Origin of terrestrial volatiles: Potential contribution of comets

B. MARTY[1]

[1]CRPG-CNRS, Université de Lorraine, Vandoeuvre les Nancy, France; bmarty@crpg.cnrs-nancy.fr

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 ^{40}Ar produced by the decay of ^{40}K and on $^{40}Ar/N/C/H_2O$ 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., $^{36}Ar/H_2O$) ratio is one order of magntitude 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 $^{36}Ar/H_2O$ 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 $^{20}Ne/^{36}Ar$ 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 $^{20}Ne/^{22}Ne$ and $^{36}Ar/^{22}Ne$ observed for terrestrial reservoirs that requires a CC end-member for terrestrial noble gases. Thus a volatile-rich mantle is still a viable possibility.

[1] B. Marty (2012), *EPSL* **313-314**, 56. [2] B. Marty & R. Yokochi (2006), *RIMG* **62**, 421. [3] A. N. Halliday (2013), *GCA* **105**, 146. [4] K. Altwegg et al. (2015), *Science* **347**, 1261952-1.