Origin of terrestrial volatiles: Potential contribution of comets

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The composition of volatile elements on Earth is subject to debate. A chondritic composition for volatiles in Earth is consistent with the isotope ratios of terrestrial H and N, but noble gases point to minor contributions of solar gases in the Earth, and to a possible cometary contribution. Here we review this problem in the light of the recent analysis of gases released by Comet 67P/Churyumov-Gerasimenko by the ROSINA instrument on board of the ESA Rosetta mission. Terrestrial noble gases are mostly in the atmosphere, and their bulk Earth budget corresponds to about 2% carbonaceous chondrite-type material contribution to the proto-Earth [1]. For major volatiles (H, C, N), a mass balance based on 40Ar produced by the decay of 40K and on 40Ar/32Ar/18O ratios in mantle-derived material yields a comparable contribution of 2 ± 1% CC, with most major elements being concentrated the mantle. This model predicts a high major volatile content, e.g., ≥4 ocean masses, in the mantle [1]. Other estimates based on the observed volatile content of mantle-derived basalts advocate low volatile concentrations in the mantle (e.g., 1-2 ocean masses for water), equivalent to <1% contribution of CC material [2,3]. In such a case, the bulk Earth noble gas/major volatile (e.g., 36Ar/H2O) ratio is one order of magnitude higher than that of CCs. Water in Comet 67P/CG has a D/H ratio 3 times the ocean value, precluding a cometary origin if 67P/CG is representative of the cometary reservoir [4]. 67P/CG is rich in Ar relative to water, with a 36Ar/H2O ratio 3-4 orders of magnitude higher than Terrestrial, thus opening the possibility that a significant fraction of atmospheric noble gases (but not major volatiles) was contributed by comets. However, a cometary contribution is not consistent with the near-chondritic 20Ne/40Ar ratio of the atmosphere because neon is not expected to be trapped in cometary ice. It is also at odds with a mixing correlation between 36Ar/22Ne and 36Ar/20Ne observed for terrestrial reservoirs that requires a CC end-member for terrestrial noble gases. Thus a volatile-rich mantle is still a viable possibility.