so the parser must be assumed to operate blindly, an assumption that violates empirical data as well as limits the complexity of the simulation. The authors clearly recognize these limitations, and take what seems to me to be a reasonable view toward them. Rather than further complicate their system, they propose to take their model into the domain of empirical tests and determine in what way it succeeds in illuminating data.

Part 3 of the book consists of six chapters in which HAM is applied to a large variety of problems that have been developed in current experimental psychology: sentence learning, linguistic abstraction, retrieval of facts, answering questions, strategies of rote learning, and interference in forgetting. These six chapters constitute in themselves a fascinating review of the current state of the field and provide a number of new experiments. They justify the author's view that HAM can serve to generate new ideas and relate scattered findings in what appear to be very different areas. As an example of their approach one may take HAM's account of the interference theory of forgetting. The basis of this theory is the finding that the ability to recall an associative relationship between two items A and B will be suppressed if the subject learns a new association between A and C. According to HAM, such interference is the by-product of its effort to avoid indefinitely long searches for particular items. Consequently the authors argue that "the acquisition of new associations will tend to bury old associations and make them inaccessible whenever the list is searched." It is apparent that interference in forgetting must be related to the abstractive nature of human memory. The suggestion that interference in recall is tied to retrieval rules which prevent long search loops is an example of the type of hypothesis that can be achieved from a general model of memory.

Human Associative Memory should serve to impel experimentation toward important areas and should also provide a heuristic representation for the empirical results so far obtained. Whether or not our memories are HAM-like, the next generation of memory researchers will need to have a representation like HAM in their memories.

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Semiconductor Physics

Deep Impurities in Semiconductors. A. G. MILNES. Wiley-Interscience, New York, 1973. xviii, 526 pp., illus. $24.95.

Impurity levels in a semiconductor may exist anywhere within the energy gap between the valence and conduction bands. Deep levels, those far from the band edges, are caused primarily by substitutional impurities that differ greatly from the host atoms and by lattice vacancies. Interest in deep levels is rapidly increasing as other aspects of semiconductor physics more closely associated with the perfect crystal, such as energy band structure, carrier transport, and excitons and shallow impurities, are becoming well understood.

Deep impurities have been used in the fabrication of light-emitting diodes and switching transistors, but they are even more important to technology because of their deleterious effects. Deep impurities cause nonradiative electron-hole recombination. Consequently they are thought to be at least partially responsible for limiting the efficiency of light-emitting semiconductor devices and causing their degradation.

Despite their recognized importance, deep impurities are poorly understood. For example, the levels associated with lattice vacancies in III-V compounds are not yet known and the mechanism whereby carriers lose their energy when they are captured by deep impurities are for the most part not known even for well-studied impurities such as gold in silicon. A major problem in this field has been the lack of sensitive and convenient techniques for detecting deep levels and measuring their properties unambiguously. Suitable techniques based on junction capacitance measurements are only now becoming available.

The author's approach in reviewing this old but poorly understood field is to discuss briefly many aspects of the subject while extensively citing the vast and widely scattered literature. To limit the size of his book he has excluded II-IV semiconductors and deep levels introduced by radiation damage. He begins by cataloging the energy levels of deep impurities observed in silicon, germanium, and III-V compounds. This is followed by a discussion of the statistics and the kinetics of carriers in the presence of deep traps and recombination centers. He then discusses the wide variety of electrical measurements that have been used to determine properties of deep impurities, including photoconductivity, capacitance, and thermally stimulated current measurements. The final section of the book treats a variety of transport phenomena involving traps, including current flow due to double injection and domains and oscillations caused by field enhanced capture of carriers.

Students and researchers interested in deep impurities will find this book valuable as a summary of factual material and as an up-to-date guide to the literature. It is well indexed and contains a bibliography of 1894 references, including some 1973 papers. Little space is devoted to theoretical foundations or to drawing general conclusions. This is appropriate, since a broad understanding of many aspects of deep impurities is yet to come.

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Gravimetry

Theory of the Earth's Gravity Field. MILOŠ PICK, JAN PÍCHA, and VINCENC VYSKOČIL. Elsevier, New York, 1973. 538 pp., illus. $34.

This book is what it says, an exposition of the theory of the earth's gravity field, plus a good bit more. In fact, it could almost be called a gravimetric pansophia. Assuming only the knowledge of partial differentiation and about a one-semester background in general physics and general geology, it brings the reader to the frontier of the subject.

Not that a student with only such background should be advised to attempt it: the book, especially in its mathematical sections, is not easy reading. But the information is there, be it the transformations of a polar coordinate system, Molodenskii's operators, or Fredholm's integral equation.

The subject matter is divided to suit the author's interests. Pick, an applied mathematician, treats potential theory, geometry of equipotential surfaces (including the shape of the earth), theory of reductions of gravity data, and astrogravimetric leveling. Pícha's interest is the instrumentation, its history, its capabilities, and its application in the field. Vyskočil contributes the chapters that tell us what can, and what cannot, be learned from gravity data about the internal constitution of the earth.

With this division of labor, we may ask, what's there to be added? The answer is that there is not much left. The practicing geophysicist might wish to find more tables, such as terrain and isostatic corrections and normal gravity. The novice, as well as the college instructor, would welcome examples of surveys, maps of actual anomalies, profiles of real mountain ranges, and the like to see how the second derivative method really works, how well the anomaly of a salt dome resembles that of a sphere, or how the Airy hypothesis compares with that of Pratt. Let us hope that those matters will be incorporated in the next edition. If such additions have to be at the cost of omitting another chapter, then let them replace the thorough discussion of the torsion balance, an instrument of historical significance only.

Pícha may be too conservative in his opinions on secular variation and on some modern methods of absolute determination of the gravity acceleration.

Vyskočil may be overplaying the importance of the nonuniqueness of the inverse boundary value problem. Fortunately for gravimetry, the range of densities of rocks is so narrow that, in practice, the ambiguity of the interpretation is not as serious as the pure mathematics of the problem tells us.

While the text is fairly free of typographical errors, there are some minor flaws the correction of which would make a good book much better. Each author has his own style and jargon, and no effort toward unification seems to have been spent. Vyskočil may use the word "reduction" where Pick uses "correction," and now the index lists "topographic correction" on p. 229, "topographic reduction" on p. 180, and "reduction—topographic" on p. 101; "correction—topographic" is not listed at all, but "correction for terrain" is on p. 178.

Russian references have been transliterated according to the British system, but they are still arranged according to the Cyrillic alphabet, so that, for example, "Gromov" follows "Vyskočil" and "Fan Cziun" follows "Tyapkin."

A more consistent notation is also desirable. Thus, for example, r may be the radial coordinate and ρ density; but later, ρ becomes the radial coordinate and r is alternately the distance between two points and a summation subscript. There is also a disparity in the background required on the part of the reader: the directional derivative is defined, but he who does not know by heart what are "Lyapunov's conditions" has to go to the French *Journal de Mathématique* of 1898 to find out.

Lyapunov, by the way, plays another trick on us: in the text and in the index, he is consistent; but in the references, he changes into Ljapunoff.

But these are minor problems that will, one hopes, be corrected before long. In general, the book is valuable not only for its content, but also because it will inform the English-speaking public about an impressive program carried out in Czechoslovakia and often published in a language with which only a few of us are familiar.

Every graduate student, instructor, practicing geophysicist, and mathematician whose interests include earth's gravity should have the book within easy reach.

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Cold-Climate Geology

Periglacial Processes and Environments. A. L. WASHBURN. St. Martin's Press, New York, 1973. vi, 320 pp., illus. $23.95.

The author of this book defines periglacial as referring to "cold-climate, primarily terrestrial, nonglacial processes and features regardless of date or proximity to glaciers" (p. 2). With this broad, pragmatic definition the reader is led into 12 succinct chapters including introductory descriptions and discussion of environmental factors, accounts of specific processes or the results of processes, and an environmental overview and reconstruction. The importance of periglacial processes is best seen in the fact that the area climatically included totals 40×10^6 square kilometers of terrain.

Washburn includes among the objectives of research into periglacial phenomena understanding of the environmental significance of these processes, application of this information to reconstruct Quaternary environments, and use of the accumulated knowledge to forecast the effects of environmental changes.

In the introduction Washburn describes the range of climates within which periglacial processes are present, using the Köppen climatic classification. Climatologists would probably prefer to see a different classification scheme adopted, but the scheme is not central to the book and certainly the Köppen scheme is best known to geologists and geomorphologists. The environmental factors that influence periglacial processes are listed as: climate, topography, rock material, and time; vegetation is classified by Washburn as a dependent variable, as is snow cover.

The most exhaustive chapters are those on frozen ground, frost action, and mass wasting, and it is in these that the author demonstrates his ability to synthesize and to include his own substantial research within the framework of other observations and theories. These chapters are well illustrated with excellent photographs and a number of diagrams and maps showing distributional patterns (particularly in Europe and the U.S.S.R.) of present-day forms as well as the Pleistocene distribution. It is worth noting that the only overall environmental reconstruction of North American fossil periglacial data was attempted in 1962 and 1964 by a German. Shorter chapters, such as the one on nivation, reflect the dearth of significant research on their subjects and thus provide valuable commentary on the state of the art and suggest topics for the enterprising researcher.

In this day of exploration of the polar areas of the world for mineral and energy resources and the attendant concern with environmental impact it is even more important to understand how periglacial processes operate and what changes can occur because of human interference with the natural ecosystem. Thus this book not only satisfies an academic interest in cold region processes but, as importantly, shows the extent and limits of our knowledge on problems that are even now in the applied realm (for example, what will happen if an area is cleared for a gravel road).

The book is very well referenced with close to 600 entries, and it has a useful index. Possibly the only topic that is not covered, which might be in the planned revision, is periglacial soils, including the widespread organic soils of the U.S.S.R. and North America. *Periglacial Processes and Environments* is a timely work, well written by a respected authority, that really says it all.

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