The $^{238}U/^{235}U$ of the Earth and the Solar System

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For this study we performed high precision $^{238}U/^{235}U$ isotope analyses of 27 bulk meteorites (carbonaceous and ordinary chondrites as well as achondrites) and 12 terrestrial basalts. Additionally, we compiled high precision $^{238}U/^{235}U$ data on bulk meteorites from the recent literature in order to constrain the distribution of U isotopic heterogeneities and to determine an average $^{238}U/^{235}U$ for the solar system.

Most meteorites overlap with the U isotope composition observed for terrestrial basalts (137.78 – 137.81, [1] and this study). The most prominent exceptions are among the ordinary chondrites (Richardton H5 = 137.711 and Elenovka L5 = 137.891). Likely, different processes are responsible for the observed U isotope variations on the bulk meteorite scale, including the decay of extant ^{247}Cm [2], evaporation/condensation [3], redox processes or nucleosynthetic heterogeneities, as indicated by different relationships of $^{238}U/^{235}U$ and Nd/U for different meteorites or meteorite components.

All meteorite samples considered here (in total 45) have $^{238}U/^{235}U$ values that define a Gausian distribution with an average value of 137.79 ± 0.03 (at 95% confidence level). The uncertainty of this value is dominated by that of the used U double spike (± 0.16‰ [4]). Notably, the average values for each of the investigated meteorite groups and that of terrestrial basalts define a narrow range between 137.787 and 137.795, which overlaps with the average value for all bulk meteorites taken together. We thus consider the average value obtained from this study ($^{238}U/^{235}U$ = 137.79) to be representative for the Earth and the Solar System, consistent with earlier estimates [3, 5, 6]. We recommend using it for Pb-Pb dating if the precise $^{238}U/^{235}U$ of the sample cannot be obtained. Compared to the Pb-Pb ages based on the previously assumed $^{238}U/^{235}U$ (137.88), the new value of this study results in 0.9 Ma younger ages.

[1] Weyer *et al*. (2008) *GCA* **72**, 345-359. [2] Brennecka *et al*. (2010) *Science* **327**, 449-451. [3] Connelly *et al*. (2012) *Science* **338**, 651–655. [4] Richter *et al*. (2008) *IJMS* 2**69**, 145-148. [5] Brennecka and Wadhwa (2012) *PNAS* **109**, 9299–9303. [6] Hiess *et al*. (2012) *Science* **235**, 1610-1614.

In-situ determination of Fe Isotopes in Kamacite-, Taenite- and Troilite-Phases of Ordinary Chondrites

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In this study we investigated the Fe isotopic composition of metal and sulphide grains in ordinary chondrites. Recent studies [1], [2] found variations in $\delta^{56}Fe$ of up to 0.8‰ in bulk grains or grain fractions, which were manually extracted and dissolved. Here we represent the first in-situ Fe isotope analyses conducted by femtosecond laser ablation-ICP-MS. Instrumental mass bias was monitored with a Ni standard solution, which was simultaneously aspirated during laser ablation. With this method a reproducibility for replicate analyses of homogeneous standards of 0.04 to 0.06 (2 SD) for $\delta^{56}Fe$ was achieved with spot-sizes as low as 30 μm. Prior to isotope analyses metal and sulfide grains were characterized with microprobe analyses.

The analyses of over 100 metal and sulphide grains in H- and L-chondrites revealed $\delta^{56}Fe$ values with a total variation of 1.6‰, ranging from -0.8‰ to +0.8‰, relative to IRMM-014. The analyzed sulphide grains (all troilite), revealed an average $\delta^{56}Fe$ of -0.47‰. Metal grains contained 80% - 90% kamacite with an average $\delta^{56}Fe$ of 0.05‰ and 10% - 20% taenite with an average $\delta^{56}Fe$ of +0.49‰.

These first results show that the abundance of taenite in ordinary chondrites may affect the Fe isotope composition of the bulk metal and that previously observed variations in $\delta^{56}Fe$ may be the result of variations in the sampling of taenite. Larger exolutions of kamacite and taenite were generally isotopically homogeneous, i.e. did not show any diffusive exchange of Fe isotopes.The large $\Delta^{56}Fe_{metal-FeS}$ of 0.6‰ – 0.8 ‰ in ordinary chondrites (compared to ~0.5‰ observed for iron meteorites [3]) indicates a very low troilite-metal equilibration temperature of <300°C (calculated after [1] using data from [4] for troilite).

[1] Theis *et al*. (2008) GCA **72**, 4440-4456. [2] Needham *et al*. (2009) *GCA* **73**, 7399-7413. [3] Williams *et al*. (2006) *ESPL* **250**, 486-500. [4] Polyakov and Soultanov (2011) *GCA* **75**, 1957-1974.

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