COMPOSITIONAL TAXONOMY OF COMETS AND THE UNIQUE CASES OF 96P/MACHHOLZ 1 AND 73P/SCHWASSMANN-WACHMANN 3. D. G. Schleicher and A. N. Bair, Lowell Observatory, 1400 W. Mars Hill Rd., Flagstaff, AZ 86001.

Introduction and Comet Taxonomy: Comets are widely believed to be the most pristine objects available for detailed study remaining from the epoch of solar system formation. As such, comets can be used as probes of the protoplanetary material which was incorporated into our Solar System. Differences in chemical composition or physical attributes among comets can indicate either differences in primordial conditions or evolutionary effects. The actual cause of a specific difference in properties can be determined by statistical analyses of the chemical, physical, and orbital properties of a large number of objects. We are now in the process of performing a new uniform reduction and set of analyses of 32 years of narrowband photometry on 153 comets which form the Lowell comet database. We will present first-look results regarding the chemical compositions of comets, including evidence for as many as 9 compositional groupings, at least some of which are associated with the comets' place of origin rather than due to subsequent evolution. In this presentation, we also focus on a pair of interesting comets observed in the past two years which provide additional strong constraints regarding the question of origin vs. evolution in comet chemistry.

Comet 73P/Schwassmann-Wachmann 3: The first important case is Comet 73P/Schwassmann-Wachmann 3, for which we measured the chemical composition in 4 components during its excellent apparition during 2005, including the apparent primary body C and 3 fragments (B, G, and R), thus permitting us to probe the composition of the interior of Schwassmann-Wachmann 3's nucleus. Abundances of carbon-chain molecules yield a classification of strongly "depleted" in our original [1] database, with the Q(C_2)-to-Q(CN) ratio depleted by factors of between 7 and 8 for components C, B, and G, and a comparable upper limit for component R. In 1990, prior to any fragmentation, S-W 3 was identified as being strongly depleted, with an upper limit on Q(C_2) corresponding to a C_2 depletion of a factor of 6.4 or greater [2]. With the material released from the interior of S-W 3 yielding comparable depletions of carbon-chain molecules as with the original surface of the nucleus, we can conclusively state that carbon-chain depletion is *not* caused by evolution of the surface, and so instead must reflect the primordial composition at the time and location that the comet accreted.

Comet 96P/Machholz 1: During its close apparition in 2007 May/June, we discovered that Comet 96P/Machholz 1 exhibited extremely anomalous molecular abundances. Machholz 1 is shown to be depleted in CN with respect to OH by about a factor of 65 from average, while C_2 and C_3 are also low with respect to OH but "only" by factors of 10-20 from most comets. When comparing C_2 directly with CN, Machholz 1 is actually enhanced by about 5× as compared to "typical" composition, as defined by [1]. In contrast to the extreme CN depletion, NH, the granddaughter of ammonia, is near the upper end of its normal range.

This extremely low CN-to-OH ratio for Machholz 1 indicates that it is either compositionally associated with Comet Yanaka (1988r; 1988 Y1), which was strongly depleted in CN and C_2 but not NH_2 [3], or represents a new compositional class of comets, since Yanaka had a much greater depletion of C_2 (>100×) than does Machholz 1. It remains unclear if these comets formed at a location in our solar system with unusual conditions and a low probability of being gravitationally perturbed into the inner solar system, or if one or both objects are interstellar interlopers.

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References: [1] A'Hearn, M. F., et al. (1995) *Icarus* **118**, 223. [2] Fink, U., and Hicks, M. (1996) *Ap. J.* **459**, 729. [3] Fink, U. (1992) *Science* **257**, 1926.