

# The lifespan of the Moon

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The fundamental questions of when the Moon formed and how long its internal geological activity persisted remain central to planetary science. Recent analyses of returned lunar samples and lunar meteorites have dramatically extended the record of lunar volcanism. Key findings include young mare basalts on the lunar nearside (~2.0 Ga)[1], farside basalts (~2.8 Ga)[2], a ~2.2 Ga KREEP-enriched basaltic lunar meteorite[3], and crucially, volcanic glass beads indicative of volcanic activity as recent as ~120 Ma[4]. These discoveries collectively point to a Moon with sustained endogenic geological vigor far longer than previously recognized.

To constrain the earliest lunar history, we employ a two-stage Pb isotope evolution model on four precisely dated mare basalt samples with well-defined initial Pb isotopic compositions. Our modeling calculates the timing of mantle source homogenization for these mare basalts to be  $\sim 4377 \pm 57/-27$  Ma. Extrapolating this model further back in time allows us to estimate the age of the Moon's primary differentiation, which we interpret as the lunar formation time, at  $\sim 4516 \pm 21/-18$  Ma[5].

This study provides chronological constraints from the Moon's late-stage volcanic products to its very origin. The results reconcile a formation time of the Moon within the context of the Giant Impact hypothesis with newly recognized evidence for its extraordinarily prolonged volcanic history.

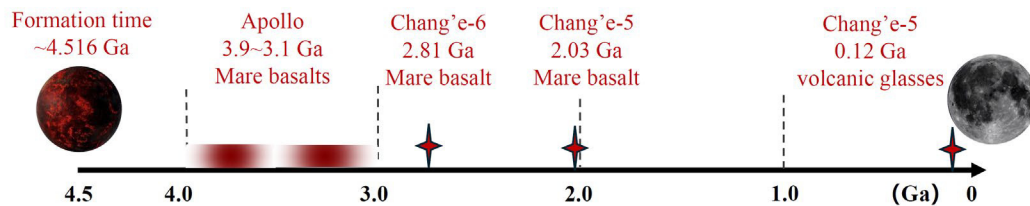


Figure 1. The lifespan of lunar volcanism. Ga = billion years ago

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- [3] Muhan Yang, Qian W.L. Zhang, Qiu-Li Li\* et al. 2025. 2.2-billion-year-old KREEP-rich volcanism on the Moon. *Science Bulletin*, 70: 3265-3271
- [4] Biwen Wang, Qian W.L. Zhang... Qiu-Li Li\*. 2024. Returned samples indicate volcanism on the Moon 120 million years ago. *Science* 385, 1077-1080.
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