D/H and the Origin of Earth's Water. M. F. A'Hearn[1] and L. M. Feaga[1], [1]Department of Astronomy, University of Maryland, College Park MD 20742-2421 USA, ma@astro.umd.edu, feaga@astro.umd.edu.

Introduction: The ROSINA mass spectrometer team on Rosetta has recently reported a D/H ratio that is 3x SMOW in comet 67P/Churymov-Gerasimenko (P/C-G) [1]. This is higher than measured in any of the several Oort cloud comets (NICs or Nearly Isotropic Comets) that have been measured, all of which cluster around 2x SMOW. Those in turn are higher than in the two other Jupiter-family comets (JFCs) that have been measured – 103P/Hartley 2 at 1x SMOW [2] and 45P/Honda-Mrkos-Padušáková (P/H-M-P) with a 3σ upper limit of 1.5x SMOW [3]. We will discuss these results in the context of the formation of comets and the question of whether comets could have provided water to Earth.

Discussion: We previously used the abundance ratios of $H_2O/CO/CO_2$ to argue that the Jupiter family comets formed in a region that largely overlapped the formation region of Oort-cloud comets but which extended closer to the sun [4]. The first two measurements of D/H in Jupiter family comets were perfectly consistent with this picture. However, the result for P/C-G suggest formation further out than the Oort-cloud comets. Numerous other species detected with ROSINA in the coma of P/C-G also imply formation at a very low temperature.

This certainly confirms our suggestion that the formation regions overlapped but indicates that the region of formation of the Jupiter-family comets extended both inward and outward from the formation region of the NICs, i.e., that the NICs formed in a relatively narrow range of heliocentric distances. Furthermore, it implies that the JFCs were well mixed after ejection to the scattered disk or the detached disk.

The key questions are whether the dynamical studies can reproduce this scenario or whether the more complex models of chemical processing and fractionation in the disk can explain the observations in a different dynamical model.

The question of Earth's water is more complex. If comets provided the water, then it must have been provided before the JFCs were mixed in the outer solar system, with a dynamical situation that was strongly selective in favor of comets formed nearer the sun than the NICs. We note that the work of Brasser and Morbidelli [5} shows a fractionation effect with planetary migration in which comets are ejected to the Oort Cloud vs. those that are ejected to the trans-Neptunian region, which is conceptually consistent with the overlap hypothesis and sunward extension of the JFC formation region. The dynamical scenario for the anti-sunward extension is less clear and a complete model is a challenge to the dynamicists.

If a more complex chemical model is required, then whether comets could provide Earth's water depends on the details of the fractionation processes in that model, which match both the D/H ratio distribution and the primary volatile ratio distribution.

Acknowledgements. We thank Kathrin Altwegg for access to much of the results from ROSINA prior to publication. MFA & LF were supported by NASA for their work on the Rosetta project.

References:

[1] Altwegg K. et al. (2014) *Science Express* 2014-12-10 and *Science*, in press. [2] Hartogh, P. et al. (2011) *Nature, 478,* 218-220. [3] Lis, D. C. et al. (2013) *Ap.J.Lett., 774*, L3. [4] A'Hearn, M. F. et al. (2012) *Ap.J., 758*, 29. [5] Brasser, R. and Morbidelli, A. (2013) *Icarus, 225*, 40-49.