## Memorial to Richard Leroy Hay (1926–2006)

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Richard L. Hay, professor of geology at the University of California–Berkeley (1957–1983) and the University of Illinois at Urbana-Champaign (1983–1997), died of pulmonary fibrosis on 10 February 2006 at his home in Tucson, Arizona. He was 79. He is survived by wife Lynn of 32 years, son Randall of Indianapolis, Indiana, stepsons George and John, and three grandchildren. His ashes (along with a bit of his jade) are buried in Goshen next to his parents' graves.

Richard, the son of Angela and Edward Hay, was born on 29 April 1926, in Goshen, Indiana. He earned his bachelor's (1946) and master's (1948) degrees from Northwestern University and his Ph.D. from Princeton (1952). After two years in the U.S. Army Corps of Engineers, Hay began his career in academia in 1955



as an assistant professor at Louisiana State University in Baton Rouge. In 1957, he moved to Berkeley, California, and became full professor at the University of California shortly thereafter. In 1983, he was named Ralph E. Grim Professor of Geology at the University of Illinois at Urbana-Champaign. He retired from the University of Illinois in 1997 and moved with Lynn to a beautiful house in Tucson. During his retirement, Hay established contact with new colleagues at the University of Arizona; participated in teaching seminars; looked for jade, agates, and "ocean jasper" from Madagascar at the Tucson Gem & Mineral Show; published papers; followed a new interest in tuff building stones and pozzolanic mortars of ancient Rome; and attended every annual meeting of the Geological Society of America—which he systematically used to keep in touch with former students and colleagues and to mentor young investigators.

Hay was a member and Fellow of the American Association for the Advancement of Science, a member and Fellow of the Geological Society of America (GSA), a member of the Mineralogical Society of America, and a Fellow of the California Academy of Sciences; he was recognized by each for his outstanding contributions to geology. In recognition of his seminal study of the environment of early humans in East Africa, Hay received both the Kirk Bryan Award in 1978 and the Rip Rapp Archaeological Geology Award in 2000 from GSA. In 2001, Hay also received the Leakey Prize, one of the most distinguished awards in the field of human origins.

Hay had a distinguished career in both sedimentary petrology and archaeological geology. He is best known for providing the definitive geological framework for two famous hominidbearing sites in East Africa (Olduvai Gorge and Laetoli); for his interpretation and work on the significance of sedimentary zeolites and phyllosilicates; for deciphering the mineralogic, geologic, and paleoclimatic record of arid environments; and for discovering the replacement of Cambrian-Ordovician strata throughout the mid-continental United States by low-temperature potassium feldspar.

Hay considered his decision to work at the University of California–Berkeley as crucial in opening research avenues; as he put it in his acceptance of the 2001 Leakey Award (which he shared with Garniss Curtis):

My acquaintance with Olduvai began in 1961 with a look at rock samples, which my colleague Garniss Curtis brought back for K-Ar dating. At that time, I was interested in the zeolites of desert lakes, and these samples were loaded with zeolites. I was quick to accept an opportunity to go there in 1962. The main purpose was to work on the stratigraphy of Bed I and resolve some of the controversy over the age of Zinjanthropus, who had been given the almost unbelievable age of 1.75 million years. The stratigraphy of the gorge quickly proved to be an irresistible puzzle. I love puzzles, and this one took me 12 years to get most of the pieces in the right places. The zeolites were great fun and developed into a nice line of evidence about the paleoclimate... I thank you very much for this honor today, and I wish all of you the same enjoyment in your work that ... [Hopwood and] I experienced at Olduvai Gorge.

Hay's time at the University of California also was crucial in another way. The study of mineral alteration and sedimentary rocks requires petrographic analysis—the unique kind of visual reasoning that an alert observer carries out with a polarizing microscope. Whether by design or serendipity, Hay came to Berkeley in 1957, when its department of geology and geophysics had the world's greatest concentration of top petrographers, including professors Howell Williams, Francis Turner, and Charles Gilbert, who had just published *the* book (*Petrography*) on the subject. Sure enough, Hay became a top petrographer himself. The crucial skill of petrographic analysis, today alarmingly neglected, would underlie not only his study of the sediments of Olduvai Gorge, but his entire work in diagenetic and weathering alteration as well as his discovery, after he moved to Illinois, of the huge low-temperature replacement of uppermost Precambrian and Cambrian-Ordovician rocks of the Midwest by potassium-feldspar. This pervasive geochemical alteration is still not understood dynamically in the context of the geological history of the North American continent. In the note he sent with the reprints of this work, Hay scribbled, "But we still don't know where the potassium comes from." Hay was a man of few words, a concise writer, and a man who loved solving geological puzzles.

Hay's publication with the most lasting impact among archaeologists and anthropologists is his *Geology of the Olduvai Gorge* (University of California Press, 1976). Here, Hay worked out the stratigraphy, magnetostratigraphy, chronology, sedimentology, and (thanks to the zeolitic alteration of the sediments) the Pleistocene paleogeography of the area, showing the contemporaneity of two hominid species living in the Olduvai region at 1.8 Ma. For geology, Hay's holistic research at Olduvai had spinoffs in magnetic stratigraphy (the "Olduvai" reversal period was discovered there) and in geochemistry and petrography. In the foreword to his book, Mary Leakey wrote, "The picture now seems so complete and is presented so clearly and precisely that one has the impression that pieces fit neatly and effortlessly together at the right places and at the right times, but this was seldom the case."

A paper in *Contributions to Mineralogy & Petrology* (1978) exemplifies Hay's "holistic" method. Field relations, petrography, and chemical, isotopic, and x-ray-diffraction analysis are beautifully intertwined and integrated into a total picture of the nature, rapid cementation, and geochemical history of the Laetolil Beds of Tanzania, located thirty kilometers south of Olduvai Gorge. As described more explicitly in Hay's papers with Mary Leakey in *Nature* (1979) and *Scientific American* (1982), these ash beds at Laetoli preserved a spectacular set of early

hominid footprints discovered by Leakey. The footprints soon allowed anatomists to establish that early man was bipedal by 3.5 million years ago, long before the human brain exploded in size, which negated the previous notion that man's bipedalism had resulted from an increase in brain size. Hay's insightful understanding of the cementation of the footprint-bearing tuff allowed anthropologists to uncover a fundamental stage of man's evolution.

Hay's influence is pervasive through many fields of geology—sedimentology; stratigraphy; low- and high-temperature geochemistry; weathering and diagenesis, especially zeolitic; the petrology and alteration of ash, tephra, and other volcanic sediments; geochronology; and, of course, archaeological geology. He wrote several review papers, the latest in 2001, on the expanding field of zeolites in sedimentary rocks, which he helped open.

Hay's influence on students and peers was gentle but lasting. He made his scientific rigor and insight look almost casual. He knew what to tell students in the field and what to leave for them to work out. Many will remember his availability and willingness to discuss ideas, evidence, and writing; his exceptional skill with the hand lens and the microscope; and above all his generosity, unfussy modesty, and exceptional qualities as a human being. Dick Hay will live on in the discoveries of his students and their students as long as people are interested in understanding the past and using that knowledge in future studies.

## SELECTED BIBLIOGRAPHY OF RICHARD L. HAY

- 1957 Mineral alterations in rocks of middle Eocene age, Absaroka Range, Wyoming: Journal of Sedimentary Petrology, v. 27, p. 32–40.
- 1962 Soda-rich sanidine of pyroclastic origin from the John Day Formation of Oregon: American Mineralogist, v. 47, p. 968–971.
- 1962 Origin and diagenetic alteration of the lower part of the John Day Formation near Mitchell, Oregon; *in* Petrologic studies, a volume to honor A.F. Buddington: Boulder, Colorado, Geological Society of America, p. 191–216,
- 1963 Stratigraphy of Beds I through IV, Olduvai Gorge, Tanganyika: Science, v. 139, p. 829-833.
- 1963 Zeolitic weathering in Olduvai Gorge, Tanganyika: Geological Society of America Bulletin, v. 74, p.1281–1286.
- 1963 (with Grommé, C.S.) Magnetization of basalt of Bed I, Olduvai Gorge, Tanganyika: Nature, v. 200, p. 560–561.
- 1965 Stratigraphy of Beds I through IV, Olduvai Gorge, Tanganyika: Appendix I in Olduvai Gorge, 1951–1961, by L.S.B. Leakey, Cambridge University Press.
- 1966 Zeolites and zeolitic reactions in sedimentary rocks: Geological Society of America Special Paper 85, 130 p.
- 1967 (with Grommé, C.S.) Geomagnetic polarity epochs: New data from Olduvai Gorge, Tanganyika: Earth and Planetary Science Letters, v. 2, p. 111–115.
- 1968 Nature and origin of palagonite tuffs of the Honolulu Group on Oahu, Hawaii, *in* Coats, R.R., Hay, R.L., and Anderson, C.A., eds., Studies in Volcanology: Geological Society of America Memoir 116, p. 331–376.
- 1970 Silicate reactions in three lithofacies of a semiarid basin, Olduvai Gorge, Tanzania: Mineralogical Society of America Special Paper 3, p. 237–255.
- 1971 (with Grommé, C.S.) Geomagnetic polarity epochs: Age and duration of the Olduvai normal polarity event: Earth and Planetary Science Letters, v. 10, p. 179–185.
- 1972 (with Curtis, G.H.) Further geologic studies and K-Ar dating of Olduvai Gorge and Ngorongoro Crater, *in* Bishop, W.W., and Miller, J.A., eds., Calibration of Human Evolution: Scottish Academic Press, Edinburgh, p. 289–301.

- 1973 (with O'Neil, J.R.) <sup>18</sup>O/<sup>16</sup>O ratios in cherts associated with saline lake deposits of East Africa: Earth and Planetary Science Letters, v. 19, p. 257–266.
- 1976 Geology of the Olduvai Gorge: University of California Press, 203 p.
- 1976 (with Brock, A.) Olduvai event at Olduvai Gorge: Earth and Planetary Science Letters, v. 29, p. 126–130.
- 1976 (with Leakey, M.D., Curtis, G.H., Drake, R.E., Jackes, M.K., and White, T.D.) Fossil hominids from the Laetolil Beds: Nature, v. 262, p. 460–466.
- 1977 (with Cerling, T.E., and O'Neil, J.R.) Isotopic evidence for dramatic climatic changes in East Africa during the Pleistocene: Nature, v. 267, p. 137–138.
- 1978 Melilitite-carbonatite tuffs in the Laetolil Beds of Tanzania: Contributions to Mineralogy and Petrology, v. 67, p. 357–367.
- 1978 (with Reeder, R.J.) Calcretes of Olduvai Gorge and the Ndolanya Beds of northern Tanzania: Sedimentology, v. 25, p. 649–673.
- 1978 (with Stoessell, R.K.) Geochemical origin of sepiolite and kerolite at Amboseli, Kenya: Contributions to Mineralogy and Petrology, v. 65, p. 255–267.
- 1979 (with Leakey, M.D.) Pliocene footprints in the Laetolil beds at Laetoli, northern Tanzania: Nature, v. 278, p. 317–323.
- 1980 The KBS Tuff controversy may be ended: Nature, v. 284, p. 101.
- 1980 (with Wiggins, B.) Pellets, ooids, sepiolite and silica in three calcretes of the southwestern United States: Sedimentology, v. 27, p. 559–576.
- 1982 (Leakey, M.D.) The fossil footprints of Laetoli: Scientific American, v. 246, p. 50-57.
- 1983 (with Montanari, A., Alvarez, W., Asaro, F., Michel, H.V., Alvarez. L.W., and Smit, J.) Spheroids at the Cretaceous-Tertiary boundary are altered impact droplets of basaltic compositions: Geology, v. 11, p. 668–671.
- 1986, (with Cerling, T.E.) An isotopic study of paleosol carbonates from Olduvai Gorge: Quaternary Research, v. 25, p. 63–78.
- 1986 (with Pexton, R.E., Teague, T.T., Kyser, T.K.) Spring-related carbonate rocks, Mg clays, and associated minerals in Pliocene deposits of the Amargosa Desert, Nevada and California: Geological Society of America Bulletin, v. 97, p. 1488–1503.
- 1989 Holocene carbonatite-nephelinite tephra deposits of Oldoinyo Lengai, Tanzania: Journal of Volcanology and Geothermal Research, v. 37, p. 77–91.
- 1989 (with Duffin, M.E., Lee, M., and Klein, G. deV.) Potassic diagenesis of Cambrian sandstones and Precambrian granitic basement in UPH-3 Deep Hole, Upper Mississippi Valley, U.S.A.: Journal of Sedimentary Petrology, v. 59, p. 848–861.
- 1991 (with Guldman, S.C., Matthews, J.C., Lander, R.H., Duffin, M.E., and Kyser, T.K.) Clay mineral diagenesis in core KM-3 of Searles Lake, California: Clays and Clay Minerals, v. 39, p. 84–96.
- 1991 (with Walter, R.C., Manega, P.C., Drake, R.E., and Curtis, G.H.) Laser-fusion <sup>40</sup>Ar/<sup>39</sup>Ar dating of Bed I, Olduvai Gorge, Tanzania: Nature, v. 354, p. 145–149.
- 1993 (with Lander, R.H.) Hydrogeologic control on zeolitic diagenesis of the White River sequence: Geological Society of America Bulletin, v. 105, p. 361–376.
- 1995 (with Hughes, R.E., Kyser, T.K., Glass, H.D., and Liu, J.) Magnesium-rich clays of the meerschaum mines in the Amboseli basin, Tanzania and Kenya: Clays and Clay Minerals, v. 43, p. 455–466.
- 1999 (with Finkelstein, D.B. and Altaner, S.P.) Origin and diagenesis of lacustrine sediments, upper Oligocene Creede Formation, southwestern Colorado: Geological Society of America Bulletin, v. 111, p. 1175–1191.

- 2001 (with Kyser, T.K.) Chemical sedimentology and paleoenvironmental history of Lake Olduvai: A Pliocene lake in northern Tanzania: Geological Society of America Bulletin, v. 113, p. 1505–1521.
- 2001 (with Sheppard, R.A.) Occurrence of zeolites in sedimentary rocks; an overview, *in* Bish, D.L., and Ming, D.W., eds., Natural zeolites: Occurrence, properties, applications: Mineralogical Society of America, Reviews in Mineralogy, v. 45, p. 217–234.
- 2002 (with Ashley, G.M.) Sedimentation patterns in a Plio-Pleistocene volcaniclastic riftmargin basin, Olduvai Gorge, Tanzania: Sedimentation in Continental Rifts, SEPM Special Publication, v. 73, p. 107–122.
- 2003 (with Liu, J., Deino, A., Kyser, T.K.) Age and origin of authigenic potassium feldspar in the uppermost Precambrian rocks in the North American Midcontinent: Geological Society of America Bulletin, v. 115, p. 422–433.
- 2003 (with Skinner, A.R., Masao, F., and Blackwell, B.A.B.) Dating the Naisiusiu Beds, Olduvai Gorge, by electron spin resonance: Quaternary Science Reviews, v. 22, p. 1361–1366.
- 2005 (with Jackson, M. D., Marra, F., Hay, R. L., Cawood, C., and Winkler, E.) The judicious selection and preservation of tuff and travertine building stone in ancient Rome: Archaeometry, v. 47, n.3, p. 485-510.

