Which origin for molecular oxygen and sulfur in Comet 67P/Churyumov-Gerasimenko?

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The observation of O_2 and S_2 in comet 67P/Churyumov-Gerasimenko[1,2] has led to a new interest regarding the origin of volatiles detected in comets. A priori, the situation seems different for those two volatiles. The former had not been detected in space for years, whereas the latter has been observed for decades in comets.

However, basing on observations, we assume that O_2 and S_2 have a similar primordial origin and we propose that they formed in the ISM, by irradiation (photolysis and/or radiolysis) of the H_2O molecules of the icy grains precursors of comets, and of the S-bearing molecules embedded in, creating voids in ices simultaneously, within which the produced volatiles can accumulate.

We have investigated the stability of O_2 and S_2 molecules in cavities formed by the irradiation, assuming that the surrounding material is made of pure H_2O ice in the case of O_2 and a mixed H_2O/H_2S ice in the case of S_2. To support this scenario, we used chemistry numerical models based on first principle periodic density functional theory (DFT). These models are shown to be well adapted to the description of compact ice and are capable to describe the trapping of the volatiles in the ice matrix. We showed that the stabilization energies of both O_2 and S_2 molecules in such voids are close to that of the H_2O ice binding energy, implying that they can only leave when the icy matrix sublimates. This is consistent with the observations and also supports our scenario of a common origin for both volatiles O_2 and S_2.

Differences can also be explained within this scenario. Unlike O_2 whose abundance correlates to H_2O, no global trend should be drawn between the variation of S_2 and H_2O abundances if S_2 can accumulate in both S_2-bearing and H_2O ices. Such results are supported by the ROSINA data collected between May 2015 (equinox) and August 2015 (perihelion), showing that, contrary to O_2, there is no correlation observed for S_2 with H_2O or H_2S in 67P/C-G.[3]

Références

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