Spadework in the Arctic

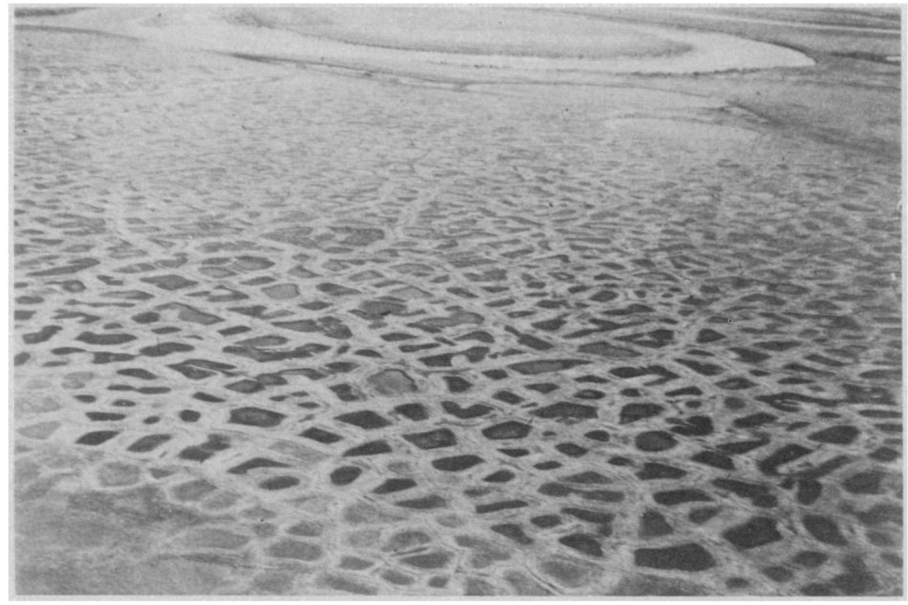
Soils of the Polar Landscapes. JOHN C. F. TEDROW. Rutgers University Press, New Brunswick, N.J., 1977. xxvi, 638 pp., illus. $60.

With this treatise a phase in polar exploration is complete. The scientific reconnaissance is over and the main descriptive data are in hand. The book is the result of 30 years of traveling with a spade, beginning at a time when all land beyond the tree line could be marked on maps as being occupied by a single nebulous entity, cold and soggy, called "tundra soil," and ending with this survey, which reveals the soils of polar lands to be various and, despite the ice, to be formed by complex chemistry.

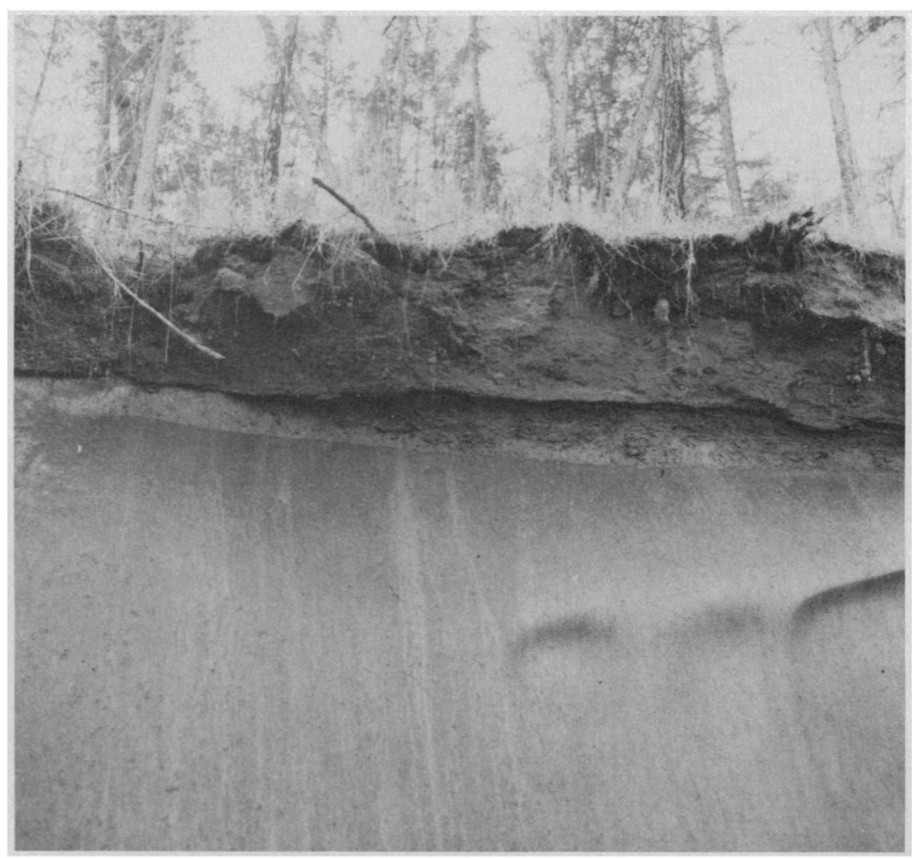
The author of the book, John Tedrow, has done more than anyone in the West to accomplish the reconnaissance. He has also burrowed deep into the Soviet literature, not only because the Soviet Union contains so much of the Arctic but because of an awareness that many of our prime insights into pedogenic processes come from the work of Russian scholars. The result of Tedrow's efforts is a first-class book, a statement of where we are that will be a standard reference for many years to come.

The 22 chapters of the book are not grouped, but three divisions are easily discerned. The first six chapters describe the Arctic as soil specialists know it: the climate, the plants, the frost, the patterns on the ground. I bounded along through these chapters, feeling the old enthusiasms for the exciting arctic landscapes as I read and increasing my understanding all the while. Tedrow is bluntly honest about the state of our knowledge of the causes of the arctic phenomena, and his accounts of pingos and polygons always leave a clear idea of what is certain and what is conjecture. The middle nine chapters discuss the varieties of polar soils and how they may be classified. These chapters are the heart of the book. The last seven chapters cover regional pedology, including that of Alaska, Canada, Greenland, Norden, the Soviet Union, Antarctica, and mountaintops.

Pedologists still agonize over problems of classification, and Tedrow strives mightily to achieve both order and a system of common sense for polar soil classification. He is courteous to various established systems of classification, including the U.S. Department of Agriculture's *Soil Classification: A Comprehensive System*, Seventh Approxima-



Oblique aerial view of a low-center ice-wedge polygon field in northern Alaska. "Low-center polygons . . . are nearly always associated with Meadow tundra or Bog soil. It is common for ice-wedge polygons to undergo a secondary growth, with the result that the original polygon is subdivided." A number of the polygons in the photograph are undergoing such division. The dark areas represent water in the depressed centers and channels in the polygon field. Most polygons measure about 15 meters across. [Photo F. C. Erickson; from *Soils of the Polar Landscapes*]



Permafrost along the Aldan River of Siberia. Permafrost results from heat exchange between the lithosphere and the atmosphere and is reported to underlie about one-fifth of the land surface of the globe. "The portion of the soil above the perennially frozen material is subject to seasonal thaw and is termed the active layer. The thickness of the active layer of soils, sediments, and bedrock, and hence the depth at which permafrost begins, is determined by local factors, such as the nature of the substrate, insulating cover, vegetation, and relief." The active layer in the photograph consists of silt and is about 2 meters thick. The sparse forest cover is Dahurian larch. [From *Soils of the Polar Landscapes*] tion, with its unspeakable language, but he is firm in his position that the system must fit the soils and not the reverse. In essence he takes the ancient Russian view that soil genesis provides the main taxonomic units, with the units being modified by parent material and drainage. He sees three soil zones, the tundra zone, the subpolar desert zone, and the polar desert zone, ringing the pole and a fourth one, the cold desert zone, covering Antarctica. In all these zones there are soil-forming processes at work, complete with active layers and physical transport of both crystalloids and colloids, probably even when the soil is frozen. Summer temperatures and precipitation determine the properties of the soils of the zones.

Within each zone, at least in the north, the principal genetic soil types may be expressed, though to different degrees. There may be in each zone wet and organic tundra soils in poorly drained places and, on better-drained sites, arctic brown soils (Tedrow's own discovery of 20 years ago) and even podzol soils. There may also be in each zone a vegetable carpet spread on rock (the ranker soils of Kubiëna, whose great influence Tedrow venerates) and primitive soils on young substrates or solifluction slopes. Tedrow's simple classification identifies each soil type and places it in the appropriate zone. It is a classification of reason; let us use it.

A biologist like this reviewer must hope that pedologists will follow Tedrow and let the taxonomic controversy lie. Soils cannot be classified as can Linnean species. Modern biology came about because of the almost magical discovery that living things were grouped into definite, distinct species and that these species had lineal, ancestral relationships one to another. But there is not a species of soil that is completely distinct from other species, let alone a distinct ancestral family. Thinking otherwise is the fallacy behind contrived systems for neatly ordering soils. Tedrow avoids the fallacy splendidly.

The very complex, and still unanswered, questions of soil genesis will yield not to systems of classification, but to studies of soil chemistry in different patterns of time and space. It seems that, aside from obvious correlations with temperature and pH values, we still have only hazy ideas of why sesquioxides are concentrated in some soils and silicates in others. Do plants really influence the process? Look at the beautiful color photograph of podzol soil in the Anaktuvuk Pass and ponder. Tedrow makes little attempt to discuss the chemistry of polar soil genesis, which is clearly a subject for the next generation. His book, however, will be the guide for those planning such work. He writes of red soils on Banks Island, of active soils in a polar desert, and of the correlation between biota and soils, asking sundry exciting questions to be answered by those who will follow him.

In the discussion of oriented lakes near Point Barrow, Tedrow misses the fact that it was D. A. Livingstone who first pointed out that the lake axes are aligned normal to the wind. Tedrow has been let down by his illustrator, who has drawn a map (p. 344) that is wrongly copied from the correct map of Sigafoos and that purports to show forest all over Seward Peninsula and beyond, although the accompanying text describes the tundra of the peninsula. This is a grave enough error to require the publisher to provide an erratum slip before any more copies are sold. Otherwise a reviewer looking for errors finds lean pickings. This is a fine book, well produced.

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Peculiar Structures

Stromatolites. M. R. WALTER, Ed. Elsevier, New York, 1976. xii, 790 pp., illus. $99.95. Developments in Sedimentology 20.

How did peculiar structures in some of the oldest limestones and dolomites come to be a household word to most geologists, engender a newsletter for 180 subscribers, and become the subject of this hundred-dollar compilation?

Stromatolites are layered rocks, not the familiar horizontal or inclined variety, but successive millimeter laminations arranged in wavy, crinkled, and onionlike forms (oncolites) or elaborated of hemispheroids that are linked or stacked, often with compound branching forms. They occur throughout the Phanerozoic, but are most abundant and varied in Late Precambrian and Early Paleozoic strata; in their heyday, stromatolites took a bewildering variety of shapes and sizes: branched growths the size of asparagus, domal cabbagelike masses meters across; columns half a meter in diameter and several meters or more tall made of successive hemispheroidal shells or of nested cones; reeflike masses tens of meters across. With the appearance of invertebrates this extravagant variation in form declined and, with some exceptions, only the more rudimentary planar, crinkled, and onionlike types continue to be formed today. The consensus view of how stromatolites grew is based largely on modern examples in which self-replicating mats of blue-green algae either alternate with laminations of fine lime sediment or through their own vital activities precipitate calcium carbonate.

The interest in stromatolites can be traced to a unique combination of extraordinary longevity (3 billion years), ubiquitous occurrence in shallow-water carbonate sediments, including those of modern shallow seas, association with metallic ores, and successive controversies about the relative roles of organisms and environment in producing variations in form and internal structure. Most of the expansion of interest has come in the last 15 years; just ten years ago there were fewer than two dozen participants from North America and Western Europe at a workshop on stromatolites (see R. N. Ginsburg, *Science* **157**, 339 [1967]) and probably no more than 30 stromatolite researchers worldwide. The present volume has 42 authors, and the worldwide community of stromatophiles probably numbers well over a hundred.

According to the editor, Malcolm Walter, the compilation aims to provide a comprehensive coverage of stromatolites for specialists and nonspecialists, with reviews of tried and tested work balanced by reports of new methods and research.

As a report of the state of knowledge, the book is on the whole well done, no small accomplishment considering the multiple authorship and the rapidly expanding field. Some of the contributions are succinct status reports. The subjects they cover include classification (Krylov), microstructure of Precambrian stromatolites (Bertrand-Sarfati), taxonomy of modern blue-green algae (Golubic), environmental range of microorganisms (Brock), microorganisms in fossil examples (Awramik, Margulis, and Barghoorn), distribution and morphogenesis of the stunning growths in Shark Bay (Hoffman, Playford, and Cockbain), and mineral deposits associated with stromatolites (Mendelsohn). Assessing the state of knowledge pertaining to microstructure, biostratigraphy, and environmental range demands much more effort on the part of the reader, for the contributions are not summarized or evaluated. Missing also is any résumé of