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The end of the atmospheric xenon Archean's evolution: a study of the Great Oxygenation Event period

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Several geochemical tracers (S, C, O, Xe) underwent irreversible global changes during the Precambrian, and in particular during the Great Oxygenation Event (GOE), between the Archean and Proterozoïc eons [1]. Xenon is of particular interest as it presents a secular isotopic evolution during the Archean that ceased around the time of the GOE. In this regard Xe is somewhat analogous to mass-independent fractionation sulfur (MIF-S) in that it can be used to categorically identify Archean atmospheric components [2]. Xe isotopes in the modern atmosphere are strongly mass-dependent fractionated (MDF-Xe), with a depletion of the light isotopes relative to the heavy ones. There was a continuous Xe isotope evolution from primitive Xe to modern Xe that ceased between 2.6 and 1.8 Ga [2] and this evolution has been attributed to coupled H^+-Xe^+ escape to space [3].

The purpose of this project is to document the Xe composition of the paleo-atmosphere trapped in well-dated hydrothermal quartz fluid inclusions with ages covering the Archean-Proterozoic transition to better constraint its link with the GOE.

We have measured an isotopically fractionated Xe composition of 2.0 ± 1.8 ‰ relative to modern atmosphere at 2441 ± 1.6 Ma, in quartz vein from the Seidorechka sedimentary formation (Imandra-Varzuga Greenstone belt, Russia). A slightly younger sample from the Polisarka sedimentary formation (Imandra-Varzuga Greenstone belt, Russia) of 2434 ± 6.6 Ma does not record such fractionation and is indistinguishable from the modern atmospheric composition. A temporal link between the disappearance of the Xe isotopes fractionation and the MIF-S signature at the Archean-Proterozoic transition is clearly established for the Kola Craton. The mass-dependent evolution of Xe isotopes is the witness of a cumulative atmospheric process that may have played an important role in the oxidation of the Earth's surface [3], independently of biogenic O_2 production that started long before the permanent rise of O_2 in the atmosphere [4].

[1] Catling & Zahnle, 2020, *Sciences Advances* 6, eaax1420. [2] Avice et al., 2018, *Geochimica et Cosmochimica Acta* 232, 82-100 [3] Zahnle et al., 2019, *Geochimica et Cosmochimica Acta* 244, 56-85. [4] Lyons et al., 2014, *Nature* 506, 307-315.