The origin of Earth's water: Local or remote source?

JONATHAN I. LUNINE*

[1]Department of Astronomy, Cornell University, Ithaca NY, USA. jlunine@astro.cornell.edu (*)

Two Planets are Better than One

The classical idea that comets supplied the Earth's oceans [1] ran into trouble when dynamical models showed that no more than 10% of Earth's crustal water could have come from comets [2]. Since the final stage of the assembly of the Earth almost certainly involved collisions among lunar- to Mars-sized embryos, it is reasonable to imagine [2] that embryos from what is now the asteroid belt provided most of Earth's water. Our scenario works from a dynamical point of view, but probably adds too much carbonaceous chondritic material to Earth to satisfy geochemical constraints [3]. An alternative is that water was adsorbed or chemisorbed into grains locally where the Earth formed, a view championed by Mike Drake [4].

A potential test of local versus remote sources of Earth's water comes from examining Mars. Because of its small size Mars could not have gained water through the addition of large embryos—it is one of them—and so under the remote source hypothesis, a much larger fraction of Martian water must be cometary than is the case for the Earth [5]. *If* the cometary D/H is significantly higher than Earth's (SMOW) and that of Martian water, the local-source hypothesis is supported. Meteoritic evidence [6] suggests a slightly elevated D/H for early Martian water relative to SMOW, but D/H in comets varies from 1-2 times SMOW [7], so the jury is still out.

The Grand Tack Maneuver Outflanks the Geochemists

Walsh et al [8] showed that if Jupiter formed before Saturn, its interaction with the disk moved it inward to as close as 1.5 AU; the subsequent formation and entry into resonance of Saturn cause both planets to then move outward. This "Grand Tack" introduced outer solar system planetesimals into the inner solar system with a high collision probability, from which the Earth could have acquired much of its water [9] without excessive accretion of carbonaceous chondritic material. Of course, the composition of these colder bodies is not known, but being plausibly more water-rich than any known chondrite, their geochemical signature on the Earth may have been muted relative to those in our "classic" scenario.

At Odds with my Boss on Science, but Collegially So

It is said that one should never lend money to a close friend nor get into a scientific disagreement with one's Department Head. I've only done the latter. Mike Drake was my senior colleague at Arizona for 27 years and my Department Head for 18 of those. Although we disagreed on how the Earth acquired its water, it never affected our personal or professional relationship. No Department Head could have been more supportive of my professional development than Mike was. He was truly a statesman of science.

[1] Delsemme (1992) *Adv. Space Res.* **12,** 5-12. [2] Morbidelli *et al.* (2000) *Met. Plan. Sci.* **35**, 1309-1320. [3] Drake&Righter (2002) *Nature* **416,** 39-44. [4] King *et al.* (2010) *Earth Plan. Sci. Lt.* **300**, 11-18. [5] Lunine *et al.* (2003) *Icarus* **165**, 1-8. [6] Leshin (2000) *GRL.* **27**, 2017-2020. [7] Hartogh *et al.* (2011) *Nature* **478**, 218-220. [8] Walsh *et al.* (2011) *Nature* **475,** 206-209. [9] Morbidelli *et al.* (2012) *AREPS* **40**, 251-275.

Sr-Nd isotope fractionation against water depth: a case study of Datong gauge station of Yangtze River

CHAO LUO [1*], HONGBO ZHENG [1] WEIHUA WU [1] AND PING WANG [1]

[1] Institute of Surficial Geochemistry, School of Earth Sciences and Engineering, Nanjing University, Nanjing 210093, China. chaoluo.niki@gmail.com (* presenting author)

This study reports Sr-Nd isotopic compositions as well as grain size distribution of suspended sediment collected from different water depths at Datong gauge station of Yangtze River during the raining season of year 2010, in order to investigate the influence of hydrological sorting during transportation on Sr-Nd. Samples were collected biweekly from surface, middle and bottome of river depth during June 12th, 2010 to Augest 29th , 2010.

Our results show that, $^{87}Sr/^{86}Sr$ decreases from surface to bottom, ranging from 0.730332 to 0.720857. $\varepsilon_{Nd}(0)$ ranges from -14.75 to -10.09, with surface sediments having the most negative values. In Yangtze River, $\varepsilon_{Nd}(0)$ decrease from the upper reaches to the lower reaches while $^{87}Sr/^{86}Sr$ increased. [1]

Hence, Sr-Nd isotopic compositions of suspended sediments in large rivers are heterogeneous from surface to bottom. In our findings, the isotope composition of suspended sediment collected from the middle of river channel can best represent the mean isotopic composition of suspended sediment transported by river. Stratification of Sr-Nd isotope may be caused by varied contributions of sources to different depths. At least in the Yangtze River, contribution from the upper reaches is larger in the bottom sediment than in the surface sediment.

Although Sr-Nd isotope is a well acknowledged tool in provenance study, our current results indicate that it is necessary to take the grain size and sampling location into consideration.

[1] Yang et al. (2007) *Science in China* **37**, 682-690.