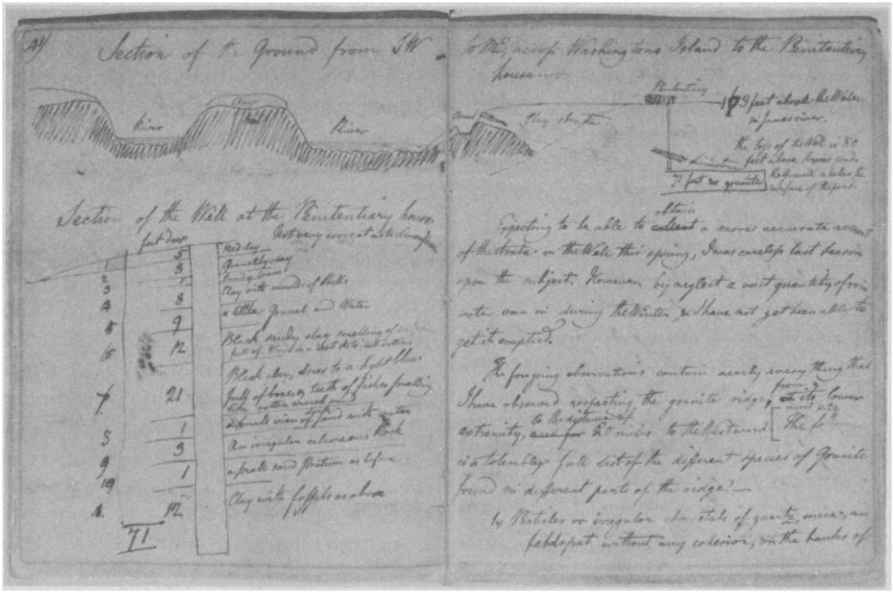

Two pages, dated 4 May 1798, from the journals of Benjamin Henry Latrobe. Latrobe "directed the construction of the United States Capitol and the White House, built the first comprehensive steam-powered water system at Philadelphia, and participated in numerous other architectural and engineering projects. He was in addition a keen scientific observer, and one of the things that excited his interest in his new country was its geology. . . . In many instances his geological knowledge was vital to the successful execution of his work." These pages show (top) "a section from south (left) to north (right) of Richmond, Virginia, and the adjacent James River. The Penitentiary (of Latrobe's design) and its well are on the right, and the strata of the well are sketched on the lower left-hand page." [Reproduced in *Two Hundred Years of Geology in America* from the papers of Benjamin Henry Latrobe, Maryland Historical Society, Baltimore. Courtesy of the Papers of Benjamin Henry Latrobe]

bear traces of the whig-versus-actualist theme. These include "Very like a spear" by oceanographer (and director of the U.S. Geological Survey) H. William Menard, historian Henry Frankel's "Why drift theory was accepted with the confirmation of Harry Hess's concept of sea floor spreading," and geologist Robert H. Dott, Jr.'s "The geosyncline—first major geological concept 'made in America.' "

Dott's excellent paper is concerned primarily with the historical development of the geosynclinal theory by two giants in American geology: James Hall and James D. Dana. After tracing this history through the latter half of the 19th century, Dott finishes by showing why American geologists were so slow to pick up the concept of continental drift early in this century. Thus the question for a scholarly whig geologist is not whether Sir Francis Bacon envisioned plate tectonics in his *Novum Organum* (1620) but how the independence of geosynclinal theory in America retarded the introduction of continental drift theory. As an aside, how many geologists know that F. B. Taylor wrote an article on continental drift as a mountain-building mechanism that appeared in the bulletin of the Geological Society of America five years before Alfred Wegener published his *Die Entstehung der Kontinente und Ozeane* (1915)? Menard's graceful contribution is truly an "oral history" regarding the birth of the plate tectonics model during the late 1950's and early 1960's. It is an example of the pure actualist viewpoint, an eyewitness account of history in the making. Both the papers by Dott and Menard should be required reading for serious geology students.

The education of young geologists is not complete without some exposure to the history of geology. A traditional approach involves the use of readings taken straight from their original sources, such as *A Source Book in Geology* compiled by Mather and Mason 40 years ago, or Cloud's more recent *Adventures in Earth History* (1970). Well-planned symposium volumes such as *Two Hundred Years of Geology in America* move beyond this tradition to provide a source of stimulation for students, professional geologists, and historians alike. Some failings are inherent to the genre, and Schneer's new volume is not exempt. A few of the papers included clearly do not belong within the 1776-1976 time frame, and coverage of the "heroic" age of American geology is incomplete (no examination of the roles of Amos Eaton and William Maclure). What Rudwick concluded in *The Meaning of Fossils* (1972) about the history of paleontology applies equally well to its parent discipline of geology: "That it should not become a-historical in outlook is important, not for nostalgic antiquarian reasons, but because the loss of historical perspective would lead to conceptual impoverishment." *Two Hundred Years of Geology in America* offers much to all its readers.

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Metallurgy in Antiquity

The Search for Ancient Tin. Papers from a seminar, Washington, D.C., March 1977. ALAN D. FRANKLIN, JACQUELINE S. OLIN, and THEODORE A. WERTIME, Eds. Smithsonian Institution, Washington, D.C., 1978 (available from the Superintendent of Documents, Washington, D.C.). viii, 64 pp., illus. Paper, $5.

There is little doubt that the sources of tin used in antiquity is an intriguing topic. In his introduction to this volume of nine symposium papers on the subject, Theodore A. Wertime speaks of each of the symposiasts as detectives involved in solving a mystery. Though the detective story told in this volume is one that has no swift denouement, tin is not quite as elusive as it used to be. Since the publication of J. D. Muhly's comprehensive *Copper and Tin* (1973) with its supplement (1976), new clues have been revealed. It is in the summary presentation of this newest information that the significance of this volume lies.

The search for geological loci of tin, in stream beds, granite masses, or the gossan caps of ore bodies, has been narrowed somewhat by recent research. J. A. Charles and George Rapp provide valuable descriptions of the main geological environments, primarily granite-associated, in which tin is to be found. These descriptions substantiate Rapp's point that the answers to many questions pertaining to ancient tin are to be found in geological and archeometallurgical field investigations.

Prentiss de Jesus's paper provides maps of the tin deposits situated in the major tin belts of the world. Most of the sources discussed by the contributors lie within the boundaries of these tin belts, in particular those in the Near East and South Asia. Perhaps the most significant new find is in the eastern desert of Egypt, as reported by Wertime. In several desert locales the presence of alluvial tin, cassiterite (SnO_2), has been confirmed along with a number of hieroglyphic inscriptions. These inscriptions date to the reign of Pepi II, around 2200 B.C.; however, they antedate by several hundred years the appearance of tin-bronze in the archeological record of Egypt.

Wertime, de Jesus, and Hugh McKerrell argue that tin concentrations must exist (or have existed) in Turkey, although reasonably extensive geological survey has failed to reveal any. These authors' arguments are difficult to reconcile with the lack of geological evidence and with the documented existence, in the early second millennium B.C., of an overland trade bringing tin to Assyrian colonies in central Anatolia. Reconstruction of this tin trade from textual information has tin arriving in Anatolia from the city of Aššur in northern Mesopotamia. It has been suggested elsewhere by M. T. Larsen that Aššur may have received some of its tin from northwestern Iran, long rumored to have a tin source. The papers of Wertime, de Jesus, and I. R. Selimkhanov, however, go far toward dispelling notions of major tin supplies in the regions of western Iran and the Caucasus. A single exception noted by Wertime is a potential source near Malyer in central western Iran, where the geological environment is suitable to the occurrence of tin.

The tin belt map of Eurasia (p. 36) shows a number of concentrations of tin in southern Central Asia in the general area of northern Afghanistan. De Jesus speaks of a tin source along the Zeravshan river in Uzbekistan, originally reported by the Soviet archeologists Masson and Sarianidi, that was exploited during the Middle Bronze Age. Muhly's paper refers to the identification by the Geological Survey of Iran of small quantities of tin, with some stannite present, along the Iran-Afghanistan border north of Zahedan. Recent, post-symposium communications now tell of tin fields discovered by Soviet geologists southwest of Herat in western Afghanistan in a region dotted with Bronze Age occupation sites. These tin deposits in Afghanistan could well be associated with those located in ancient Drangiana, the modern region of Seistan, referred to by Strabo. It is also possible, as Muhly has suggested (1973), that tin extracted from the "greater" Seistan region could be the fabled tin of Meluḫḫa known from Mesopotamian texts and thought to lie to the east of the Zagros mountains. Furthermore, in this volume Muhly reaffirms his assertion of a potential connection, as yet undefined, between tin and the Bronze Age trade in lapis lazuli. The transport of lapis has been postulated from its source area in Badakhshan province of northeastern Afghanistan to Mesopotamian markets via an overland route across Iran. Such a trade would have provided a ready exchange network between tin sources in Afghanistan and tin-using Mesopotamia during the third millennium B.C.

The availability of tin supplies in the Indian subcontinent is reconfirmed in the discussions of K. T. M. Hegde. From the analyses carried out by Hegde on post-Harappan bronzes and from those previously reported on Harappan bronzes it appears that sufficient tin supplies were available in this area in antiquity to supply internal needs and perhaps to have served as a source of tin traded between the Indus Valley and Mesopotamia.

With regard to the issues of the tin trade, information presented by R. F. Tylecote on tin ingots and cassiterite finds in Europe and the Mediterranean region from Roman and Medieval contexts is significant for any attempt to trace how and in what forms tin may have moved in the same regions during the Bronze Age.

Important to understanding the advent of tin-bronze metallurgy are discussions of the phase that preceded it, namely the use of arsenical copper. The majority of contributors to this volume, with the exception of McKerrell, view this alloy as derived from the exploitation of arsenic-rich copper ores. McKerrell's thesis is that a master alloy of high-arsenic copper was used as the main alloying ingredient. To date, however, there is insufficient evidence to document the use of such a master alloy, in part because great variability in arsenic content is found in artifacts analyzed from Europe and the Near East. Thus there is little indication that metalsmiths in antiquity could control arsenic content in the artifacts they produced. The only control likely to have been exercised was an augmentation of arsenic content by selective mining followed by hand sorting of the ore by weight and color.

In their discussions of the types of tin ores, Wertime and Charles both mention a probable link between the exploitation of arsenical ores of copper and the subsequent use of tin ores in bronze production. Wertime points out the polymetallic nature of many ore bodies, and Charles emphasizes the colors that tin ores have in common with arsenical copper ores. Charles suggests that one tin ore, stannite (Cu_2FeSnS_4), not only resembles arsenopyrite in appearance but also may be arsenical. Both Wertime and Charles suggest that stanniferrous gossans that may cap sulfide ore bodies are yet another context where miners could have come into contact with tin inadvertently, especially if such gossans were used to flux copper-smelting operations. It is clear, then, that such links between ores could have facilitated the gradual transition from one type of metallurgy to the next.

The exceedingly rare occurrence of metallic tin in Bronze Age contexts casts doubt on McKerrell's suggestion that tin bronzes were produced from their outset by melting together metallic tin and copper. Charles reports that stannite and cassiterite will smelt readily when added to molten copper. Both Charles and Tylecote see the addition of cassiterite to molten copper as the most common means of bronze production in the Early and Middle Bronze Age; however, other research suggests that this method produces low-quality bronze and that the direct addition of cassiterite will allow the production of a bronze with little more than 1 percent tin content. Further research should resolve this disparity in opinion.

Rapp's paper on the trace element analysis of tin sources worldwide provides an updating of progress on this ambitious project. It is interesting to note the relatively high iron contents in the tin ores sampled. An important point not raised in this symposium is the possibility of a link between the development of the metallurgy of metallic tin and that of iron. Wertime tells of his search for tin traces in the placer-deposited magnetite "black sands" in the Sefid Rud flowing into the Caspian Sea in northern Iran, both Muhly and Charles refer to the accumulation of alluvial gold and tin in the same stream-bed placer deposit, and Tylecote mentions Axel Hartmann's study of the presence of alluvial tin in large quantities of gold artifacts from Bronze Age Europe. But the occasional co-occurrence of all three of these alluvial ores, gold, tin, and magnetite, in placer deposits goes unmentioned. Magnetite would not have separated easily from the other two ores given the use of primitive techniques of separating the ores from the unwanted residues in the placer; therefore, the smelting of tin under certain conditions with magnetite present could result in the production of small amounts of metallic iron. Metallic iron also could have been produced inadvertently when stannite was being smelted in an overdriven furnace. The end product in the furnace would have been a tin-iron "bear" exhibiting the metallic properties of iron. The chronological proximity of regular smelting of tin ores for metallic tin and the advent of iron metallurgy in the Late Bronze Age appears to be more than coincidental.

To conclude, though much of the basic information about ancient tin has appeared elsewhere in a variety of sources, this volume serves the useful purpose of bringing together the latest information in a single reference. Moreover, the volume is important in that in it physical scientists, archeologists, and historians confront a single problem, the sources for and the initial uses of tin. These scholars go beyond the barriers of their particular disciplines and provide an interdisciplinary dialogue not generally achieved in similar academic endeavors.

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Energy Transitions

Non-Radiative Decay of Ions and Molecules in Solids. R. ENGLMAN. North-Holland, Amsterdam, 1979 (U.S. distributor, Elsevier, New York). xiv, 336 pp., illus. $58.50.

In a review of nonradiative decay processes in solids—basically the mechanisms by which the energy of electronic excitation of molecules or ions is converted into vibrational or thermal energy—I would have expected to find reference to a few definitive theoretical papers that would serve as the basis for interpretation of a wide variety of experimental results.

A perusal of Englman's book confirms the breadth of the experimental activity in the field, as evidenced by the reference to over 250 papers, most of them published in the last ten years, giving nonradiative decay rates for transition element ions, rare earth ions, defect centers, *s*- or *p*-state impurities, organic molecules, and biological systems. A surprise, however, was to discover that over two-thirds of the more than 1000 papers cited are theoretical discussions. Though in part perhaps a reflection of the author's own role as a contributor to the theoretical basis of the subject, the extensive citation of theoretical literature is primarily an indication of the intrinsic complexity of the subject. There are many distinct relaxation mechanisms to be treated and a number of limiting cases to be taken as a starting point for model calculations; and the essential roles of many degrees of freedom and of vibrational inharmonicity give the virtuosic theorist ample opportunity to display his or her wares.

Englman presents an exhaustive, and exhausting, review of the field. The style is terse and to the point, often with arguments abridged to the point that they are not easy to follow. An advanced student familiar with the techniques of theoretical condensed-matter physics will find this a splendid introduction to and review of the field. An experienced experimentalist, with principal theoretical reliance on the "Golden Rule," will make contact with many familiar points but will not find sufficient detail of exposition to follow the arguments presented. The book will serve him or her, however, as a valuable guide to the literature and as an important source of questions and ideas that deserve careful consideration.

Particularly refreshing is the attention to related, often deeper, issues such as coherence effects, the properties of state evolution, the consequence of the memory of state preparation, and irreversibility. Here, particularly, one would have liked to see a more extensive and occasionally (in the case of Poincare cycles, for example) more accurate discussion of these issues.

Englman's book would seem an essential reference for anyone seriously involved in studies of nonradiative transitions in biology or condensed-matter physics or chemistry.

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Neurophysiology

The Concept of a Blood-Brain Barrier. MICHAEL BRADBURY. Wiley-Interscience, New York, 1979. viii, 466 pp., illus. $55.

In this book Michael Bradbury describes in quite considerable detail the current state of knowledge concerning an important aspect of neural plumbing: the processes involved in the exchanges of water and solutes between the blood and the extracellular fluids of the central nervous system.

The vertebrate blood-brain barrier has always seemed to me, an invertebrate physiologist, to be a rather mysterious article. First, there is the daunting complexity of the vertebrate brain, which presents formidable conceptual problems and also very considerable practical difficulties, for example in the application of electrophysiological techniques that are routinely used in the relatively simple invertebrate preparations. Second, there are the lingering uncertainties from the "years of doubt" when, as chronicled by Bradbury, the very existence of the blood-brain barrier was questioned by various heretics armed with the then recently acquired ultrastructural knowledge of cerebral tissues and a desire for economy of hypothesis. The beleaguered faithful (led by Hugh Davson and sustained by August Krogh's original concept) were eventually relieved, largely by the acquisition of additional ultrastructural observations that provided an anatomical basis for a barrier to water-soluble substances in the form of the tight junctions that appear to effectively seal the clefts between the endothelial cells of the cerebral capillaries. Finally, there is the confusion created by the retention of the term "barrier" to describe phenomena some of which clearly do not involve obstruction or restricted access to the cerebral tissues, for example the rapid transcellular transport of monosaccharides and some amino compounds or the rapid permeation by substances that have favorable partition coefficients. It seems to me that it would be more logical if the phenomena described in the book were merely regarded as properties of the blood-brain interface and not lumped together with one particular property—the restricted intercellular access of water-soluble ions and molecules.

The book provides a clear and authoritative description of these properties. Account is given of the ultrastructural organization and the permeability of the blood-brain interface and of the various physiological processes that occur behind it, for example the exchanges of ions and molecules between the underlying extracellular fluids and the nerve cells. Consideration is also given to ontogeny and phylogeny, to equivalent systems in insects, and to the "blood-testis barrier" of vertebrate animals.

The combined effect of the processes described in the book is to provide fluid environments, of appropriately controlled composition, that are necessary for the integrated electrical signaling within the central nervous system. It is surprising therefore that the extensive studies of the homeostatic control mechanisms in vertebrate brain seem rarely to have been related to the actual processes of nervous transmission. This is reflected in the book by the absence of even a single action potential in the illustrations