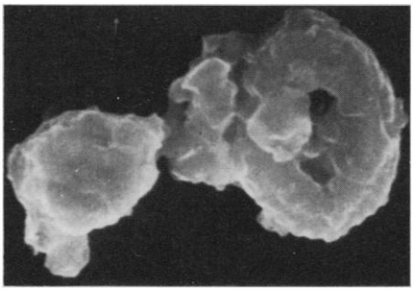
good forgers must possess. Their products have deceived the Nazis and, occasionally, have punctured inflated pretensions of professional art critics and archeologists. Moreover, although scientific work in museum-associated laboratories has until recently had forgery detection as its main incentive, it has incidentally served to establish the basic facts of technique development which are necessary for building a proper historical understanding of technology in human affairs on a larger scale. The unbiased record of action and thought that is preserved in the composition and structure of ancient objects can be read only in the laboratory, but it reflects an important aspect of the past that is ignored in the written records favored by conventional historical scholarship. Museum scientists and their collaborators in industrial and university laboratories can in some degree relive the individual human experience of technology that underlies all social change—but to do so they must go beyond simply providing ingeniously gathered data to aid a curator or art historian or to prevent a collector from being swindled (which is the main orientation of the present book) and must learn to ask their own questions of history.

Fleming presents, at a level appropriate both for the collector or curator and for scientists in general, the principal techniques that have proved useful in the recognition of forgery. These involve more or less absolute methods of dating based on radioactive decay (carbon-14) or radiation damage (thermoluminescence) and the characterization of materials in terms of their chemical or isotopic composition or in terms of the internal structural evidence for the methods used in producing them. Findings obtained by any of these methods have to be interpreted against a background of comparative data collected laboriously by experience with authentic objects.

The introduction discusses types of fakes and gives some history of fake detection. Part 2, on paintings, shows how the identification of pigments and vehicles by microscopy and neutron-activation analysis can reveal anachronisms when the history of their production is known, while radiography uncovers overpainting and exposes the work habits of individual artists. Part 3, on ceramics, is mainly on thermoluminescent dating, with a rather unclear explanation of the physics underlying the new "predose" method for dating recent objects and with a discussion of pigment analyses on Chinese blue-and-white ware, the latter inexplicably relegated to the appendix. Part 3, on metals, shows the value of composition studies (mainly by x-ray fluorescence) on coinage, with a little on the evidence for the techniques used in bronze casting and working and on the telltale effects of corrosion. The widely informative methods of radiocarbon dating and the very revealing lead isotope studies of glass and metal again are dealt with in the appendix. It is only in the part of the book dealing with metals that there is adequate emphasis on the statistical viewpoint that is essential in the interpretation of laboratory results. Not only does one have experimental error (too frequently of shocking extent, hidden beneath computer printouts that give three or four "significant" figures when even one is doubtful) to contend with, there are also real variations within groups of authentic objects. Sampling is of the utmost importance. In metals large variations of local composition arise from internal segregation or from external treatment in shaping, finishing, or subsequent weathering. Though desirably nondestructive, the superficial or localized sampling invited by the sensitivity of modern instrumental methods of analysis carries great danger of giving misleading results. Museum scientists must learn to be at least as informedly skeptical of their own methods as art curators are of the authenticity of their objects.



Scanning electron micrograph of a coccolith, *Zygodiscus*, from the chalk ground of the painting of the Gerbier family. "Up to 1850 only natural sources of chalk were exploited; then an artificial form was produced . . . as a precipitated calcium carbonate. . . . Natural chalk . . . is littered with the fossil remains of unicellular algae, whereas precipitated chalk is fossil-free." The coccoliths in the ground of this painting, as revealed by the scanning electron microscope, indicate "that the chalk used is from a deposit laid down in the Cretaceous period, as one might expect for a painting produced in Flanders." [Reproduced in *Authenticity in Art*, courtesy Dr. R. L. Feller, Mellon Institute, Pittsburgh]

With its bibliography to lead to more detailed treatment of any aspect, this book provides a fine introduction to a timely and important topic and should be widely read.

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Qualities of a Discoverer

By the Evidence. Memoirs, 1932–1951. L. S. B. LEAKEY. Harcourt Brace Jovanovich, New York, 1974. x, 276 pp. + plates. $9.95.

Leakey's Luck. The Life of Louis Seymour Bazett Leakey, 1903–1972. SONIA COLE. Harcourt Brace Jovanovich, New York, 1975. 448 pp. + plates. $14.95.

Human Origins. Louis Leakey and the East African Evidence. GLYNN LL. ISAAC and ELIZABETH R. MCCOWN, Eds. Benjamin, Menlo Park, Calif., 1976. xiv, 592 pp., illus. Cloth, $17.95; paper, $10. Society for the Study of Human Evolution, Perspectives on Human Evolution, vol. 3. W. A. Benjamin Series in Anthropology; A Staples Press Book.

Louis Leakey was the most widely known and widely acclaimed paleoanthropologist of this century. This extensive reputation came about to some extent through the *National Geographic Magazine* and television films: most literate people of the English-speaking world have heard the names of Leakey and Olduvai. It was a reputation as deserved as it was widespread. Leakey was a man of genius in his field, a man of passionate energies whose enthusiasm kindled most of those he met, a superlative lecturer and teacher, who made a lasting contribution to the science of human evolution.

Leakey was not so much a scientist, however, as a naturalist. He could have turned his hand to any branch of natural history without trouble, and he did venture into many. His were indeed the qualities of genius: a remarkable intelligence, tremendous energy, unfailing patience, and the capacity to take infinite pains. Moreover, he seemed to thrive on difficulties, which he customarily took as a challenge. These admirable qualities are unselfconsciously demonstrated in the second volume of his autobiography, *By the Evidence* (which follows the first volume, *White African*, 1937, reprinted by Schenkman in 1966).

Leakey's father was a missionary in Kikuyuland, and Louis grew up with the Kikuyu people. He was initiated into the tribe when he was 13 and sat night after night around the fire while the elders taught the history, legends, and rules of behavior to the Kikuyu boys. When he was 13 he built his own house, as his Kikuyu friends did at that age, and insisted on living in it. His intelligence and self-confidence, however, enabled him to transcend the limitations of his background, such as they were. At the same time, he benefited enormously by growing up in two cultures, for his spirit was tamed neither by African nor by European traditions. The passion of his search for knowledge obviated compromise with social mores.

Leakey's relationship with the Kikuyu people was uniquely close for a white man and made it possible for him to do a great deal for the Kikuyu during the traumatic experience of the Mau Mau rebellion. This is one side of Leakey's life which is not well known, yet his contribution to peace and understanding was impressive. (He has two or three small books on the Kikuyu in print and a long unpublished manuscript.) But he, for his part, owed much to Africa. His teacher Joshua was descended from one of the aboriginal hunter-gatherers of that region who lived there before the Kikuyu came. Joshua taught Louis the habits, calls, and tracks of every animal in the neighborhood; Louis absorbed from him a love of nature and a knack for minute observation which gave him a deep affinity with the natural world.

Scientific writing by its very nature requires objectivity and impersonality, qualities appropriate for the transmission of evidence and ideas. An autobiography, on the other hand, provides a unique opportunity to write in a subjective, personal manner. Any autobiography that does not contain at least some clues to the author's emotional life is in grave danger of being either boring or frustrating. Leakey's book unfortunately is impersonal to an extraordinary degree. His concerns and sensitivity come across in relation to animals, but are very rarely exposed in relation to people. He cannot have been unmoved, for example, when his wife narrowly escaped death by lion, but his laconic style reveals not one missed heartbeat. It is a great pity that he could not or would not express his heart; one gets the feeling that perhaps it had to be sacrificed to his head.

Louis Leakey's choice of his central interest in paleontology may have been initiated by fate, in the form of a head injury he suffered when playing rugby at Cambridge which resulted in his having to take a year off work. It was then, in 1924, that he spent eight months in Tanzania with the Canadian paleontologist William Edmund Cutler, and acquired invaluable experience. But fortune was as often against him as on his side, and the title of Sonia Cole's biography is perhaps misleading. Though he himself sometimes referred to "Leakey's luck," his achievements were ultimately the result of immense persistence and diligence. He worked at Olduvai from 1931 to 1959 before he gathered substantial fossil hominid remains. The great discoveries with which his name is associated came very late in his life, and then were rarely made by him. He depended much on his African staff and his remarkable and gifted wife, Mary. Yet Leakey was behind it all—his drive and determination eventually led to a revolution in our ideas about man's evolution.

Leakey's Luck is an excellent biography, informative, scholarly, and accurate. Although most of Leakey's friends and his family are still living, Sonia Cole does not pull her punches and gives us a fairly well rounded description of the man, with the strengths and weaknesses we might expect in someone of his temperament. Those who are interested in the history of the study of human evolution will find this book a gold mine: dates of expeditions, excavations, and discoveries are all recorded, together with a detailed account of the way Leakey set about raising money for his research. (He gave his first money-raising public lecture at the age of 21, after his eight months with Cutler, and lost 5 shillings and fourpence.) He changed the profession of paleontologist from that of an individual and often amateur collector to that of a scientist who leads well-planned, long-term interdisciplinary projects. Cole demonstrates how he made very considerable scientific contributions in a field previously rather lacking in scientific approach: any one of his skulls from Olduvai has proved as valuable as two or three from previous decades because its geological, paleontological, and archeological context was accu-

"Mary Leakey and Louis Leakey show visiting scientists the fossil skeleton of a deinotherium that Mary has exposed by excavation in Bed II, Olduvai Gorge. Among the bones, they found stone artifacts which were evidently used by early hominids as butchery tools. The visitors include Raymond Dart, Camille Arambourg, and J. Desmond Clark." [Photograph by Des and Jen Bartlett, reproduced, through the help of the National Geographic Society, in *Human Origins*]

rately and fully recorded at the time of discovery. (The archeological work of Mary Leakey is among the finest ever carried out.) Louis Leakey's contribution to paleontology cannot perhaps yet be fully assessed, but had it not been for him the prehistory of East Africa might remain uncovered to this day.

But there were other aspects to his work. He was an ardent and effective conservationist in Kenya, and was especially interested in the higher primates. Cole describes how he inspired Jane Goodall to undertake what was then an extraordinary research project on the shores of Lake Tanganyika, and Goodall was followed by two other intrepid women, Dian Fossey and Biruté Brindamour. Thanks to him, all three of the great apes have acquired worthy biographers, and the work he set in motion will continue for many years to come.

Some other aspects and views of Leakey the man and his work are presented in *Human Origins: Louis Leakey and the East African Evidence*, prepared as a tribute to Leakey. The volume includes biographical chapters by colleagues, such as J. Desmond Clark and Phillip Tobias, and a complete annotated bibliography of Leakey's writings by Shirley Coryndon, along with some valuable papers on hominids from East Rudolf by his son Richard and papers by various other authors on topics pertaining to the reconstruction of the environment of early man and of early hominid behavior in East Africa.

Louis Leakey was a fearless man, and in the modern landscape of institutional anonymity he stands out as a giant. He was interested in all of nature and was perennially young in ideas. He was a sensitive man, and often ahead of his time. Looking at the record of his life, I feel we should pay attention when he speaks. This quotation from his autobiography set me thinking:

> When I think back over the problem of my eagles and also of the serval cat and a baboon that I had as pets in my childhood days—and that eventually I had to house in large cages—it makes me sad. It makes me sadder still, however, and also very angry, when I think of the innumerable adult animals and birds deliberately caught and locked up for the so-called "pleasure" and "education" of thoughtless human beings. I appreciate that many people cannot afford to travel to far countries to see wildlife in nature's own setting, but surely there are today so many firstclass films, often in beautiful color, about almost every wild species in its natural habitat that the cruelty of keeping wild creatures in zoos should no longer be tolerated.

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Seismology and the Test Ban

Nuclear Explosions and Earthquakes. The Parted Veil. BRUCE A. BOLT. Freeman, San Francisco, 1976. xxiv, 310 pp., illus. $9.95. A Series of Books in Geology.

The solution of the technical problems involved in monitoring a treaty banning the testing of nuclear weapons has been a goal of research in the United States and a few other nations for about 15 years. A treaty banning testing in the atmosphere, in space, and underwater has been in effect since 1963 and has been honored by the United States, the Soviet Union, and the United Kingdom, who were signatories, though France and the People's Republic of China, who were not, have proceeded with testing. The overriding technical obstacle in the way of a ban on testing in the remaining environment, underground, has been the lack of reliable methods for detecting underground explosions and distinguishing them from the thousands of earthquakes that occur every year.

There is hardly an earthquake seismologist now active in the United States who has not participated in some aspect of our national research program, known as Project Vela-Uniform, to establish such methods. The present high level of development of seismology in this country owes very much to the resources made available by the Department of Defense for support of this program.

Bruce Bolt has written an informative and thorough account, with a minimum of technical jargon, of the detection problem and recent attempts to solve it. The book is intended for the nonspecialist, and Bolt has provided the necessary background for understanding the questions that arise and the methods used in seeking the answers. A large amount of material about the work of global-scale geophysicists, valuable to the general reader apart from any interest he might have in test monitoring, is summarized.

A useful history of nuclear explosions, including a chronology beginning with the Trinity test, 16 July 1945, is followed by a brief introduction to the physics and engineering of a nuclear explosive and the phenomenology of an underground explosion. This reviewer's experience with concerned laymen has demonstrated that the inclusion of this information is essential for them because it gives some assurance that the apparently incomprehensible chaos in the region surrounding a nuclear blast can, in fact, be described in terms of well-understood and predictable processes.

A "short course" in elementary seismology then leads into the heart of the book, a historical treatment of test-ban research. The major problems, the sources of the disagreements between the United States and the Soviet Union, the contributions of the research groups in various nations, and the recent status of detection and discrimination (telling a bomb from an earthquake) are discussed.

Some schemes for evasion of a surveillance system by a would-be violator of a treaty are analyzed briefly, but this discussion primarily reflects the viewpoint of weapons laboratory scientists as presented about five years ago. Though it is natural for the scientist working on detection to think of ways he could beat his own methods, evasion was not considered a subject for polite conversation in the earlier days of the research, and the matter has not been widely studied in the scientific community. For a painstaking analysis of the methods of evasion outlined by Bolt, the reader is referred to Jack F. Evernden's "Study of seismological evasion" in the February 1976 issue of the *Bulletin of the Seismological Society of America*. Evernden's conclusion is that the operator of the surveillance system has a far less complicated task than does the evader.

Bolt is a strong proponent of the use of nuclear explosives for such peaceful engineering projects as large-scale excavation of harbors and canals and stimulation of oil and gas flow in impervious formations. This reviewer has also strongly supported the view that it would be desirable that a treaty banning testing of nuclear weapons be drawn so as to permit the exploitation of this relatively inexpensive source of energy. Realization of the extreme difficulty of distinguishing between a "peaceful uses" shot and the test of a new weapon (perhaps only espionage would be effective) has lessened my conviction of the feasibility of ac-