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15 Years of Comet Photometry: A Comparative Analysis of 80 Comets.

D.J. Osip[4,1], D.G.Schleicher[1], R.L. Millis[1], M.F. A;Hearn[2], P.V. Birch[3]

1. Lowell Observatory 2. University of Maryland

3. Perth Observatory 4. University of Florida

ABSTRACT

In 1976 we began a program of narrowband photometry of comets that has encompassed well over 400 nights of observations. To date, the program has provided detailed information on 80 comets, 11 of which have been observed on multiple apparitions. In this paper we present the observed range of compositions (molecular production rate ratios) and dustiness (gas production compared with Afρ) for a well sampled group of comets. Based on these results we present preliminary analysis of taxonomic groupings as well as the abundance ratios we associate with a 'typical' comet.

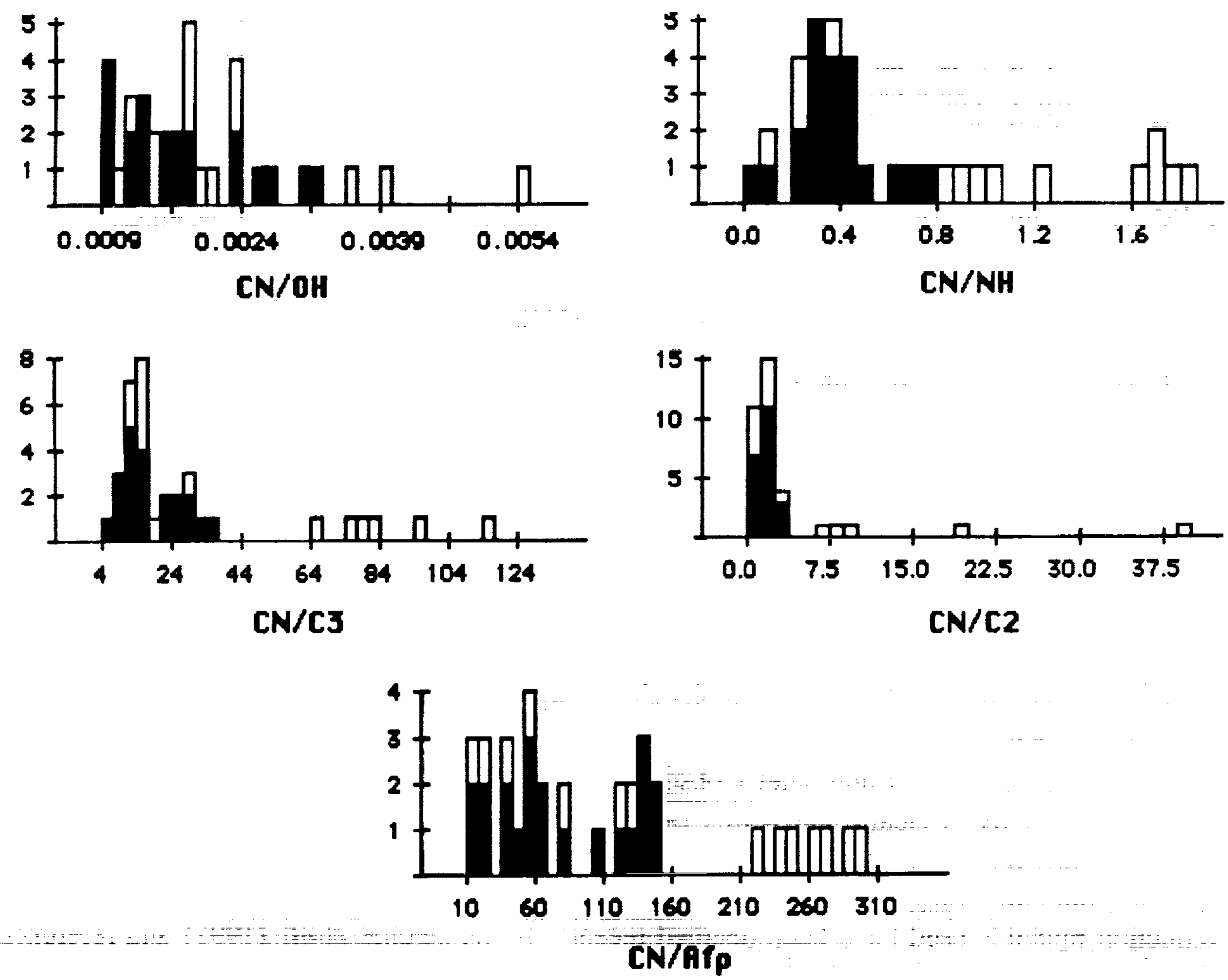
INTRODUCTION

Given the ever increasing number of comets that have been studied extensively, it is becoming possible to consider a statistically meaningful database of cometary observations and to determine what is typical for the production rate ratios (or molecular abundances) of comets. It is just such a database of observations that will be considered here, with 80 comets observed on 428 nights over the past 15 years. By applying some reasonably stringent criteria to initially limit the discussion to only the comets with well determined and verified abundances, one is able to define which comets are typical and which have deviations that may indicate actual taxonomic groupings. One wishes also to determine the correlations in the behavior of different molecular abundances, i.e., to determine which molecular species are most closely related in their apparent activity in comets as a whole.

The narrowband filter photometry observations discussed here are part of a 15 year program begun in 1976 by A'Hearn and Millis (A'Hearn *et al.*1977). The project began with filters isolating emission of CN and C_2 as well as continuum band filters and later additional filters isolating the emission bands of C_3, NH, and OH were included. Observational techniques and reduction methods used have been detailed recently by Schleicher *et al.* (1991) and references therein. Parameters involved in the reduction and modelling of the data have evolved over time and accordingly, we have recently re-reduced the entire database. The Haser model was applied to convert molecular measurements to production rates, Q, as an aperture independent quantity. Similarly, in order to quantify the production of dust grains from our continuum data, we have used the now familiar quantity Afρ, the product of the albedo of the grains, the fraction of the aperture filled by the grains, and the projected aperture radius (A'Hearn *et al.* 1984).

ANALYSIS and DISCUSSION

To minimize any errors introduced by modelling, prior to the actual analysis of the general characteristics of comets, the data for each individual comet was normalized to a common heliocentric distance of 1.5 AU using an r_H-dependence of –3 for the emission species and –2 for the dust. In the normalization and calculation of a mean production rate for each species, only the observational data obtained between 0.8 AU and 2.8 AU were included due to the adverse effects that a change in scalelengths used can have outside of this region. To insure that the observations were indeed representative of the comet, a given comet had to be observed on two or more nights and have three or more observations. Finally, only comets with observations in all filters (OH, NH, CN, C_3, C_2, and continuum) were included in this early analysis. Histograms showing the ratios of CN to each of the emission species as well as dust are given in the following figure for the 30 comets that satisfy all the above criteria.



The most important thing to note in the histograms is that the comets that stand out as anomalous in one molecular abundance ratio are not necessarily the same as those that stand out in another ratio. In fact, we have observed two strong correlations; one between those that stand out as depleted in C_2 and C_3 and another between those that are anomalously low in OH and NH with respect to CN. Although not presented here, separate two dimensional plots of the species in question versus CN show the correlations very clearly. Further analysis also indicates the groupings that are suggested by the histograms are real and when one applies a rigorous cluster analysis, the groupings are clearly identifiable. It is not yet possible, however, to distinguish in all cases between distinct groups or the tail of a continuous distribution.

While the comets that are anomalous in some of the abundance ratios can appear quite ordinary in others, only those that show no anomalous behavior in any ratios are used to determine the range for a 'typical' comet. Note that four of the comets that exhibit normal molecular abundance ratios but have distinctly high gas-to-dust ratios are also excluded from the determination. The results for a 'typical' comet as determined by this reduced set of 17 of the 30 comets are the dark shaded regions of the histograms. The majority of the remaining 50 comets that did not meet the original selection criteria can also be classified within the bounds set here for a 'typical' comet. This supports our preliminary analysis defining what kind of molecular abundance ratios can be considered ordinary for a 'typical' comet.

CONCLUSIONS

Preliminary analysis of our data indicates a division of taxonomic groupings among comets based on differing molecular abundances. As indicated in the histograms, groupings include: a) comets depleted in C_2, C_3, and to a lesser degree, NH; b) comets with anomalously low OH, NH, and dust with respect to CN, but with normal ratios amongst the carbon bearing species; and c) a number of comets with distinctly high gas-to-dust ratios but indicating normal abundances for the emission species. Also apparent in the data are strong correlations between OH and NH, and between C_2 and C_3.

Finally, our preliminary analysis suggests the following molecular abundance ratios as normal for a 'typical' comet based on the restricted database.

	CN/OH	CN/NH	CN/C3	CN/C2	CN/dust
Mean	1.75e-3	0.65	20.69	1.64	91.72
Sigma	0.6e-3	0.34	9.43	0.76	57.21

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