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ECR 2026 / C-29069

Non-Destructive X-ray CT Characterization of the Antikythera Mechanism: Advances in Internal Gear Reconstruction

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Purpose

To demonstrate how high-resolution X-ray computed tomography enables the non-destructive internal characterization of Fragment A of the Antikythera Mechanism, allowing the identification, three-dimensional reconstruction, and functional interpretation of concealed gears, structural components, and inscriptions despite extensive corrosion[Fig 1].¹⁻³

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Methods and materials

The Antikythera Mechanism (1st century BCE) is regarded as the most complex technological artifact of Antiquity, incorporating a dense system of bronze gears designed to model astronomical cycles. Severe corrosion and mineralization have rendered direct visual or mechanical inspection impossible, making non-destructive imaging essential for its study. Advances in high-energy X-ray computed tomography (CT) have enabled internal visualization of gears, inscriptions, and structural components previously concealed within corrosion layers, significantly ^{1,2,4-10}High-resolution X-ray computed tomography data from Scan A6 of Fragment A were obtained from the...

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Results

High-resolution X-ray computed tomography of Fragment A revealed a highly compact and multilayered internal mechanical structure that is entirely obscured by surface corrosion and mineralization. Tomographic analysis enabled the differentiation of original bronze components from corrosion products and sedimentary deposits based on radiographic density, allowing the internal architecture of the fragment to be examined in detail[Fig 2][Fig 3][Fig 4].Between 50 and 60 individual mechanical elements were identified within Fragment A, representing the highest concentration of preserved components in the Antikythera Mechanism. These include 28–32 gears,...

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Conclusion

High-resolution X-ray computed tomography proved essential for the non-destructive investigation of Fragment A of the Antikythera Mechanism, enabling the identification and reconstruction of a dense and previously inaccessible internal mechanical system. The integration of CT imaging with digital segmentation, three-dimensional modeling, and physical reconstruction allowed the recovery of key structural and astronomical information, confirming the central functional role of Fragment A and demonstrating the value of advanced radiological methods in archaeometric research.^{1–3}

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Personal information and conflict of interest

J. Pinheiro: Nothing to disclose L. Anselmo: Nothing to disclose L. Luz: Nothing to disclose E. Seica: Nothing to disclose L. Silva: Nothing to disclose R. Gonçalves: Nothing to disclose N. Petrouleas: Nothing to disclose

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Fig 1: Fragment A of the Antikythera Mechanism. National Archaeological Museum of...

Component category	Estimated number	Description / Observations
Gears	28-32	Include complete, fragmentary, and apical gears representing functional parts of the mechanism.
Wheels / Racks	15-18	Some partially preserved, possibly identified by radiographic signatures (enamel displacement).
Reaction gears	25-28	Small metal cogwheels (crown gears) and plates many positioned in high radiographic absorption structures.
Spacers	5-7	Double or triple forked spacers connect/correlate gear and reaction wheel alignments.
Main structural plates	2	Frontplate and back plate of the mechanism.
Internal plates / supports	1-3	Thin elements supporting gears and facilitating the internal space.
Substructure fragments	5-10	Components whose function cannot be determined due to fragmentation or corrosion include small metal blocks and structural members.
Estimated total	54-68 components	Figures with the highest structural and functional complexity within the mechanism.

Table 1: Classification and estimated number of components identified in Fragment A.

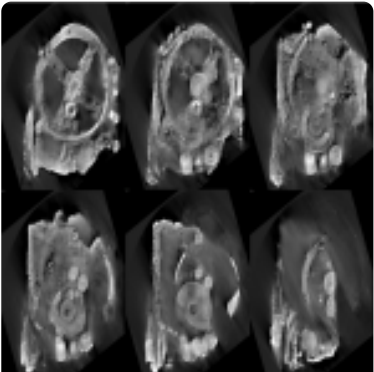


Fig 2: Overview of selected key slices illustrating the components of the Mechanism.

Type of inscription	Inscribed content	Location within the fragment	Readability / Interpretation status
Epigraphic (Latin text)	Text in Latin script, possibly a dedication or inscription.	Central area of the fragment, above the gear mechanism.	Partially legible due to wear and damage.
Technical drawing	Diagram of a gear or mechanical component.	Below the Latin text, on the left side.	Clear and well-defined.
Geometric drawing	Diagram of a gear or mechanical component.	Below the Latin text, on the right side.	Clear and well-defined.
Epigraphic (Greek text)	Text in Greek script, possibly a dedication or inscription.	Central area of the fragment, below the Latin text.	Partially legible due to wear and damage.
Technical drawing	Diagram of a gear or mechanical component.	Below the Greek text, on the left side.	Clear and well-defined.
Geometric drawing	Diagram of a gear or mechanical component.	Below the Greek text, on the right side.	Clear and well-defined.
Epigraphic (Latin text)	Text in Latin script, possibly a dedication or inscription.	Central area of the fragment, below the Greek text.	Partially legible due to wear and damage.
Technical drawing	Diagram of a gear or mechanical component.	Below the Latin text, on the left side.	Clear and well-defined.
Geometric drawing	Diagram of a gear or mechanical component.	Below the Latin text, on the right side.	Clear and well-defined.

Table 2: Typology and description of inscriptions identified in Fragment A.



Fig 3: Schematic reconstruction of the gears based on CT projections.



Fig 4: 3D print derived from photographs of the fragment.

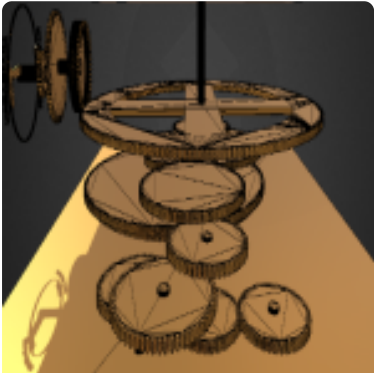


Fig 5: Preparation of a 3D model for printing based on the imaging acquisitions.



Fig 6: Main components of Fragment A assembled after 3D printing.