Geophysical Research Abstracts
Vol. 18, EGU2016-12990, 2016
EGU General Assembly 2016
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Estimation of the extraterrestrial ^{3}He and ^{20}Ne fluxes on Earth from He and Ne systematics in marine sediments

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Sediments contain interplanetary dust particles (IDPs) carrying extraterrestrial noble gases, such as ^{3}He, which have previously been used to estimate the IDP accretion flux over time and the duration of past environmental events. However, due to its high diffusivity, He can be lost by diffusion either due to frictional heating during entry in the atmosphere, or once it has been incorporated in the sediments. Therefore the absolute values of ^{3}He IDP fluxes cannot be known. Due to its lower diffusivity, Ne is less likely to be lost by diffusion than He and can potentially provide an absolute IDP flux value. Here, we studied the Ne and He isotopic composition of 21 sediments of different ages (3 to 38 Myr, 56 Myr and 183 Myr) in order to better constrain the retention of ^{3}He in such deposits. The samples are carbonates from 2 sites of the Integrated Ocean Drilling Program (IODP), which previously showed evidence of detectable extraterrestrial ^{3}He, and from the Sancerre core in the Paris basin. The ^{3}He/^{4}He, ^{20}Ne/^{22}Ne and ^{21}Ne/^{22}Ne ratios of decarbonated residues vary respectively from 0.09×10^{-6} to 76.5×10^{-6}, 9.54±0.08 to 11.30±0.60 and from 0.0295±0.0001 to 0.0344±0.0003. These isotopic compositions can be explained by a mixing between two terrestrial components (atmosphere and radiogenic He and nucleogenic Ne present in the terrigenous fractions) and an extraterrestrial component. The linear relationship between ^{20}Ne/^{22}Ne and ^{3}He/^{22}Ne ratios shows that the extraterrestrial component has a unique composition and is similar to the He and Ne composition of implanted solar wind. This composition is different from the individual stratospheric IDPs for which the Ne and He isotopic compositions have been measured. We suggest that this difference is due to a bias in the sampling of the individual IDPs previously analyzed toward the largest ones that are more likely to lose He during entry in the atmosphere. Our data further constrains the size of the majority of the IDPs to be less than 10 μm in diameter. In addition, the constant ^{3}He/^{22}Ne ratio of the extraterrestrial component present in the samples, which is similar to the implanted solar wind composition, suggests that no diffusive loss of ^{3}He occurred in the atmosphere or on the seafloor. Thus, neglecting any non-fractionating He and Ne loss by weathering and/or alteration of the host phases on the seafloor, the extraterrestrial ^{3}He and ^{20}Ne fluxes between 3 to 38 Myr ago are respectively $0.2\pm0.1\times10^{-12}$ cm^{3}.cm^{-2}.kyr^{-1} and $0.2\pm0.1\times10^{-11}$ cm^{3}.cm^{-2}.kyr^{-1}. During the sharp increases of the late Eocene and late Miocene, the IDP ^{3}He and ^{20}Ne fluxes reach values up to five times higher.