WATER AND ORGANICS: ASTEROID DELIVERY?

T. OWEN
U. HAWAII
• WE DON’T KNOW!!

• 1. WATER

• 2. MAIN BELT “COMETS”

• 3. ORGANICS
WATER

(HYDROGEN—D/H)
Figure 2. Histograms of distributions of the water D/H ratio in Carbonaceous Chondrites, in LL3 chondrules and clays, in Hot Cores and in interstellar ice (personal compilation of published data). According to this diagram, LL3 chondrites exhibit the best preserved record of the primordial isotopic heterogeneity of the solar system water. Note the similarity between the high D/H values in LL3 chondrites and in interstellar ices.

\[
f = \frac{(D/H)_{\text{H}_2\text{O}}}{(D/H)_{\text{H}_2}}
\]
Xenon Isotopes – II
Mars = Earth!

![Graph showing Xe isotopic mass vs. [Xe/130 Xe] Mars/Solar ratio. The graph includes data points for Mars atmosphere, Earth atmosphere, and Chondrites, with a linear trend line. The y-axis represents the ratio, and the x-axis represents the Xe isotopic mass. The graph indicates that Mars and Earth have similar Xe isotopic compositions.]
MBC: COMET OR ASTEROID?

BOTH?

TEST

D/H IN H₂O: $3.2 \times 10^{-4} \rightarrow$ COMET

$1.6 \times 10^{-4} \rightarrow$ ASTEROID

$2.4 \times 10^{-4} \rightarrow$ ASTERCOM
MBC: SOURCE OF EARTH WATER?

REQUIRES:

• $D/H = 1.6 \times 10^{-4}$

• NOBLE GAS ABUNDANCES (AND XENON ISOTOPES)

MATCH EARTH ATMOSPHERE
TOTAL ORGANIC MATTER DELIVERED BY METEORITES/ASTEROIDS/COMETS

COMPARABLE TO TOTAL MASS OF BIOSPHERE
--(CHYBA, SAGAN ET AL. 1989, 1990.)

BUT THIS ESTIMATE

IGNORES LIMIT SET ON METEORITIC CONTRIBUTIONS BY MIS-MATCH OF NOBLE GASES.

{SIMILAR LIMIT MAY APPLY TO COMETS}

AND THUS

INVITES NEW ESTIMATE, ALSO USING NEWER DATA ON IMPACT HISTORY OF EARLY EARTH.

FROM WHENCE CAME CARBON AND IN WHAT GUISE?
ORGANIC COMPOUNDS IN METEORITES

IOM
INSOLUBLE ORGANIC MATTER
90 TO 99% of carbon in meteorites

SOM
SOLUBLE ORGANIC MATTER
~10% of carbon
~0.1% is Amino Acids:
70 identified—J. Cronin
All Life on Earth uses 20

“Building Blocks” of Protein
The Central Dogma

DNA → Transcription → RNA

Translation: the synthesis of a polypeptide specified by an mRNA

Protein
CONCLUSIONS: DELIVERIES?

Some water—How Much?

Some Organics—How Much? Which?

Noble Gases and Isotopes Will Provide References.
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REPORTS Organic Globules in the Tagish Lake Meteorite: Remnants of the Protosolar Disk
Keiko Nakamura-Messenger,1,2* Scott Messenger,1 Lindsay P. Keller,1 Simon J. Clemett,1,3 Michael E. Zolensky1 Coordinated transmission electron microscopy and isotopic
The Wrong Xenon Problem:

Atmosphere exhibits the wrong isotope architecture for xenon — compared to meteorites

“Planetary component” of meteoritic noble gases is misnomer!
MBC: COMET OR ASTEROID?

BOTH?

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D/H IN H$_2$O: 3.2 X 10$^{-4}$ => COMET
1.6 X 10$^{-4}$ => ASTEROID
2.4 X 10$^{-4}$ => ASTROCOM
PROTOSOLAR NITROGEN

$^{15}N/^{14}N$

- HCN COMETS
- NH$_3$ COMETS (?)
- N$_2$ JUPITER = SUN

$10^{-3}$ $10^{-2}$
WATER

(HYDROGEN—D/H)
Bulk N contents and N-isotopic compositions of meteorites.

Krot et al. (2003), Ivanova et al. (2006)
PROTOSOLAR NITROGEN

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$10^{-2}$
$10^{-3}$
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MBC: SOURCE OF EARTH WATER?

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- NOBLE GAS ABUNDANCES (AND XENON ISOTOPES)

MATCH EARTH ATMOSPHERE
ORGANICS

NITROGEN---$^{15}\text{N}/^{14}\text{N}$

$\text{NH}_3$ $\text{HCN}$

{WE SEE $\text{N}_2$, $\text{Nxx}=>$ amino acids}
ORGANIC COMPOUNDS

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INSOLUBLE ORGANIC MATTER
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“Building Blocks” of Protein
RULES:

1. The Angels Are in the Global View
2. There is no Isotope Exchange Between a Solid and a Gas
3. There are Two Stable Isotopes of Hydrogen: D and H
   Nitrogen: $^{14}\text{N}$ and $^{15}\text{N}$
4. $\text{N}_2 \nleftrightarrow \text{NH}_3$
5. Never Forget Einstein:
PROTOSOLAR HYDROGEN

D/H

JUPITER $\text{H}_2 = \text{(PROTO-SUN)}$

SATURN

COMETS HCN

COMETS H$_2$O

(ICY PLANETESIMALS)
• Physical Properties of Main-Belt Comet P/2005 U1 (Read)

• The main-belt comets occupy dynamically asteroidal orbits in the main asteroid belt.

• Henry H. Hsieh (1 and 2), David Jewitt (1), Masateru Ishiguro (3) ((1) University of Hawaii, (2) Queen’s University Belfast, (3) Seoul National University)
Alles sollte so einfach wie möglich gemacht werden, aber nicht einfacher.

Albert Einstein