Is Earth’s Core Home to Hidden Primordial Helium?

Description

The unexpected revelation that one of the lightest elements in the Universe—helium—can bond with iron under extreme pressure to form iron helide suggests a fundamental reevaluation of the geochemical processes occurring within the Earth's profound depths.

This discovery indicates the potential presence of helium within the Earth's core, where iron exists in its most pressurized state. A research team led by physicist Haruki Takezawa from the University of Tokyo suggests that our planet's dense iron core may conceal a substantial reservoir of primordial helium.

On our planet, helium manifests in two stable isotopes. The predominant isotope, helium-4, features a nucleus comprising two protons and two neutrons, accounting for approximately 99.99986 percent of all helium on Earth. Conversely, helium-3, which contains two protons and one neutron, constitutes merely around 0.000137 percent of the total helium.

Shock Helium Discovery Could Rewrite The History of Earth's Formation
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The diamond anvil (left) and the iron helide structure created on it (right). (Takezawa et al./APS 2025)

Helium-4 is primarily produced by the radioactive decay of uranium and thorium found within the Earth. In contrast, helium-3 is largely primordial, originating from the early moments after the Big Bang, with some produced as a by-product of the radioactive decay of tritium (hydrogen-3).

Notably, volcanic eruptions release small quantities of helium-3 in gases emitted from deep within Earth, leading scientists to theorize that primordial helium may be trapped within the mantle, remnants from the solar nebula from which Earth formed.

The research conducted by Takezawa and his team proposes a different source for this helium.

"I have dedicated many years to studying the geological and chemical processes occurring deep within the Earth. To replicate the intense conditions present, we utilize a laser-heated diamond anvil cell to apply such pressures to our samples," explains physicist Kei Hirose from the University of Tokyo, where the experiments were performed.

"In this instance, we subjected iron and helium to pressures ranging from 5 to 55 gigapascals and

temperatures between 1,000 and nearly 3,000 kelvins, equivalent to approximately 50,000 to 550,000 times atmospheric pressure. These elevated temperatures could even melt iridium, which is frequently utilized in spark plugs due to its exceptional thermal resistance."

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An ion mass spectrometry image of an iron sample post-experiment. (2025 Hirose et al., CC-BY-ND)

Previous studies have indicated that helium binds to iron in trace amounts, typically on the order of a few parts per million. In contrast, the team reported helium content in iron as high as 3.3 percent—nearly 5,000 times greater than documented in earlier research. This remarkable finding is attributed to the experimental design.

"Helium is prone to escape under normal conditions; everyone has witnessed a deflating balloon. Therefore, we needed a strategy to retain our measurements," Hirose elaborates.

"While we conducted the material synthesis at elevated temperatures, the chemical measurements were performed at cryogenic temperatures to prevent helium from escaping, enabling us to detect the presence of helium in iron."

This discovery implies that although helium is typically chemically inert at standard conditions, it can be induced to interact under extreme circumstances.

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Image not found or type unknown
The crystal structure of iron helide. (Haruki Takezawa)

This could suggest that primordial helium was absorbed as Earth formed, binding with iron and becoming sequestered in the core during planetary differentiation. The same may hold true for the cores of the Moon and Mars.

If validated, this scenario might explain the presence of helium isotopes in volcanic gases as originating from the core rather than being trapped in the lower mantle. Furthermore, hydrogen—the lightest element—also exists in a primordial form. If primordial helium was abundant during Earth's formation, primordial hydrogen may also have been present, potentially contributing to Earth's early water supply.

Future research should delve into these intriguing possibilities.

The findings are detailed in the publication titled *Physical Review Letters*.

Vocabulary List:

1. **Reevaluation** /ˌriːˌiːvæljuˈeɪʃən/ (noun): The process of assessing something again in light of new information.
2. **Manifest** /ˈmænɪˌfɛst/ (verb): To display or show (a quality or feeling) by one's acts or appearance.
3. **Predominant** /prɪˈdɒmɪnənt/ (adjective): Having the greatest importance or influence.
4. **Reservoir** /ˈrɛzəvwɑːr/ (noun): A place where something is stored; in this context a supply of a substance.
5. **Sequestered** /sɪˈkwɛstərd/ (verb): To isolate or hide away someone or something.
6. **Thermal** /ˈθɜrməl/ (adjective): Relating to heat.

Comprehension Questions

Multiple Choice

1. What does the unexpected revelation about helium bonding with iron under extreme pressure suggest?

   Option: A. The formation of new isotopes
   Option: B. A reevaluation of geochemical processes within the Earth
   Option: C. Increased radioactivity levels in the Earth's core
   Option: D. Helium escaping from Earth's core

2. What is the predominant isotope of helium on Earth?

   Option: A. Helium-4
   Option: B. Helium-3
   Option: C. Helium-5
   Option: D. Helium-2

3. Where was the research team led by physicist Haruki Takezawa from?

   Option: A. Stanford University
   Option: B. University of Tokyo
   Option: C. Harvard University
   Option: D. Oxford University

4. What temperatures were used to subject iron and helium to pressure in the experiments?

Option: A. 100 to 500 kelvins
Option: B. 500 to 1000 kelvins
Option: C. 1000 to 3000 kelvins
Option: D. 3000 to 5000 kelvins

5. What element is frequently utilized in spark plugs due to its exceptional thermal resistance?

Option: A. Gold
Option: B. Copper
Option: C. Silver
Option: D. Iridium

6. What is the primary source of helium-3 on Earth?

Option: A. Volcanic eruptions
Option: B. Radioactive decay of uranium
Option: C. Radioactive decay of tritium
Option: D. Early moments after the Big Bang

True-False

7. Helium-3 constitutes approximately 99.99986% of the total helium on Earth.

8. Helium can easily escape under normal conditions.

9. The experimental design played a crucial role in detecting high helium content in iron.

10. Chemically inert helium can interact under extreme circumstances.

11. The research suggests that primordial helium was only present in the Earth's mantle.

12. Helium binding to iron in trace amounts is well-documented in previous research.

Gap-Fill

13. Iron and helium were subjected to pressures ranging from 5 to 55 gigapascals and temperatures between 1,000 and nearly _____ kelvins.

14. Helium is typically chemically inert at standard conditions, but it can be induced to interact under _____ circumstances.

15. If validated, the presence of helium isotopes in volcanic gases may originate from the _____ rather than being trapped in the lower mantle.

16. Primordial hydrogen may have been present during Earth's early formation, potentially contributing to the planet's early _____ supply.

17. Future research should delve into these intriguing _____.

18. The discovery of helium binding with iron may require a fundamental reevaluation of geochemical processes within the Earth's _____.

Answer

Multiple Choice: 1. B. A reevaluation of geochemical processes within the Earth 2. A. Helium-4 3. B. University of Tokyo 4. C. 1000 to 3000 kelvins 5. D. Iridium 6. D. Early moments after the Big Bang
True-False: 7. False 8. True 9. True 10. True 11. False 12. True
Gap-Fill: 13. 3,000 14. extreme 15. core 16. water 17. possibilities 18. depths

Vocabulary quizzes

Multiple Choice (Select the Correct answer for each question.)

1. What are the paths followed by asteroids in space called?
   Option: Orbits
   Option: Trajectories
   Option: Loops
   Option: Routes

2. Which term describes the potential danger posed by an asteroid collision?
   Option: Friendly
   Option: Safe
   Option: Hazardous

Option: Predictable

3. Which lifestyle choice is characterized by little physical activity?

Option: Active
Option: Sedentary
Option: Dynamic
Option: Vigorous

4. What are new plans or strategies to address a particular issue called?

Option: Campaigns
Option: Endeavors
Option: Strategies
Option: Initiatives

5. Which term refers to extreme tiredness resulting from mental or physical exertion?

Option: Energy
Option: Vitality
Option: Fatigue
Option: Enthusiasm

6. What is the overall health and happiness of a person referred to as?

Option: Contentment
Option: Well-being
Option: Joy
Option: Satisfaction

7. Which term describes relying on someone or something for support or aid?

Option: Independence
Option: Freedom
Option: Self-reliance
Option: Dependence

8. Which word means to display or show a quality or feeling clearly?

Option: Hide
Option: Conceal
Option: Reveal
Option: Manifest

9. What term is used to describe related to heat or temperature?

Option: Cooling
Option: Thermal
Option: Chilled
Option: Frozen

10. Which word means to isolate or hide away?

Option: Presented
Option: Exposed
Option: Revealed
Option: Sequestered

Gap-Fill (Fill in the blanks with the correct word from the vocabulary list.)

11. The asteroid _____ can have devastating effects on Earth.

12. The asteroid's _____ visits to our solar system create awe and concern among astronomers.

13. Genetic _____ can influence one's likelihood of developing certain health conditions.

14. Understanding the causes of _____ is crucial for improving healthcare outcomes.

15. Regular _____ of blood pressure is essential for managing hypertension.

16. The _____ of stress can lead to physical and mental health problems.

17. The team made _____ progress in a short amount of time.

18. Efforts must be made to address social _____ to ensure fairness for all.

19. The study aimed to assess the _____ of the new treatment method.

20. Periodic _____ of business strategies is essential for adapting to market changes.

Matching Sentences (Match each definition to the correct word from the vocabulary list.)

21. The bank required \\\\ to secure the loan against default.
22. The marathon runner collapsed from \\\\ after crossing the finish line.

23. The medication was effective in \\\\ the patient's pain.
24. As a young adult she valued her \\\\ and freedom.
25. The new software was designed to \\\\ communication among team members.
26. Customer \\\\ was evident in the negative online reviews.
27. In her artwork the \\\\ color was vibrant red.
28. The mountain spring served as a natural \\\\ for the nearby village.
29. The \\\\ insulation in the building helped conserve energy.
30. His frustration was \\\\ in his tone of voice.

Answer

Multiple Choice: 1. Trajectories 2. Hazardous 3. Sedentary 4. Initiatives 5. Fatigue 6. Well-being 7. Dependence 8. Manifest 9. Thermal 10. Sequestered
Gap-Fill: 11. impact 12. periodic 13. predispositions 14. mortality 15. self-monitoring 16. accumulation 17. considerable 18. inequities 19. efficacy 20. reevaluation
Matching sentence: 1. collateral 2. exhaustion 3. alleviating 4. independence 5. facilitate 6. dissatisfaction 7. predominant 8. reservoir 9. thermal 10. manifest

CATEGORY

1. Sci/Tech - LEVEL5

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Author
aimeeyoung99