UH scientists analyze a tiny comet grain to date Jupiter's formation

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Comet 81P/Wild 2 was brought to Earth in 2006 by NASA's Stardust spacecraft. Credit: NASA/JPL/Caltech

Particles from comet 81P/Wild 2 brought to Earth in 2006 by NASA's Stardust spacecraft indicate that Jupiter formed more than three million years after the formation of the first solids in our Solar System. The new finding helps test Solar System formation theories, which do not agree on the timing of Jupiter though it is certain the formation of this giant planet affected how materials moved, collided, and coalesced during the complex planet-forming process.

Published in the February 1, 2012 issue of the Astrophysical Journal Letters are new results from laboratory analyses on a tiny fragment in one of the comet Wild 2 particles. Dr. Ryan Ogliore, a postdoctoral researcher at the Hawaii Institute of Geophysics and Planetology (HIGP, University of Hawaii) conducted the research with Drs. Gary Huss and Kazuhide Nagashima, also from HIGP, and colleagues from the University of California at Berkeley, University of Washington, and the Lawrence Berkeley National Laboratory.

Comets formed in the frigid Kuiper belt out beyond Neptune, but analyses of the Wild 2 samples showed that comets are composed of low-temperature and high-temperature materials that must have come from completely different environments. The team led by Ogliore analyzed a chondrule fragment known from previous research to have formed by high-temperature processes in the inner solar nebula—the cloud of gas and dust surrounding the infant Sun from which the planets formed. What could be more contradictory than high-temperature objects from the innermost regions near the Sun becoming the predominant dust components of an icy comet in the outer solar nebula? Ogliore and colleagues set out to determine when this grand, outward migration of materials occurred.

Using the University of Hawaii Cameca ims 1280 ion microprobe, the team measured magnesium isotopes (26Mg is the decay product of the short-lived radioactive isotope 26Al) and elemental aluminum (27Al) in their sample to bracket its formation age. Aluminum-26, with a half-life of 730,000 years, is the extremely useful clock that cosmochemists use to date ancient events since the 26Al/27Al ratio varies in objects that formed at different times. Ogliore and team found no evidence for extinct 26Al, meaning the cometary fragment formed after nearly all the 26Al had decayed. Assuming homogenous distribution of 26Al in at least the inner solar nebula, their results suggest the fragment formed at least three million years after the first solids formed. And this would

have happened before Jupiter could have interfered, for theory says that a growing Jupiter would have accreted material so efficiently as to open a gap in the solar nebula. This gap would have posed a barrier to the outward migration of any material formed nearer the Sun than Jupiter's orbit, such as the fragment analyzed by Ogliore and team. The timing implies Jupiter formed more than three million years after the formation of the first solids in our Solar System. "We were surprised to find such a late-forming, high-temperature little rock in these cometary samples," said Dr. Ogliore. "That we are able to test theories about the formation time of Jupiter and consequently, the origins of our Solar System is really a testament to the importance of sample-return missions like Stardust."

More information: Ogliore, R. C., Huss, G. R., Nagashima, K., Butterworth, A. L., Gainsforth, Z., Stodolna, J., Westphal, A. J., Jowsiak, D., and Tyliszczak, T. (2012) Incorporation of a Late-forming Chondrule into Comet Wild 2, Astrophysical Journal Letters, v. 745:L19-L23, doi:10.1088/2041-8205/745/2/L19

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