Constraints on the formation and evolution of the Earth's atmosphere from cometary noble gases

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Determining the origin and timing of volatile delivery to planetary bodies is essential for understanding the origin and evolution of Earth's atmosphere and oceans. Comets represent some of the most pristine, volatile-rich bodies in the Solar System. However, their potential to have distributed volatiles throughout the planets of the inner Solar System remains poorly understood.

Measurements of noble gases within Comet 67/P Churyumov-Gerasimenko by the ROSINA mass spectrometer on board the ESA Rosetta spacecraft have allowed constraints to be placed on the contribution of comets to the Earth's atmosphere. Xenon isotopes indicate that the Earth's primordial atmosphere is a mixture of 22 % comets with the remainder being solar or chondritic in origin [1]. The identification of cometary Xe in the Earth's atmosphere highlights the possibility for comets to have supplied other volatile species to the Earth and other planetary bodies.

Here we present new calculations for the amount of cometary volatiles delivered to the Earth, based on recently measured Kr isotopes from Comet 67/P [2]. Krypton isotopes confirm that the atmosphere is a mix of cometary and chondritic volatiles, with solar being ruled out as the dominant atmospheric precursor. Coupled Kr and Xe isotope constraints allow new information on the formation and evolution of the atmosphere to be revealed.

[1] Marty et al., (2017), *Science*; [2] Rubin et al., in review, *Sci. Adv.*