Kenneth J. McNamara
Department of Earth and Planetary Sciences,
Western Australian Museum,
Francis Street, Perth,
Western Australia 6000
E-mail: mcnamk@muswa.dialix.oz.au

References

1. S. M. Awramik, *Science* **174**, 825 (1971); M. R. Walter and G. R. Heys, *Precamb. Res.* **29**, 149 (1985).
2. S. M. Awramik, in *Early Organic Evolution: Implications for Mineral and Energy Resources*, M. Schidlowski *et al.*, Eds. (Springer-Verlag, Berlin, 1992), pp. 435–449; K. J. McNamara and S. M. Awramik, *Sci. Prog. Oxf.* **77**, 1 (1994).

■

Airborne Particle Analysis

In the Perspective "Airborne particle analysis for climate studies" (6 Sept., p. 1352), Thomas Peter discusses upcoming methods of online airborne-particle analysis using time-of-flight mass spectrometry. In the description of the analytical capabilities of the method, Peter points out that "general rules on how to construct an optimal particle grouping under field conditions are still missing." But it has now been described in the literature how an automized classification of particles in an unknown particle population can be performed (*1–3*). The techniques to analyze and classify airborne particles in real time are available. On the basis of the ideas and developments of several groups described during the last decade, methodologies such as on-line mass spectrometry of airborne particles (*4*) and fuzzy clustering of spectral data (*5*) have evolved into a powerful technique that allows for a quick and precise description of the current particle population of the surrounding air.

Meanwhile, there is a common understanding that only a simultaneous analysis of both positive and negative ions formed by laser desorption ionization is able to unambigiously characterize and classify single particles by mass spectrometry. This conceptual paradigm has been validated by a study (*1*) demonstrating that the gain of analytical information by using both ion polarities is by far higher than just a factor of two, as compared with using just one ion polarity. With this approach of data collection, real-time particle classification by statistical methods such as fuzzy clustering can become a reality for atmospheric research (*3*).

*Bernhard Spengler**
Klaus-Peter Hinz
Raimund Kaufmann
Institute of Laser Medicine,
University of Duesseldorf,
D-40001 Duesseldorf, Germany
**E-mail: spengler@uni-duesseldorf.de*

References

1. K.-P. Hinz, R. Kaufmann, B. Spengler, *Aerosol Sci. Technol.* **24**, 233 (1996).
2. K.-P. Hinz, F. Drews, R. Lange, R. Kaufmann, B. Spengler, in *Proceedings of the 44th ASMS Conference on Mass Spectrometry and Allied Topics* (American Society for Mass Spectrometry, Portland, OR, 12 to 16 May 1996), p. 1136.
3. K.-P. Hinz, R. Kaufmann, B. Spengler, *J. Aerosol Sci.* **27** (suppl. 1), 171 (1996).
4. J. Marijnissen, B. Scarlett, P. Verheijen, *ibid.* **19**, 1307 (1988); P. J. McKeown, M. V. Johnston, D. M. Murphy, *Anal. Chem.* **63**, 2069 (1991).
5. B. Treiger, I. Bondarenko, H. Van Malderen, R. Van Grieken, *Anal. Chim. Acta* **317**, 33 (1995).

Response: New techniques for real-time chemical analysis of individual particles may open up a rich new understanding of tropospheric and stratospheric aerosol effects and processes. Some of these upcoming possibilities were illustrated in the Perspective, as well as some of the critical steps we will have to overcome on the way to these goals. Three examples served to illustrate the state of the art: simultaneous particle chemical and size analysis (*1*), the first available measurements in the field (*2*), and the development of quantitative techniques for stratospheric aerosol research (3). Other important recent advances include the detection of both positive and negative ions (4), referred to by Spengler *et al.*; analysis of particles 20 nanometers in diameter (5); and the application of MS-MS to ions from a single aerosol particle (6).

As Spengler *et al.* mention, advanced analysis algorithms such as fuzzy cluster analysis (FCA) (4) or regression trees (7) show great promise for dealing with the data from single particle analysis. However, FCA is only part of the solution to data analysis (8). FCA is appropriate for some data sets, but simpler techniques can be more conclusive for others. When one studies the atmosphere, there is no substitute for carefully selecting data from locations and in meteorological conditions appropriate for a particular question in aerosol formation and chemistry. This process is slow and requires scientific insight that is not easily transferred to automated analysis.

Thomas Peter
Max Planck Institute for Chemistry,
D-55020 Mainz, Germany
E-mail: peter@nike.mpch-mainz.mpg.de
Daniel M. Murphy
Aeronomy Laboratory,
National Oceanic and Atmospheric
Administration, 325 Broadway,
Boulder, CO 80303, USA
E-mail: murphyd@al.noaa.gov

References

1. C. A. Noble and K. A. Prather, *Environ. Sci. Technol.* **30**, 2667 (1996).
2. D. M. Murphy and D. S. Thomson, *Aerosol Sci. Technol.* **22**, 237 (1995); *J. Geophys. Res.*, in press.
3. K. Mauersberger and J. Schreiner, personal communication.
4. K.-P. Hinz, R. Kaufmann, B. Spengler, *Aerosol Sci. Technol.* **24**, 233 (1996).
5. W. D. Reents Jr. *et al.*, *ibid.*, p. 263.
6. P. T. A. Reilly, R. A. Gieray, M. Yang, W. B. Whitten, J. M. Ramsey, paper presented at the American Association for Aerosol Research Conference, Orlando, FL, 14 to 18 October 1996.
7. K. R. Neubauer, S. T. Sum, M. V. Johnston, A. S. Wexler, *J. Geophys. Res.* **101**, 18 (1996).
8. B. Treiger, I. Bondarenko, H. Van Malderen, R. Van Grieken, *Anal. Chim. Acta* **317**, 33 (1995).

Letters to the Editor

Letters may be submitted by e-mail (at science_letters@aaas.org), fax (202-789-4669), or regular mail (*Science*, 1200 New York Avenue, NW, Washington, DC 20005, USA). Letters are not routinely acknowledged. Full addresses, signatures, and daytime phone numbers should be included. Letters should be brief (300 words or less) and may be edited for reasons of clarity or space. They may appear in print and/or on the World Wide Web. Letter writers are not consulted before publication.