Pergamon

Geochimica et Cosmochimica Acta, Vol. 67, No. 24, pp. 4661–4664, 2003

0016-7037/03 $30.00 + .00

doi:10.1016/j.gca.2003.08.007

The multifarious scientific career of Robert M. Walker

THOMAS J. BERNATOWICZ*
Laboratory for Space Sciences and Department of Physics, Washington University, St. Louis MO 63130, USA

(*Received May* 29, 2003; *accepted in revised form August* 14, 2003)

In March of 2003, the McDonnell Center for the Space Sciences and Laboratory for Space Sciences at Washington University hosted a two day symposium to celebrate the life and scientific work of one of the great visionaries in the space sciences, Robert M. ("Bob") Walker. The symposium was attended by over a hundred of his colleagues and former students who, through formal presentations of their current research and informal discussions, gave testimony to his support, guidance, scientific leadership and inspiration. Bob's imagination, sense of scientific rigor, and passion for the microscopic world and its use as a window on the Cosmos, has been imprinted on several generations of physicists, space scientists and cosmochemists. Those who have been fortunate enough to work with Bob know well that he reserves little patience for glorification of the person—rather, it is the work that counts. The organizers of the Walker Symposium therefore considered that an appropriate tribute to his scientific legacy would be a Special Issue of *Geochimica et Cosmochimica Acta* consisting of research papers that treat some of the topics to which he contributed substantially, and that reflect the broad influence he has had on numerous colleagues, postdoctoral scientists and students. This volume is the result.

The remarkable breadth of Bob's interests and contributions is evidenced in the subjects treated in the two dozen papers herein. The research areas addressed range from ancient stardust, meteorites and interplanetary dust particles, to organics and trace elements in meteorites, to lunar science, to cosmochemistry and geochemistry, to mass spectrometry and isotopic analysis, and to remote sensing. Even this impressive list is incomplete, however, and does not touch on his fundamental contributions to particle physics, nuclear physics (particularly the invention of fission track dating), cosmic ray physics (studies of heavy cosmic rays and their detection), solid state physics (radiation effects in solids), and archeometry (the dating of archeological objects by thermoluminescence and fission tracks).

Bob's earliest professional work was at Brookhaven, where he was the first student to use the Cosmotron. His Ph.D. thesis (1954) in particle physics at Yale University involved the interaction of neutrons with lead plates in a cloud chamber, and led to the discovery that strange particles are produced in pairs (Walker et al., 1955). In 1954 he joined the General Electric Laboratory in Schenectady, set up a spin resonance spectrometer and started investigating radiation effects in solids. His research on the behavior of copper exposed to electrons (Corbett, Smith, and Walker, 1959a,b) is still regarded as the final

Fig. 1. Young Bob.

word in this area. In 1962 he discovered that chemical etching could reveal charged particle tracks in insulators (Price and Walker, 1962) and shortly thereafter applied this knowledge to develop a new geochronometer based on fission tracks (Price and Walker, 1963a) and a means to measure very low uranium concentrations in minerals (Price and Walker, 1963b). With his coworkers, he became the first to observe radiation damage in meteorites due to cosmic rays (Maurette, Pellas, and Walker, 1964), and he also discovered tracks from spontaneous fission of the extinct nuclide ^{244}Pu in meteorites (Fleischer, Price, and Walker, 1965a). In the period 1965–67, he applied the track etching technique to diverse problems in neutron dosimetry (Fleischer, Price, and Walker, 1965b), dating by α-recoil tracks (Huang and Walker, 1967), cosmic-ray exposure ages (Fleischer et al., 1965a), and in archaeology and anthropology (Fleischer et al., 1965b,c). In 1967 he founded the study of extremely heavy cosmic rays when he discovered tracks from cosmic rays

* Author to whom correspondence should be addressed (tom@wuphys.wustl.edu).

heavier than iron in meteorites (Fleischer et al., 1967a) and pioneered in the use of plastics to detect such nuclei in cosmic ray balloon flights (Fleischer et al., 1967b).

During this period (1966), Bob came to Washington University as the first McDonnell Professor of Physics and began to set up the Laboratory for Space Sciences. In his new academic post, he continued his studies of solar-flare and galactic cosmic-ray tracks in meteorites (Blanford et al., 1969) and participated in several NASA planning committees for the impending lunar landings. When moon rocks finally became available in 1969, he was able to realize his dream of using them to determine the energy spectrum and flux of cosmic rays. Work along these lines, as well as thermoluminescence studies of the lunar regolith, occupied him for the next few years (e.g., Crozaz et al., 1970; Walker and Zimmerman, 1972; Walker and Yuhas, 1973).

Bob's profound dedication to the general progress of planetary science, and his exceptional strategic skills, led him naturally to assume an increasingly heavy administrative burden in addition to his own research. In his uniquely effective style of fostering innovative science, he collected talented individuals in an environment conducive to research, including independent colleagues as well as those who would work under his own direction. Bob played a large role in bringing Charles Hohenberg to the Physics Department in 1970 and in helping to revitalize the Geology Department (now the Department of Earth and Planetary Sciences, which consistently receives high national rankings) with the appointments of Ray Arvidson, Ghislaine Crozaz, Frank Podosek and G. Jeffrey Taylor to the Earth Science faculty in 1973, and Larry Haskin and his group in 1976. He also added new faculty strength to the Department of Physics in rapidly developing areas of astrophysics and space physics. His intense efforts toward building a world-class laboratory culminated in 1974 in the establishment of the McDonnell Center for the Space Sciences, providing for endowed faculty positions in space-related fields, as well as graduate student fellowships and a program for visiting scientists. The legacy of Bob's vision is manifest in the McDonnell Center, which today consists of some 80 professors, research scientists and graduate students working in such diverse areas as meteoritics, lunar science, planetary imaging and geophysics, theoretical and observational astrophysics, high energy astrophysics, general relativity, extraterrestrial materials sciences, and cosmic rays.

Despite the demands on his time from such organizational involvements, he was able to maintain an impressive pace of creative research, on such topics as neon isotope anomalies in meteorites (Audouze et al., 1976) and the search for traces of superheavy elements in meteorites (Fraundorf et al., 1977). With characteristic foresight, he recognized even at this early date the potential importance of the ion microprobe in making isotopic measurements on microscopic samples (Zinner et al., 1976), and after much effort in securing private funding was able to add this instrument to the Laboratory in 1982. All of the recent spectacular results on the identification and characterization of stellar condensates in meteorites and their use in constraining models of stellar nucleosynthesis can be traced to his early pursuit of this conviction. In a similar manner he quickly seized upon the study of interplanetary dust particles as an important research direction for learning about primitive solar system components (Fraundorf et al., 1982), in the hope that this material would contain presolar grains (ultimately, 20 years elapsed before this hope was realized). The character of his laboratory assumed its modern form at this time with his visionary emphasis on applying multiple microanalytical techniques to the same small particle to extract the maximum physicochemical information and to relate it to conditions in astrophysical environments. This approach led, among other things, to the identification of deuterium anomalies in interplanetary dust particles (Zinner, McKeegan and Walker, 1983) and to their infrared characterization (Sandford and Walker, 1985).

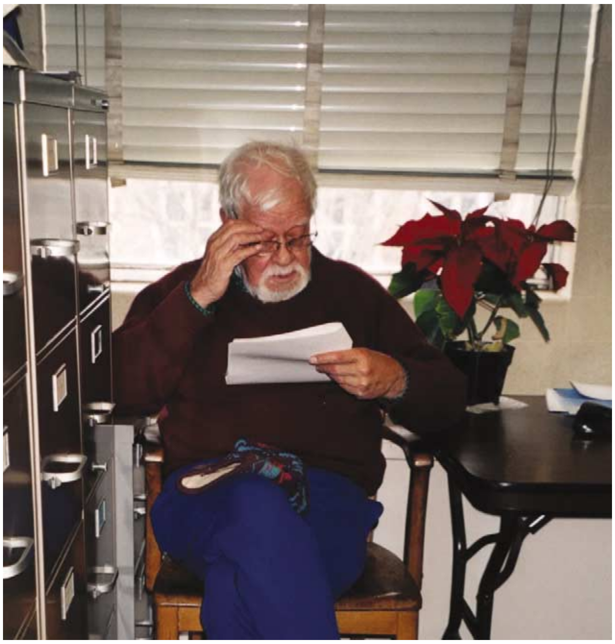

Fig. 2. Older Bob.

Bob also designed micrometeorite capture cells which were flown aboard NASA's Long Duration Exposure Facility, verified the extraterrestrial origin of polar micrometeorites (Maurette et al., 1989), devised an X-ray mapping technique to locate in situ presolar SiC in meteorites (Alexander, Swan and Walker, 1990), and collaborated in the identification of complex aromatic molecules in interplanetary dust particles (Clemett et al., 1993) and presolar graphite (Messenger et al., 1998). He also devised the novel technique of ion imaging in the ion microprobe to locate rare types of circumstellar condensates in collections of meteoritic grains, a technique which was instrumental to the pathbreaking analyses of circumstellar oxide grains from oxygen-rich red giants (Nittler et al., 1994) and of silicon nitride grains from supernovae (Nittler et al., 1995). Always in pursuit of newer ways of precisely analyzing small amounts of material, Bob has devoted the last few years to the development and implementation of nanoscale secondary ion mass spectrometry (NanoSIMS) for the study of individual submicrometer presolar grains, which has led to the discovery of presolar silicates in interplanetary dust particles (Messenger et al., 2003).

The above list of scientific achievements speaks for itself, but this account of Bob's role in the advancement of space science would be incomplete without some remarks on his professional conduct and character. Bob Walker has always been concerned first and foremost with the pursuit of science for its own sake, rather than for his own glory. For this reason most of the literature citations in this narrative do not list him as first author (he has generally insisted on alphabetical authorship). He has been content to bring together excellent people, pose interesting problems, and let natural curiosity take over. Giving freely of himself, he has imparted his knowledge and skill to numerous students and postdoctoral researchers, many of whom have gone on to outstanding scientific careers. Bob has also been a tireless spokesman and lobbyist for science, participating in numerous national committees. While recent years have seen the promotion of national centers for research as a new way of doing science, the doors of Bob's laboratory have for decades been open to an international multitude of graduate students, postdoctoral fellows, and visiting scientists. For Bob, the quality and importance of the science is always the bottom line. It is virtually impossible to conduct a conversation with him, even on what appears to be a purely administrative matter, without the flow of thought and words turning at some stage to the latest intellectual gem he has discovered and the prospects it opens for a new scientific adventure.

Although eschewing personal glorification, Bob has nonetheless been the recipient of many symbols of recognition by academic and scientific communities. He became a Member of the National Academy of Sciences in 1973. Among many awards, he received the E. O. Lawrence Memorial Award of the U. S. Atomic Energy Commission in 1971, the J. Lawrence Smith Medal of the National Academy of Sciences in 1991, and the Leonard Medal of the Meteoritical Society in 1993. He was also awarded an honorary doctorate by Union College in 1967 and Docteur Honoris Causa by the University of Clermont-Ferrand, France, in 1975.

Perhaps the deepest insight into Robert Walker's brand of constructive activism and his firm conviction in the good of science is provided by the following story. In 1958, while pondering a failed experiment at the G. E. Lab, he showed up at a discussion group of the Mohawk Association of Scientists and Engineers and asked the assembled company how much money for technical assistance was being channeled to the Third World. Appalled by the answer, he reflected upon what a small group of talented people could do, and immediately helped to found the Technical Assistance Committee, which in 1960 became VITA (Volunteers in Technical Assistance) with him as its first president.

Associate editor: F. A. Podosek

REFERENCES

Alexander C. M. O'D., Swan P., and Walker R. M. (1990) In situ measurement of interstellar silicon carbide in two CM chondrite meteorites. *Nature* **348,** 715–717.

Audouze J., Bibring J. P., Dran J. C., Maurette M., and Walker R. M. (1976) Heavily irradiated grains and neon isotope anomalies in carbonaceous chondrites. *Astrophys. J.* **206,** L185–L189.

Blanford G. E. Jr., Friedlander M. W., Klarmann J., Walker R. M., Wefel J. P., Wells W. C., Fleischer R. L., Nichols G. E., and Price P. B. (1969) Observation of trans-iron nuclei in the primary cosmic radiation. *Phys. Rev. Lett.* **23,** 338–342.

Clemett S. J., Maechling C. R., Zare R. N., Swan P. D., and Walker R. M. (1993) Identification of complex aromatic molecules in individual interplanetary dust particles. *Science* **262,** 721–725.

Corbett J. W., Smith R. B., and Walker R. M. (1959a) Recovery of electron-irradiated copper. I. Close pair recovery. *Phys. Rev.* **114,** 1452–1459.

Corbett J. W., Smith R. B., and Walker R. M. (1959b) Recovery of electron-irradiated copper. II. Interstitial migration. *Phys. Rev.* **114,** 1460–1472.

Crozaz G., Haack U., Hair M., Hoyt H., Kardos J., Maurette M., Miyajima M., Seitz M., Sun S., Walker R., Wittels M., and Woolum D. (1970) Solid state studies of the radiation history of lunar samples. *Science* **167,** 563–566.

Fleischer R. L., Price P. B., and Walker R. M. (1965a) Spontaneous fission tracks from extinct Pu^{244} in meteorites and the early history of the solar system. *J. Geophys. Res.* **70,** 2703–2707.

Fleischer R. L., Price P. B., and Walker R. M. (1965b) Neutron flux measurement by fission tracks in solids. *Nucl. Science Engr.* **22,** 153–156.

Fleischer R. L., Naeser C. W., Price P. B., Walker R. M., and Maurette M. (1965a) Cosmic ray exposure ages of tektites by the fission-track technique. *J. Geophys. Res.* **70,** 1491–1496.

Fleischer R. L., Price P. B., Walker R. M., and Leakey L. S. B. (1965b) Fission track dating of a mesolithic knife. *Nature* **205,** 1138.

Fleischer R. L., Price P. B., Walker R. M., and Leakey L. S. B. (1965c) Fission track dating of bed I, Olduvai Gorge. *Science* **148,** 72–74.

Fleischer R. L., Price P. B., Walker R. M., Maurette M., and Morgan G. (1967a) Tracks of heavy primary cosmic rays in meteorites. *J. Geophys. Res.* **72,** 355–366.

Fleischer R. L., Price P. B., Walker R. M., Filz R. C., Fukui K., Friedlander M. W., Holeman E., Rajan R. S., and Tamhane A. S. (1967b) Tracks of cosmic rays in plastics. *Science* **155,** 187–189.

Fraundorf P., Flynn G. J., Shirck J. R., and Walker R. M. (1977) Search for fission tracks from superheavy elements in Allende. *Earth Planet. Sci. Lett.* **37,** 285–295.

Fraundorf P., McKeegan K. D., Patel R. I., Sandford S. A., Swan P., and Walker R. M. (1982) Multidisciplinary studies of individual stratospheric micrometeorites. *Lunar Planet. Sci.* **13,** 229–230.

Huang W. H. and Walker R. M. (1967) Fossil Alpha-particle recoil tracks: A new method of age determination. *Science* **155,** 1103–1106.

Maurette M., Pellas P., and Walker R. M. (1964) Cosmic-ray-induced particle tracks in a meteorite. *Nature* **204,** 821–823.

Maurette M., Olinger C., Walker R., and Hohenberg C. (1989) Noble gas measurements of extraterrestrial particles from polar sediments. *Lunar Planet. Sci.* **20,** 640–641.

Messenger S., Amari S., Gao X., Walker R. M., Clemett S. J., Chillier X. D. F., Zare R. N., and Lewis R. S. (1998) Indigenous polycyclic aromatic hydrocarbons in circumstellar graphite grains from primitive meteorites. *Astrophys. J.* **502,** 284–295.

Messenger S., Keller L. P., Stadermann F. J., Walker R. M., and Zinner E. (2003) Samples of stars beyond the solar system: Silicate grains in interplanetary dust. *Science* **300,** 105–108.

Nittler L. R., Alexander C. M. O'D., Gao X., Walker R. M., and Zinner E. K. (1994) Interstellar oxide grains from the Tieschitz ordinary chondrite. *Nature* **370,** 443–446.

Nittler L. R., Hoppe P., Alexander C. M. O'D., Amari S., Eberhardt P., Gao X., Lewis R. S., Strebel R., Walker R. M., and Zinner E. (1995) Silicon nitride from supernovae. *Astrophys. J.* **453,** L25–L28.

Price P. B. and Walker R. M. (1962) Chemical etching of charged-particle tracks in solids. *J. Appl. Phys.* **33,** 3407–3412.

Price P. B. and Walker R. M. (1963a) Fossil tracks of charged particles in mica and the age of minerals. *J. Geophys. Res.* **68,** 4847–4862.

Price P. B. and Walker R. M. (1963b) A simple method of measuring low uranium concentrations in natural crystals. *Appl. Phys. Lett.* **2,** 23–25.

Sandford S. A. and Walker R. M. (1985) Laboratory infrared transmission spectra of individual interplanetary dust particles from 2.5 to 25 microns. *Astrophys. J.* **291,** 838–851.

Walker R. M., Preston R. S., Fowler E. C., and Kraybill H. L. (1955)

Production of neutral *V*-events by Cosmotron neutrons. *Phys. Rev.* **97,** 1086–1092.
Walker R. and Zimmerman D. (1972) Fossil track and thermoluminescence studies of Luna 16 material. *Earth Planet. Sci. Lett.* **13,** 419–422.
Walker R. and Yuhas D. (1973) Cosmic ray track production rates in lunar materials. *Proc. Lunar Sci. Conf.* **4,** 2379–2389.
Zinner E., Walker R. M., Chaumont J., and Dran J. C. (1976) Ion probe analysis of artifically implanted ions in terrestrial samples and surface enhanced ions in lunar sample 76215,77. *Proc. Lunar Sci. Conf.* **7,** 953–984.
Zinner E., McKeegan K. D., and Walker R. M. (1983) Laboratory measurements of D/H ratios in interplanetary dust. *Nature* **305,** 119–121.