Meteor Storm Evidence Against the Recent Formation of Lunar Crater Giordano Bruno

Paul Withers
withers@lpl.arizona.edu

32nd LPSC - #1007
2001.03.13

Medieval Chronicle of Gervase of Canterbury, 1178 AD

...On the Sunday before the Feast of St. John the Baptist...was witnessed by some five or more men...Now there was a bright new Moon...and suddenly the upper horn split in two. From the midpoint of this division a flaming torch sprang up, spewing out...fire, hot coals, and sparks...The body of the Moon which was below writhed...throbbed like a wounded snake. Afterwards it resumed its proper state. The phenomenon was repeated a dozen times or more. [Finally] the Moon...along its whole length took on a blackish appearance. [The witnesses] are prepared to stake their honour on an oath that they have made no addition or falsification in the above narrative.

Eyewitnesses to a lunar impact?

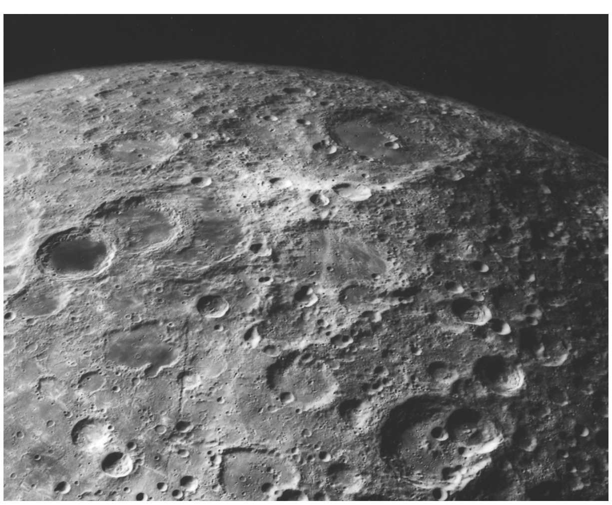
In 1976, Hartung proposed that Gervase had recorded an eyewitness account of a lunar impact in June, 1178 AD.

The crater Giordano Bruno, 22 km in diameter, was suggested as the impact site based on its obvious youth and proximity to the north-eastern limb of the Moon.

Dramatization of the impact, from
http://members.tripod.co.uk/petergrego/ft105.htm
by Peter Grego

AS8-12-2209

Views of Giordano Bruno
from Apollos 8 and 16



A16 metric
frame 3008

Scientific Importance of this Hypothesis

If this hypothesis is correct then

The Earth and human civilization narrowly avoided disaster in 1178 AD. Terms such as “regional devastation” and “global climatic catastrophe” are appropriate.

Our knowledge of impact cratering will benefit from studies of a large, pristine crater.

Great education/public outreach tool.

An Alternative Interpretation of the text

How can “fire, hot coals, and sparks” near the Moon be differentiated from one another by terrestrial observers?

How can any impact phenomenon be “repeated a dozen times or more”?

This is a meteor in transit of the Moon – Nininger and Huss, 1977

Lunar Laser Ranging Evidence

A large impact on the Moon will cause it to oscillate. Lunar laser ranging measures such oscillations. In 1978, Calame and Mulholland found this data to be consistent with the formation of Giordano Bruno in 1178, and said so on the front cover of *Science*. However, a 1981 analysis of a more complete dataset by Yoder found that a recent impact could not explain the unexpectedly large oscillations of the Moon and proposed turbulent core-mantle friction as their source.

Ejecta and Earth

In a Meteoritical Society abstract of 1991 concerning Hartung's hypothesis, Gault and Schultz said that "Earth accreted more than 10^{13} g in a week following the impact." The abstract does not comment further on the ejecta size, speed, place or time of arrival. Here, I describe the meteor storm likely to have been caused by the arrival of Giordano Bruno ejecta on Earth.

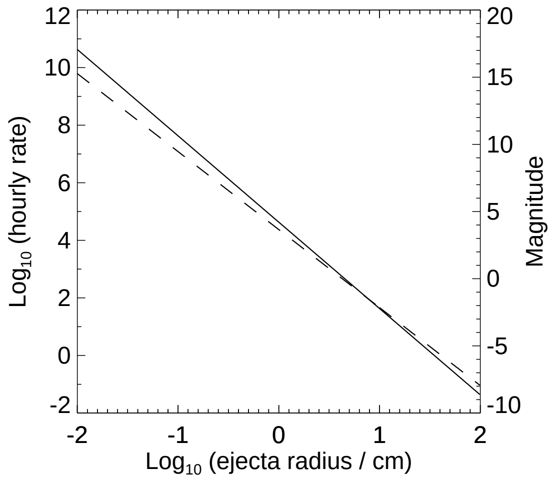
For personal reasons, Gault did not continue this work.

Meteor Storm

Traditional power law size distributions for ejecta apply to the ejecta blanket as a whole, not to that portion that reaches escape velocity. Studies of secondary craters and theoretical calculations of the size of melt droplets suggest that the characteristic radius of ejecta reaching the Earth is 0.1 – 10 cm.

Assuming 2.5 g cm^{-3} density, 11.2 km s^{-1} speed, 1 cm radius, log M (g) = 6.06 - 0.62 m_{vis} - 3.89 log V° (km/s) - 0.67 log (sin(radiant altitude, 45^o)), uniform flux over surface of Earth for one week, meteors visible at 70 km, total mass of 10^{13} g…

Observe 50 thousand magnitude 1.7 meteors per hour within 30^o of line of sight. Anywhere on Earth. For a week.



Hourly rate in solid line, visible magnitude in dashed line, likely range of radius is 0.1 – 10 cm.

Any reasonable size distribution between 0.1 and 10 cm will produce an exceptional meteor storm.

There are no European, Arab, Chinese, Japanese, or Korean records of such a storm in June, 1178 AD.

Hence the formation of Giordano Bruno did not occur in June, 1178 AD.

Other Problems with the Hypothesis

Gervase only mentions one group of five eyewitnesses. No other chronicle has similar records. The event occurred an hour after sunset and would have been visible over much of Western Europe. Interestingly, a meteor appearing directly in front of the Moon has only a 1 km diameter footprint on the ground.

The Moon was not visible until the day after that given by Gervase.

How old is Giordano Bruno?

- It is the youngest crater of its size or larger. The expected interval between such cratering events is 15 Ma.
- Spectral maturation of its ejecta suggests an age of less than 100 Ma – Grier.
- Observed weathering suggests that it “is substantially older than 800 years” – Pieters et al.

Conclusions

Assuming Gault and Schultz's work to be correct, that the ejecta was somewhat spread out in its time and place of arrival, and that it didn't all arrive at local noon, an exceptional meteor storm would have occurred after the formation of Giordano Bruno. There are no records of such of storm in June, 1178 AD, hence Giordano Bruno did not form then.

Acknowledgements, References, and Caveat

AE Bernstein, W Bottke, JA Grier, WK Hartmann, LL Hood, L Keszthelyi, JS Lewis, JI Lunine, HJ Melosh, E Pierazzo, BE Schafer, M Schuchardt, T Swindle, and an anonymous reviewer.

Calame and Mulholland (1978) Science **199,** 875
Gault and Schultz (1991) Meteoritics **26,** 243
Grier (1999) PhD Thesis, University of Arizona
Hartung (1976) Meteoritics **11,** 187
Nininger and Huss (1977) Meteoritics **12,** 21
Pieters et al (1994) Science **266,** 1844
Yoder (1981) Phil. Trans. Roy. Soc. **303,** 327

To correctly describe the meteor storm, first use a hydrocode to calculate the size-velocity distribution of the ejecta, then use an orbital dynamics code to track them to Earth. The work here is a back-of-the-envelope approximation.