OBSERVATIONS OF COMET C/2009 P1 (GARRADD) AT 2.4 AND 2.0 AU BEFORE PERIHELION. L. Paganini[1,4], M. J. Mumma[1], G. L. Villanueva[1], M. A. DiSanti[1,2], B. P. Bonev[1,2], M. Lippi[3], H. Boehnhardt[3]. [1]Goddard Center for Astrobiology, NASA-GSFC, Greenbelt, USA (lucas.paganini@nasa.gov). [2]Department of Physics, Catholic University of America, Washington, DC, USA. [3] Max-Planck-Institut für Sonnensystemforschung, Katlenburg-Lindau, Germany. [4]NASA Postdoctoral Fellow.

Introduction: Until 2005, cometary nuclei were thought to be primordial remnants from the giant planets' accretion zone (then viewed as 5–30 AU from the proto-Sun), but subsequent dynamical studies challenge this view and demonstrate the need for an alternative metric of cometary origins [1,2,3]. Those origins are most directly inferred from the properties of native materials (dust, ice) in the nucleus.

Since 1985, measurements of nucleus composition have revealed major diversity amongst comets, based on crystallinity of silicates and/or the chemistry of native ices. The interpretation, however, is partly linked to questions of orbital evolution. A comet making its first apparition after ejection from the long-term storage reservoir (Kuiper Belt, Oort Cloud) may reveal primordial composition (although cosmic ray processing might affect the properties of the outer layers of cometary nuclei during dynamical storage). Comets in short period orbits, on the other hand, may have experienced thermo-chemical evolution over successive apparitions that may induce changes from primordial composition. In addition, the number of comets quantified to date in terms of primary (parent) volatiles is still relatively small, restricting full taxonomic classification of origins. We present results obtained from near IR observations of Oort Cloud (OC) comet C/2009 P1 (Garradd), hereafter C/2009 P1, including chemical abundance (relative to water) and 1-D spatial profiles for several primary volatiles, and discuss them in the context of an emerging taxonomy based on primary volatiles in comets. The high fractional abundance of CO identifies comet C/2009 P1 as a CO-rich comet.

Observations: Comet C/2009 P1 was discovered at R_h = 8.7 AU by G. J. Garradd on UT 2009 August 13, when it displayed a circular (15″ diameter) coma with a visual magnitude ~17. Its orbit is inclined to the ecliptic by 106.2°, and the Tisserand parameter (Tj) and original semi-major axis are –0.432 and 2564.1 AU, respectively. Together, these classify C/2009 P1 as a nearly isotropic (long period) comet from the OC reservoir. We observed comet C/2009 P1 with the Cryogenic high-Resolution InfraRed Echelle Spectrograph (CRIRES) at ESO's Very Large Telescope (VLT), located in the Atacama desert (Chile), on UT 2011 August 7 and on five consecutive nights spanning September 17–21. CRIRES provided a spectral resolution ($\lambda/\Delta\lambda$) of about 50,000 using an entrance slit of 0.4″ (in width) and spatial coverage of 40″ (in length).

The (relatively) High Abundance of CO: Measurements of cometary composition have suggested carbon monoxide to be rather low (or depleted) relative to H_2O in most comets [4,5]. The measured abundance ratios (from ground-based studies) range from 0.2% to ~24%, but only four comets displayed CO > 10%, relative to water. A recent survey of 18 comets (10 JFCs and 8 OC comets) at heliocentric distances between 1 and 4 AU by the AKARI mission [6], found a similar paucity of comets enriched in CO. Comets within 2.5 AU of the Sun revealed little (or no) CO content (mostly upper limits were retrieved), though their CO_2 abundance varied from a few to ~30% (relative to water). On the other hand, comets such as C/1995 O1 [7], C/1996 B2 [8,9], C/1999 T1 [10], C/2008 Q3 [6], and C/2009 P1 [11,12,13], revealed high abundances of CO relative to H_2O, and thus these "peculiar" exceptions (compared to the normal trend) are not trivial. We discuss possible implications to their origins. Given the relatively large heliocentric distance of C/2009 P1, we also explore the effect of water not being fully sublimated within our field of view and identify the "missing" water fraction needed to reconcile the retrieved abundance ratios with the mean values found for "organics-normal" comets.

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