New generation multi-collector mass spectrometers require new ^{40}Ar/^{39}Ar standards

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The accuracy of ^{40}Ar/^{39}Ar ages is dependent on the availability of mineral standards of known age. Popular standards include Fish Canyon Tuff sanidine (FTCs) [1], Alder Creek Rhyolite sanidine (ACRs) [2] and Mt Dromedary biotite (GA1550) [3]. Despite common usage, the ages of these standards is contentious, with published values varying by >2% [4, 5]; well beyond the ±0.1% goal of EARTHTIME.

In this study, we report ultra-high precision, ^{40}Ar/^{39}Ar analyses of FCTs, ACRs and GA1550 biotite aliquots, using a multi-collector ARGUSVI mass spectrometer. Step-heating results resolve distinct (~1%) age gradients for all samples, attributed to argon loss and/or extraneous argon contamination. This discordance complicates efforts to assign accurate ages to these standards, with different heating protocols also likely to cause inter-laboratory bias.

These data suggest that these minerals are non-ideal as high precision ^{40}Ar/^{39}Ar standards. In broader terms, the results mandate a re-evaluation of high precision ^{40}Ar/^{39}Ar ages referenced to these standards, including the astronomically calibrated ages for FCTs [6], and ^{40}Ar/^{39}Ar ages used to define new decay constants [4].

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Lack of isotopic exchange between organics and clays in Semarkona chondrite: submicrometer scale heterogeneity of the D/H ratio.

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Organics and clays are the main hydrogen bearing phases in non-equilibrated chondrites. These primitive solid reservoirs recorded the signatures of the early solar system. While organics are formed prior to accretion of the parent body, clays are thought to have formed during its aqueous alteration. As a consequence, clays may contain the H isotopic signature of the hydrothermal fluids and may provide the composition of the ice accreted on the parent body. Both phases can exhibit highly heterogeneous D/H ratios depending on the chondrite [1–4]. However, their intimate mixing within the chondrite matrix [5] makes it difficult to investigate possible interactions between clays (water) and organics, because local isotopic measurements are not possible with current analytical techniques.

An analytical protocol was developed using the nanoscale secondary ion mass spectrometer NanoSIMS 50. D^-/H^- and OD^-/OH^- ratios were deconvoluted to allow localized semi-quantitative information on the isotopic composition of organics and clays to be obtained [6]. Using this protocol, measurements were carried out on Au-pressed matrix pieces of the Semarkona unequilibrated ordinary chondrite.

No isotopic equilibrium was observed between organics and clays. Relatively isotopically homogeneous organic matter (δD ~ 2000‰) is mixed with extremely heterogeneous clays (with δD from 0 to more than 10,000‰), attesting to a lack of global isotopic exchange between organics and water. Moreover, micrometer-size areas of exceptionnally D-rich inorganic material were identified and these are surrounded by D-poor material (mostly clays and/or organics). The origin of the most D-rich inorganic material remains puzzling, however, the observations demonstrate the limited extent (few µm) of aqueous alteration on the Semarkona parent body and suggest that the parent body accreted ice from several regions of the solar system.

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