However, this strength is tied to electric charge, which exists in two forms: positive and negative.[24] This duality is the key to its role in the cosmos. In contrast, gravity is the weakest of the four forces. Its "charge" is mass, and critically, mass is only positive; it is always attractive.[21]

This fundamental difference leads to a dramatic "power inversion" as we move from the microscopic to the macroscopic scale. On large scales, matter is overwhelmingly electrically neutral. Celestial bodies like asteroids, planets, and stars contain a near-perfect balance of positively charged protons and negatively charged electrons. As a result, their powerful attractive and repulsive electromagnetic forces cancel each other out almost completely.[21] This "great cancellation" means that despite its intrinsic strength, the effective range and influence of electromagnetism are drastically curtailed for large objects.[24] Gravity, however, never cancels. Every particle of matter, no matter how small, adds to the total gravitational pull of an object. This relentless, cumulative, and always-attractive nature, combined with its infinite range, makes gravity the dominant force responsible for holding together planets, stars, and entire galaxies.[21]

This physical reality is perfectly reflected in the astronomical story of our solar system's creation, as described by the **nebular hypothesis**. This model, the most widely accepted for planetary formation, begins with the gravitational collapse of a vast, cold cloud of gas and dust.[27] As this cloud collapsed under its own weight, it formed a spinning protoplanetary disk around the nascent Sun. In the very earliest stages, as dust grains first began to clump together, electrostatic forces—a manifestation of electromagnetism—likely played a role, causing small particles to stick together like dust bunnies under a bed.[29] However, once these clumps grew to about a kilometer in size, becoming objects we call planetesimals, a critical threshold was crossed.[28] At this stage, their collective mass became gravitationally significant. The process then entered a phase known as

runaway accretion, driven entirely by gravity. The larger a planetesimal became, the stronger its gravitational pull, allowing it to sweep up material in its orbital path more and more rapidly. This gravitational feedback loop is the primary engine that built planetesimals into Moon- and Mars-sized planetary embryos, the direct precursors to the planets we see today.[28] For any

theory of electromagnetic accretion to be viable, it would first need to propose a physical mechanism capable of creating and sustaining a massive net electrical charge on a planetary scale within a neutral plasma environment. In the absence of such a mechanism, the hypothesis fails, as it cannot overcome the fundamental principle of charge neutrality in the cosmos.

A Critical Analysis of the Electromagnetic Growth Hypothesis

The proposal that metallic asteroids like Psyche might grow primarily through electromagnetism, perhaps amplified by radioactivity or powerful solar events, is an intriguing line of inquiry that challenges the standard model. However, a critical analysis of the proposed mechanisms, in light of known physical principles, reveals significant obstacles.

First, let us consider the role of radioactivity. Radioactive decay is indeed a crucial process in planetary science, but its primary function is as an *internal heat source*, not an external attractive force. The decay of short-lived radioactive isotopes, such as Aluminum-26 (26Al), which were abundant in the early solar system, generated immense heat within the interiors of newly formed planetesimals.[31] This heat was sufficient to melt rock and metal, enabling the process of

planetary differentiation, where heavier elements like iron and nickel sink to form a core.[33] This process can, in fact, lead to magnetism, but only indirectly. If the molten metallic core is large enough and convects, it can generate a powerful magnetic field through a dynamo effect, just as Earth's liquid outer core does today.[16] Evidence from ancient meteorites confirms that many asteroid parent bodies did possess such magnetic fields in the distant past.[35] However, this creates a

local magnetic field that envelops the asteroid itself; it does not produce a long-range attractive force capable of pulling in other asteroids from the vast distances that separate them in the asteroid belt. The user correctly identifies a link between radioactivity and magnetism, but the causal chain is one of internal heating and dynamo generation, not external attraction.

Next, we evaluate the potential influence of extreme solar events, such as a Carrington-class solar storm. The Carrington Event of 1859 was the most intense geomagnetic storm in recorded history, triggered by a massive solar flare and an associated coronal mass ejection (CME).[37] A CME is a vast eruption of magnetized plasma from the Sun.[39] When this plasma cloud slammed into Earth's magnetosphere, it induced powerful electrical currents in long

terrestrial conductors like telegraph wires, causing equipment to spark and even catch fire.[37] While undeniably powerful, the effect of such an event on asteroid accretion would be negligible. The force exerted by a CME's plasma and magnetic field diminishes with the square of the distance from the Sun, making it far weaker in the asteroid belt than at Earth's orbit. Furthermore, the event is transient, lasting only hours or days. While it could induce weak surface currents or electrostatic charging on an asteroid, the resulting force would be infinitesimal compared to the persistent and cumulative force of gravity acting over millions of years.[41] The immense emptiness of the asteroid belt, where objects are separated by vast distances, further underscores the inadequacy of such a fleeting, weak force for the task of accretion.[42] Gravity succeeds because the Sun's dominant gravitational field holds all bodies in the belt, ensuring that their orbits interact over geological timescales, leading to the low-velocity collisions that enable growth.[30]

In summary, neither radioactivity nor solar flares provide a viable mechanism for large-scale electromagnetic accretion. Radioactivity is an engine of internal change, and solar flares are temporary surface phenomena. The fundamental obstacle of charge neutrality on a cosmic scale remains insurmountable, leaving gravity as the undisputed primary architect of the planets.

From Planetesimal to Planet: The True Role of Metallic Cores

While the proposed mechanism of electromagnetic growth is not supported by physical evidence, the core intuition behind it—that large metallic bodies are the fundamental precursors to planets—is profoundly correct. This idea aligns perfectly with the modern scientific understanding of how planets are built, a process in which gravity plays two distinct and sequential roles: first as an assembler, and second as a sorter.

The story begins after gravity, in its role as assembler, has gathered countless smaller bodies into a large, homogenous planetesimal through the process of accretion.[28] At this stage, the object is a relatively uniform mixture of rock, metal, and, in the outer solar system, ice. This is where the second act of creation begins:

planetary differentiation.

This great separation is driven by heat. The interior of the growing planetesimal heats up from three primary sources: the kinetic energy of constant impacts during accretion, the immense pressure from gravitational compression, and, most significantly, the decay of short-lived radioactive elements inherited from the solar nebula.[31] This combination of heat sources

eventually raises the internal temperature to the melting point of its constituent materials.[33]

Once the interior becomes molten or plastic, gravity can act in its second role as a sorter. In this fluid environment, materials are free to move according to their density. The heaviest elements, primarily iron and nickel, begin to sink under their own weight, migrating toward the center of the body. Simultaneously, the lighter silicate materials, which form rock, rise toward the surface.[32] Over millions of years, this gravitational sorting process results in a layered internal structure: a dense, metallic

core at the center, surrounded by a rocky silicate **mantle**, and topped with a thin, low-density **crust**.[33] This process is not unique to Earth; it is a universal step in the formation of all terrestrial planets, dwarf planets like Ceres, and even many large moons and asteroids like Vesta.[33]

This brings the focus directly back to 16 Psyche. The leading "stripped core" hypothesis places Psyche as the direct, tangible result of this exact process.[10] It is what remains of a differentiated planetesimal whose mantle and crust were violently removed. Therefore, Psyche

is the metallic precursor to a planet, or at least a preserved piece of one. The idea that metallic bodies are the building blocks of planets is a cornerstone of planetary science. The final stage of planet formation involves these differentiated planetesimals—each with its own metallic core—colliding and merging over tens of millions of years to form the full-sized worlds we see today. Thus, the initial hypothesis and the established scientific model converge on the same conclusion: metallic cores are the fundamental building blocks of rocky planets. Psyche stands as the ultimate testament to this process, offering us a direct view of a planetary heart.

Echoes of Impact: Searching for a Metallic Impactor on the Moon

The final component of the inquiry concerns whether a large metallic body, similar to the hypothesized nature of Psyche, could have crashed into the northern region of the Moon. To investigate this, we can first look for a proof-of-concept elsewhere on the lunar surface and then apply the same methods of detection to the North Pole. The evidence for such an event is not found at the north, but at the south.

The Moon's **South Pole-Aitken (SPA) basin** is a colossal impact structure, the largest confirmed crater in the entire solar system, stretching some 1,600 miles (2,500 kilometers)

across.[44] Deep within this basin lies a remarkable feature: a massive

gravity anomaly. This is a region where the Moon's gravitational pull is unexpectedly strong, indicating a huge concentration of dense material buried beneath the surface.[45] This "mascon" (mass concentration) was detected using data from NASA's Gravity Recovery and Interior Laboratory (GRAIL) mission, which precisely mapped the lunar gravity field by measuring minute changes in the distance between two orbiting spacecraft.[47] The leading hypothesis for this anomaly is that it is the dense, iron-nickel core of the asteroid that created the basin some four billion years ago, a metallic remnant that remains embedded deep within the lunar mantle.[45] The SPA basin thus provides compelling evidence that large, metallic impactors have indeed shaped the history of other worlds.

With this precedent established, we turn our attention to the Moon's North Pole. The geology of this region is characterized by ancient, heavily cratered highlands, composed primarily of lower-density silicate rock.[49] Some of its craters are in a state of permanent shadow, allowing them to act as cold traps for water ice.[49] An examination of gravity data from the GRAIL mission for this region reveals a complex field with various anomalies. However, there is no single, massive, basin-centered positive anomaly comparable to the one found at the SPA basin.[52] The most prominent features are long, linear gravity anomalies, which are thought to be ancient tectonic structures buried beneath the cratered surface, not the signature of a massive impactor.[53]

Further evidence comes from magnetic field data. The Moon lacks a global magnetic field today, but its crust retains patches of localized magnetism, relics from a time when a dynamo may have been active or from the impacts themselves.[55] In fact, many of the strongest magnetic anomalies are found antipodal to (on the opposite side of the Moon from) large impact basins, suggesting they were formed by the focusing of impact-generated plasma.[56] When we examine the magnetic maps of the poles, the data indicates that magnetic anomalies are significantly more prevalent and stronger near the South Pole than the North Pole.[58] There is no major magnetic signature at the North Pole that would indicate the presence of a giant, buried metallic body.[59]

Based on the combined analysis of gravity and magnetic data, there is currently no evidence to support the hypothesis of a large metallic impactor buried beneath the Moon's North Pole. While such impacts are a fundamental part of solar system history, as demonstrated so dramatically at the South Pole, the echoes of such an event are not apparent in the northern lunar region. The asymmetries between the Moon's poles—in geology, impact history, and magnetism—are themselves important clues, painting a picture of a world shaped by a chaotic and stochastic series of ancient collisions.

Conclusion: A Synthesis of Inquiry and Evidence

This investigation began with a bold and creative hypothesis: that metallic worlds like 16 Psyche are not formed by gravity, but are instead grown through the power of electromagnetism, fueled by radioactivity and solar storms. Through a detailed, multi-angle evaluation, we have journeyed from the definition of fundamental materials to the grand forces that shape the cosmos, and from the origins of asteroids to the impact history of the Moon.

The analysis concludes that gravity, not electromagnetism, is the primary architect of the planets. While electromagnetism is immensely powerful at small scales, its influence is neutralized in large, electrically balanced celestial bodies. Gravity, though weaker, is cumulative and relentless, making it the dominant force for accretion on a planetary scale. The proposed mechanisms of radioactivity and Carrington-level solar events, while representing real and powerful physical phenomena, do not function as long-range attractive forces for accretion. Radioactivity serves as an internal heat engine that drives differentiation, while solar flares are transient events whose physical force is insufficient to overcome the vast distances and gravitational dynamics of the asteroid belt.

Simultaneously, this report affirms the most profound insight of the initial query. The idea that metallic bodies are the precursors to planets is fundamentally correct and lies at the very heart of modern planetary science. The process of planetary differentiation, driven by heat and sorted by gravity, forges dense metallic cores inside nascent planetesimals. These differentiated bodies are the essential building blocks of terrestrial worlds. The asteroid 16 Psyche, as the exposed remnant of one such core, is the ultimate proof of this process. The NASA *Psyche* mission is a journey to confirm this very concept.

Finally, the investigation into a possible metallic impactor at the Moon's North Pole reveals the power of indirect evidence in planetary science. While the data from gravity and magnetic field mapping does not support the presence of such an object at the North Pole, the massive anomaly beneath the South Pole-Aitken basin confirms that such cataclysmic events have indeed occurred.

The spirit of inquiry that motivated this question—to challenge a fundamental assumption and construct a new model from first principles—is the essence of scientific progress. While this specific electromagnetic hypothesis is not supported by the current body of evidence, the act of asking such questions pushes the boundaries of our knowledge and forces a deeper, more rigorous understanding of the universe we inhabit.

Works cited

1. Metalloid - Wikipedia, accessed September 9, 2025,

https://en.wikipedia.org/wiki/Metalloid
2. 6.7: Metalloids - Chemistry LibreTexts, accessed September 9, 2025, https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Introductory_Chemistry_(CK-12)/06:_The_Periodic_Table/6.07:_Metalloids
3. Metalloids - Characteristics, Properties and Characteristics | CK-12 Foundation, accessed September 9, 2025, https://flexbooks.ck12.org/cbook/ck-12-chemistry-flexbook-2.0/section/6.7/primary/lesson/metalloids-chem/
4. Metalloids - - Diamond Light Source, accessed September 9, 2025, https://www.diamond.ac.uk/Campaigns/2019/Year-of-the-Periodic-Table/Metalloids.html
5. Metalloids - (Physical Science) - Vocab, Definition, Explanations | Fiveable, accessed September 9, 2025, https://library.fiveable.me/key-terms/hs-physical-science/metalloids
6. en.wikipedia.org, accessed September 9, 2025, https://en.wikipedia.org/wiki/M-type_asteroid#:~:text=M%2Dtype%20(metallic%2Dtype.the%20source%20of%20iron%20meteorites.
7. M-class asteroid | Britannica, accessed September 9, 2025, https://www.britannica.com/science/M-class-asteroid
8. M-type asteroid - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/M-type_asteroid
9. Asteroid spectral types - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/Asteroid_spectral_types
10. Psyche (spacecraft) - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/Psyche_(spacecraft)
11. NASA's Psyche Mission Could Unlock Secrets to How Planets Are Formed, accessed September 9, 2025, https://aerospace.org/article/nasas-psyche-mission-could-unlock-secrets-how-planets-are-formed
12. Psyche | NASA Jet Propulsion Laboratory (JPL), accessed September 9, 2025, https://www.jpl.nasa.gov/missions/psyche/
13. Psyche Mission Overview - NASA Science, accessed September 9, 2025, https://science.nasa.gov/mission/psyche/mission-overview/
14. Asteroid Psyche - NASA Science, accessed September 9, 2025, https://science.nasa.gov/solar-system/asteroids/16-psyche/
15. The Psyche mission: A visit to a metal asteroid - Space, accessed September 9, 2025, https://www.space.com/psyche-mission-metal-asteroid.html
16. Science | NASA Jet Propulsion Laboratory (JPL), accessed September 9, 2025, https://www.jpl.nasa.gov/press-kits/psyche/mission/science/
17. The Nature of M-Class Asteroids from 3-??m Observations | Request PDF - ResearchGate, accessed September 9, 2025, https://www.researchgate.net/publication/223327386_The_Nature_of_M-Class_Asteroids_from_3-m_Observations
18. NASA Projected to Advance Understanding of Planetary Formation With 16 Psyche, the Asteroid Remnant of a Proto-planet - The ANSI Blog, accessed

September 9, 2025, https://blog.ansi.org/ansi/16-psyche-protoplanet-asteroid-nasa/
19. Mission | NASA Jet Propulsion Laboratory (JPL), accessed September 9, 2025, https://www.jpl.nasa.gov/press-kits/psyche/mission/
20. Psyche Mission | A Mission to a Metal World, accessed September 9, 2025, https://psyche.ssl.berkeley.edu/
21. Fundamental interaction - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/Fundamental_interaction
22. Forces - NASA Science, accessed September 9, 2025, https://science.nasa.gov/universe/overview/forces/
23. 23.1 The Four Fundamental Forces | Texas Gateway, accessed September 9, 2025, https://texasgateway.org/resource/231-four-fundamental-forces
24. Why is gravity the strongest force? | Science Questions with Surprising Answers, accessed September 9, 2025, https://wtamu.edu/~cbaird/sq/2013/05/22/why-is-gravity-the-strongest-force/
25. Electromagnetic Force vs. Gravitational Force | nuclear-power.com, accessed September 9, 2025, https://www.nuclear-power.com/nuclear-power/reactor-physics/atomic-nuclear-physics/fundamental-interactions-fundamental-forces/electromagnetic-interaction-electromagnetic-force/electromagnetic-force-vs-gravitational-force/
26. en.wikipedia.org, accessed September 9, 2025, https://en.wikipedia.org/wiki/Fundamental_interaction#:~:text=Although%20the%20electromagnetic%20force%20is,planets%2C%20stars%2C%20and%20galaxies.
27. History of Solar System formation and evolution hypotheses - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/History_of_Solar_System_formation_and_evolution_hypotheses
28. Nebular hypothesis - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/Nebular_hypothesis
29. 8.2: Origin of the Solar System—The Nebular Hypothesis - Geosciences LibreTexts, accessed September 9, 2025, https://geo.libretexts.org/Bookshelves/Geology/Book%3A_An_Introduction_to_Geology_(Johnson_Affolter_Inkenbrandt_and_Mosher)/08%3A_Earth_History/8.02%3A_Origin_of_the_Solar_SystemThe_Nebular_Hypothesis
30. Accretion and Solar System Bodies - Teach Astronomy, accessed September 9, 2025, https://www.teachastronomy.com/textbook/How-Planetary-Systems-Form/Accretion-and-Solar-System-Bodies/
31. McSween et al.: Thermal Evolution Models of Asteroids - Faculty, accessed September 9, 2025, https://faculty.epss.ucla.edu/~eyoung/reprints/mcsweenetal.pdf
32. Planetary differentiation | Geochemistry Class Notes - Fiveable, accessed September 9, 2025, https://library.fiveable.me/geochemistry/unit-1/planetary-differentiation/study-gui

de/CCsOlAcxjsfsq8Dw
33. Planetary differentiation - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/Planetary_differentiation
34. 3.3 Differentiation and Internal Structure – Introduction to Planetary Geology, accessed September 9, 2025, https://pressbooks.cuny.edu/introplanetarygeology/chapter/3-3-differentiation-and-internal-structure/
35. Death of a dynamo – a hard drive from space | University of Cambridge, accessed September 9, 2025, https://www.cam.ac.uk/research/news/death-of-a-dynamo-a-hard-drive-from-space
36. A magnetic field mystery in space - Yale News, accessed September 9, 2025, https://news.yale.edu/2023/08/01/magnetic-field-mystery-space
37. Five historically huge solar events | National Oceanic and Atmospheric Administration, accessed September 9, 2025, https://www.noaa.gov/heritage/stories/five-historically-huge-solar-events
38. Carrington Event - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/Carrington_Event
39. What was the Carrington Event, and why does it matter? - EarthSky, accessed September 9, 2025, https://earthsky.org/human-world/carrington-event-1859-solar-storm-effects-today/
40. NASA's STEREO: Mitigating Space Weather Damage, accessed September 9, 2025, https://www.teledynespaceimaging.com/en-us/News/Pages/SpaceImagingWorld/Mitigating-Space-Weather-Damage-with-NASA%E2%80%99s-STEREO.aspx
41. asteroid deflection by means of electromagnetic forces during an ..., accessed September 9, 2025, https://www.esa.int/gsp/ACT/doc/MAD/pub/ACT-RPR-MAD-2009-AstDeflectionFlyBy.pdf
42. Asteroid - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/Asteroid
43. Earth's differentiation | Research Starters - EBSCO, accessed September 9, 2025, https://www.ebsco.com/research-starters/earth-and-atmospheric-sciences/earths-differentiation
44. Ice at the Lunar Poles | American Scientist, accessed September 9, 2025, https://www.americanscientist.org/article/ice-at-the-lunar-poles
45. What is the massive thing under the Moon's surface? - Big Think, accessed September 9, 2025, https://bigthink.com/hard-science/moon-anomaly/
46. Gravitational anomaly discovered weighing down surface of moon - Sky News, accessed September 9, 2025, https://news.sky.com/story/gravitational-anomaly-discovered-weighing-down-surface-of-moon-11739564
47. Gravity 'Anomaly' at Moon's South Pole Could Be Buried Metallic Asteroid | Extremetech, accessed September 9, 2025,

https://www.extremetech.com/extreme/292954-gravity-anomaly-at-moons-south-pole-could-be-buried-metallic-asteroid
48. Gravitation of the Moon - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/Gravitation_of_the_Moon
49. PERMANENTLY SHADOWED LUNAR NORTH POLE CRATERS: GEOLOGY AND IMPLICATIONS FOR VOLATILES. J. B. Plescia1,2, 1Department of Geology, - Universities Space Research Association, accessed September 9, 2025, https://www.hou.usra.edu/meetings/lpsc2020/pdf/2851.pdf
50. Geology of the Moon - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/Geology_of_the_Moon
51. The Poles of the Moon, accessed September 9, 2025, https://www.lpi.usra.edu/science/moonPoles/
52. The global map of lunar gravity anomalies generated from our local... - ResearchGate, accessed September 9, 2025, https://www.researchgate.net/figure/The-global-map-of-lunar-gravity-anomalies-generated-from-our-local-solutions-at-its-full_fig9_355314380
53. Linear Gravity Anomalies | NASA Jet Propulsion Laboratory (JPL), accessed September 9, 2025, https://www.jpl.nasa.gov/images/pia16580-linear-gravity-anomalies/
54. GRAIL Spots Gravity Anomaly | NASA Jet Propulsion Laboratory (JPL), accessed September 9, 2025, https://www.jpl.nasa.gov/images/pia16581-grail-spots-gravity-anomaly/
55. Magnetic field of the Moon - Wikipedia, accessed September 9, 2025, https://en.wikipedia.org/wiki/Magnetic_field_of_the_Moon
56. MIT Scientists May Have Finally Solved the Moon's Magnetic Mystery - SciTechDaily, accessed September 9, 2025, https://scitechdaily.com/mit-scientists-may-have-finally-solved-the-moons-magnetic-mystery/
57. Magnetic Anomalies of the Moon and Their Implications for Its Internal Structure and Evolution | by Boris (Bruce) Kriger | GLOBAL SCIENCE NEWS | Medium, accessed September 9, 2025, https://medium.com/global-science-news/magnetic-anomalies-of-the-moon-and-their-implications-for-its-internal-structure-and-evolution-79d3d07461e8
58. Lunar Magnetic Anomalies and Polar Ice - ResearchGate, accessed September 9, 2025, https://www.researchgate.net/publication/365520274_Lunar_Magnetic_Anomalies_and_Polar_Ice
59. North Polar Magnetic Anomaly Map (MAG/ER) | NASA Jet Propulsion Laboratory (JPL), accessed September 9, 2025, https://www.jpl.nasa.gov/images/pia02050-north-polar-magnetic-anomaly-map-mager/