The Oldest Planetary Astrochemical Mystery, Jupiter's Great (but Shrinking) Red Spot

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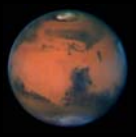
Jupiter and its Galilean Moons

Some Recognizable Objects in our Solar System

Lunar Craters

Rings of Saturn



Martian Polar Caps

Jupiter's Great Red Spot (GRS)

Galileo (1610)

Hooke (1664)

Cassini (1665)

19th-century observers

Hubble (HST)

Pioneer 10 & 11

Voyager 1 & 2

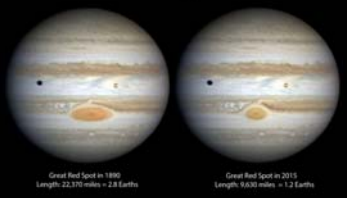
Galileo

Cassini

New Horizons

The Incredible Shrinking Spot

1890 Simulated



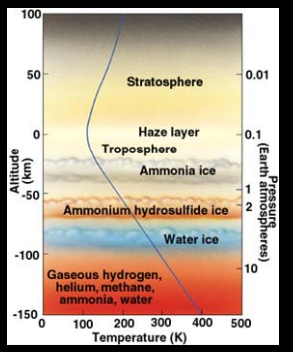
2015 Actual

GRS Shrinkage

15° × (1 year / 0.5°) = 30 years !

Not as red as sometimes depicted

Some Background



Many Proposed Explanations

Tables of R. West et al., 1986 and 2004

1986 → 2016 ??

Proposed Explanations

Carl Sagan
(1934-1996)

Bishun Khare
(1933-2013)

Harold Urey
(1893-1981)

Francis O. Rice
(1890-1989)

Rupert Wildt
(1905-1976)

Coloring agents?

Some Atmospheric Suspects

H_2 He H_2O

NH_3 NH_4SH

Energy – radiation & UV

Ammonium Hydrosulfide NH_4SH … What's Known?

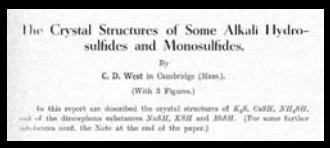
$NH_3(g) + H_2S(g) \rightarrow NH_4SH(s)$

➡ crystal structure density

color vapor pressure

spectra reaction products

NH_4SH



The Crystal Structures of Some Alkali Hydrosulfides and Monosulfides.

By

C. D. West in Cambridge (Mass.).

(With 3 Figures.)

Zeit. für Kristall., 1934, 88(2), 97

tetragonal, Z = 2, d = 1.18 g / cm^3

moderate birefringence, slow sublimation at room temperature

Who is C. D. West?

Cutler DeLong West

1903 born in Glenn Falls, NY
Attended Glenn Falls High School

1924 – Wesleyan Univ., bachelor's
1929 – Harvard, master's
1934 – Harvard, Ph.D. (chemistry)

1934 – hired by Edwin Land (Mr. Polaroid)
1941 – World War II

Cutler DeLong West's war service with Polaroid

crystal growth … $NaNO_3$

Life, June 18, 1945

Polaroid PR, *ca.* 1945

Popular Science, Dec., 1945

"Cutler was always a pleasure"

"kind and very quiet"

"He was said to have more money than Rockefeller, but rode a women's 3 speed bike."

"a genius"

"Edward Land's right hand man."

(Scott R Chamberlain, Boston Raleigh Users Group)

"rode his beat-up bike to Polaroid every day"

"ate all his meals in the company cafeteria"

"exuded the Polaroid legend of mad scientist"

(Edna Dorfman, artist & photographer)

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1941 – World War II
1993 – died on March 3 (Boston Globe)

Ammonium Hydrosulfide NH_4SH … What's Known?

$NH_3(g) + H_2S(g) \rightarrow NH_4SH(s)$

crystal structure — density

color — vapor pressure

spectra — reaction products ⬅

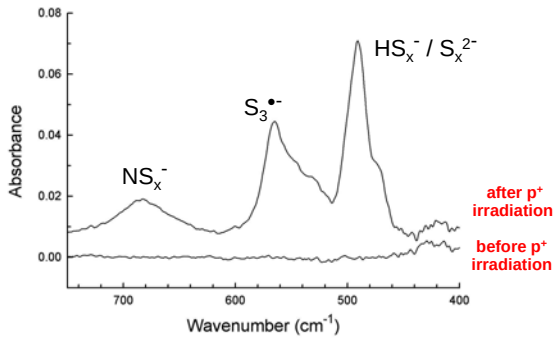
Three Tests for the GRS and NH_4SH Reactions

1. Infrared spectra
   - Can identify reaction products?

2. Colors
   - Looks like GRS?

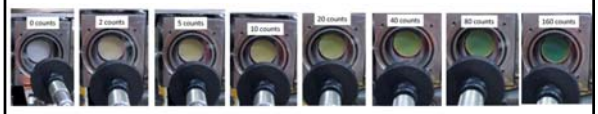
3. UV-vis spectrum
   - Matches Hubble telescope data?

Radiation Products of NH_4SH – Thermal Stability



The Great Green Spot ?!?!

Color changes in NH_4SH on irradiation at 120 K …

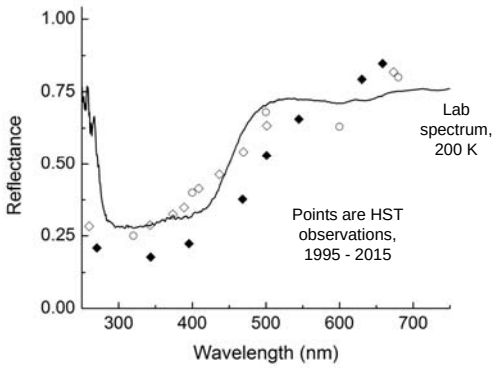


15.6 Mrad

2.5 MGy = 250 Mrad

GRS Voyager 2 Image

The GRS and Hubble Space Telescope Results



New Observations of Jupiter Coming Hubble Space Telescope

Hubble Telescope result from 2015

Polysulfide work to be continued.

JWST to launch in October 2018.

Fuming Liquor of Boyle

Robert Boyle (1627 - 1691)

The Experimental History of Colours – Part 3, Expt. 34 (1664)

Next, take of common brimstone finely powdered five ounces, of sal-armoniac likewise pulverized an equal weight, of beaten quicklime six ounces, mix these powders exquisitely, and distil them through a retort placed in sand by degrees of fire, giving at length as intense a heat as you well can in sand; there will come over (if you have wrought well) a volatile tincture of sulphur, which may probably prove an excellent medicine, and should have been mentioned among the other preparations of sulphur, which we have elsewhere imparted to you, but that it is very pertinent to our present subject, the change of colours. For though none of the ingredients be red, the distilled liquor will be so: and this liquor, if it be well drawn, will, upon a little agitation of the phial first unstopped (especially if it be held in a warmer hand) send forth a copious fume, not red, like that of nitre, but white; and sometimes this liquor may be so drawn, that I remember, not long since, I took pleasure to observe in a parcel of it, that ingredients not red, did not only yield by distillation a volatile spirit that was red, but though that liquor did upon the bare opening of the bottle it was kept in, drive us away with the plenty and sulphureous scent of a white steam which it sent forth, yet the liquor itself being touched by our fingers, did immediately dye them black.

ammonium polysulfide $(NH_4)_2S_x$

For More Information …

The Astrochemistry Subdivision of the American Chemical Society

Frontiers of Solar System Chemistry: Planets to Comets and Beyond

ACS National Meeting – Philadelphia, August 2016

Organizers – Reggie Hudson & Stefanie Milam

Acknowledgments

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Nancy Chanover New Mex. State Univ.

NASA $$ Programs **Planetary Atmospheres Planetary Astronomy**

On the Web **http://science.gsfc.nasa.gov/691/cosmicice/**