REVIEWS

R. J. E. Brown – Permafrost in Canada. Toronto, Canada, University of Toronto Press, 1970, 234 p., 40 figures, 9 maps, references, bibliography, and index. *Canadian Building Series,* No. 4. $ 12.50.

What started out as a doctoral dissertation some years ago has grown into a most timely, excellent, and useful book on environmental problems connected with seasonally and perennially frozen ground in the north. It is not the first book in English on permafrost in North America but the first concerning Canada alone and the first since the pioneer compilation in World War II by S. Muller from the Russian literature. It is a wonderful summary of permafrost in the modern periglacial environment of Canada.

Dr. Brown is well qualified to author such a volume by virtue of his 17 years as a research scientist with the Division of Building Research, National Research Council of Canada. Work with this organization permitted him to work in permafrost areas of the vast half of the country underlain by perennially frozen ground. He also studied the frozen ground in Scandinavia and in remote areas of Siberia.

Permafrost is defined as a thickess of the earth's crust in which a temperature colder than 32° F has existed continually from two to tens of thousands of years. The existence of this perennially frozen ground causes many serious problems for the development of northern regions. The presence of permafrost may seriously influence water supply, sewerage disposal, agriculture, mining, and construction. This book is one which conveys the general nature of permafrost and its impact on the economic development of the north. It is not the author's objective to present an engineering handbook of how to build on permafrost with detailed engineering data, nor is it strictly an academic treatise on the origin of permafrost, ice wedges, or heat flow in the north. It treats the fundamental aspects of permafrost including distribution and relationship to climate and different types of terrain; then, the application of permafrost to the environment is discussed.

The subject is treated in nine chapters. The first chapter is a good nontechnical introduction to the nature of permafrost with an important up-to-date map of permafrost in Canada. After a brief statement of engineering considerations there follows a discussion of the history of permafrost investigations in Canada. The rest of the volume is well organized into chapters dealing with buildings, services, transportation, mining and oil production, and agriculture. These discussions first consider general principles of each of the subjects and then outline experiences in Canada under each topic. Discussion of buildings is good but perhaps because of the widespread use of piles in construction in permafrost regions there could be a longer, more illustrated discussion of pile foundations. One can only marvel at the detailed collection of case history outlines regarding building and other activities connected with permafrost in Canada that have been compiled.

The chapter on services illustrates water supply and sanitation problems with good examples from the new village of Inuvik on the east side of the Mackenzie delta, Dawson, Yellow Knife, and elsewhere. The discussion of transportation, in addition to roads and railroads, include a pertinent section on pipelines; however, the brief description of Canadian experience does not add any new data that would aid in the problem of the heated oil pipeline in permafrost now being struggled with in Alaska.

The longest chapter deals with mining and oil production in the north and he further reviews difficulties imposed on mining in permafrost areas. Almost any kind of mining can technologically be done but permafrost does impose an economic factor that must be considered. Dr. Brown states that agriculture in Canada's permafrost regions is undeveloped and therefore less problems have been encountered than in Alaska or U.S.S.R.

One important aspect that probably could have been more carefully explained, even on this nontechnical level, is the ice in the ground. It is the ice content of permafrost which causes all the problems. A more thorough discussion of the existence of pingo ice, ice wedge ice and Taber ice, and a differentiation between them is all important. Perhaps diagrams and photographs of each type of ice would have helped. The amount of ice in the ground is extraordinary and results in many difficulties of operating in this periglacial environment. For example, Dr. Jerry Brown of the U. S. Army Cold Regions Research and Engineering Laboratory estimates that in similar terrain in northern Alaska 10% by volume of the upper 10 feet on the Coastal Plain is composed of ice wedges. Taber ice, ice wedges, and pingo ice is extensive. In places ice represents 75% of the ground by volume. These figures illustrate the enormous amount of ice present in many permafrost areas and the reason for serious problems upon thawing of the perennially frozen ground.

This interesting volume is really an introduction to the multitude of problems in development of permafrost regions and does not aim to tell how to solve them in detail. This will come later and much information is in the files of government and university scientists and engineers who work with these problems in North America. The volume describes the frozen ground in a modern periglacial environment. It does not attempt to discuss periglacial features (ice wedge casts, etc.) that exist in southern Canada beyond the area of present permafrost.

This book should find wide adoption and is well recommended to scientists, engineers, city planners, ecologist, and others during this time of great interest in development in permafrost areas of North America.

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The Encyclopedia of Geomorphology. Edited by Rhodes W. Fairbridge, 1240 p., Reinhold Book Corp., New York, 1968.

Professor Fairbridge has compiled a massive and useful alphabetical encyclopedia of geomorphology, said to be the first of its kind. It is the third volume in a series of eight planned in the earth sciences. They are part of the Reinhold's one-volume series of encyclopedias in many scientific subjects from atmospheric sciences to x-rays. This review, with minor changes, has appeared in a North American Geological Journal.

This 1,295-page book contains 412 entries from ablation moraine to Yazoo River and was written by 150 contributors. The authors are leaders from 22 different countries and include such non-American greats as Cotton, Dylik, Gerasimov, King, Muller, Pecsi, and Rapp, as well as many leading North American scientists.

Evidence of thoroughness and usefulness is plentiful in the overall plan of the book as well as on every page. Almost all the geomorphological topics that one could think of are

covered. The system of referencing leads the reader to other sources. If a term is not in this volume, it may be in one of the companion volumes. For example, under *beach* one is directed to Volume VI (Applied Geology and Sedimentology) for sedimentary structures, cross bedding, and other headings. In the body of the article references are made to other topics taken up in the book. For example, in the discussion of blind valleys the term *polje* comes up as well as dry valley and uvala, and others. Such terms referred to in the text are italicized for easier recognition. Cross references are given at the end of the article. For instance, under earth pillars it says „see: cross references bad lands, denudation, and others".

At the end of each article is a list of leading references which include some historically important papers as well as many current authoritative reports. An asterisk indicates references which have long bibliographies.

The volume is well illustrated. Every major article has several diagrams or photographs, many that have been taken by Fairbridge. As editor he has supplied and inserted many photographs, but they tie in very well with the articles written by the various contributors. The photographs are international in scope and reproduction is fair to good. The fine sketches by Garner in the tropical weathering article are quite striking.

The editor realized that there would be some overlap of information based on the manner in which the articles were solicited, and in most part this is good. One article may present one view of a particular topic and another article may present the contrary viewpoint. One example of perhaps too much overlap is the subject of mass wasting and mass movement. In most instances there was an attempt to condense into a few hundred words a summary of the meaning of the term. In what I suppose might be called the most important terms, subjects, or ideas, a longer discussion has been allowed, up to several pages. The articles range in length from 100 to 200 words to as many as 5 or 6 pages.

While the book is an encyclopedia of geomorphological terms and concepts, a few other good ideas are included. As the editor mentions, there is discussion or definition of the major lakes of the world. Because of the editor's interest there is a series of articles dealing with the seas and coasts. Interesting other items that one would not expect, but are very useful, for example, are the international scientific organizations associated with geomorphology, such as the International Geographical Union, and others. The various commissions and the members of the commissions are also listed.

This book is expensive, and yet is well worth the $ 38.50 to any serious student of geomorphology. It should be in all major libraries, and also in most departmental libraries, where it is available to the students. Not only is of use to students but also to all researchers and teachers of the subject. I would recommend it also very highly to geographers, archaeologists, zoologists, physical science teachers, civil engineers and workers in allied fields.

No volume of this size can be compiled without some errors or omissions, and the reviewer has taken the liberty to point out a few, mostly minor. Polygonal ground, figure 4C, page 374, appears as "poly-nomial polygons". This is a typographical error, but it is more important to realize that they are not ice wedge polygons, as one would derive from the text, but are fossil wedge or ice wedge cast polygons. On figure 3, page 230, it should be indicated that the drawing has been modified by the editor and is not Bryan's original diagram. The terms "permafrost", and "active layer", and others have been inserted and this should have been noted in the caption. In the article on pediments one is amazed to see, first, that it is so short, and second, that it does not list the thorough paper by A. D. Howard in the references.

A rather serious error from the reviewer's standpoint was the basic article on frost action; the author states that ice segregates in silt and sand. It is in silt and clay, not sand, that ice segregations, such as Taber ice occur.

In at least two different places altiplanation terraces are referred to as being formed by solifluction. This must be based only on casual observations. Altiplanation terraces are formed by nivation; solifluction aids in removing the material at the time of formation. Later, solifluction tends to reduce and destroy the altiplanation terraces.

References listed with each article are generally complete but it was a rather major error under the ventifact discussion not to include Sharp's classic paper of field experimentation on the rate of ventifact formation. Also, the article on tafoni has no references to the classical work and description of tafoni (cavernous weathering) in southwestern United States by Kirk Bryan.

Even a casual look at the book will reveal Fairbridge's stamp. A closer look, or a few months use, will show just how much the book is Fairbridge. He is more than a compiler or an editor, he is the major author of articles as well as chief collector of the illustrations. Fairbridge states he had to fill in for many delinquent authors, and as we may note he took the task of compiling the multitude of short articles. He has contributed 45% of the 412 articles. Although many of the articles are short he has contributed 35%, or 429 pages, of the entire book. His greatest contribution is in writing the many major articles of several pages in length, such as the ones on beaches, continents, craters, denudation, glacial lakes, glaciation, Holocene, islands, land masses, mountain topography, terraces, and his longest article, that of the Quaternary.

Despite the diversity of articles they are well done and illustrate the vast range and international scope of interest of the editor. It would have been difficult to select a more qualified editor. Not only has he the necessary familiarity with the field, but between "good friends", punch cards, and hard work, he has compiled a most usefuf encyclopedia that belongs in every major library and physical science department in the world.

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T. L. Péwé, R. E. Church, M. J. Andresen: Origin and paleoclimatic significance of large-scale patterned ground in the Donnelly Dome area, Alaska. *Geol. Soc. Amer., Special Paper* no. 103, 1969, 89 pages, 25 figures, 11 photographs, 2 plates, 1 map.

The authors present very interesting results of comparative research on fossil frost fissure polygons developed in gravel area of Central Alaska, which is characterized by the presence of discontinuous permafrost. The polygons have been compared with non-active fissure ice, known in the Fairbanks environment, and with active fissure ice which is intensely developing in the areas of Northern Alaska. This research provided basis to reconstruction of paleogeographic conditions, mainly climatic, of the development and subsequent vanishing of fissure ice in the Donnelly Dome area and in the whole Central Alaska as well.

Frost fissure polygons in the Donnelly Dome area in the SE part of Central Alaska

The authors have discovered vast fragments of polygonal pattern, containing over 30 polygons, which developed on the outwash plain. Ancient fissures appear in shape of distinct troughs 1–2 m wide and 0,3–1 m deep. The polygons are 3- to 6-sided,

but the majority have 4 or 5 sides. The length of sides varies from 25 to 30 m; in one case, however, the measured side of a polygon was 61 m. The troughs are not always straight, they are often curved and capricious.

In correspondence with the irregular features of the surficial pattern there is usually the shape of the fissures showing numerous vertical sections normal to the strike of the troughs. Popular wedges limited by straight lines are totally lacking. Instead, there dominate outlines of shapes which are hardly to be compared with wedge forms. They change in width and terminate in sharp hooks and indistinct veinlets. Mostly the lowermost parts of the fissures are wide and nearing in their shape lenses whose long axes have almost horizontal orientation.

The fissures developed in the Wisconsin (Würm) outwash deposits which are overlaid by loess, Holocene in age. The main textural characteristic of the material filling the fissures is lack of systematic variation of coarse and fine particles. The single very distinct feature of the structure of filling is the perfect orientation of elongated pebbles and cobbles in the middle and lower segment of some fissures. The stones in the middle parts are oriented with their long axes more or less vertically. Many stones in lower segments, usually enlarged, show the preference for nearly horizontal orientation and they are parallel to untouched subjacent sediments. The preferred orientation of pebbles appears to be the dominant feature of sediments near the fissures. Stones in the direct vicinity of upper parts of the fissures have vertical position. Also typical is the downbending of the bedding of sediments near the fissures.

The authors have considered thoroughly the problem of the origin of the polygons in the Donnelly Dome area. They discuss in detail and exhaustively the theortically possible hypotheses of desiccation and of the three types of thermal contraction. This discussion results in the elimination of the following hypotheses: desiccation, seasonal thermal contraction and primitive infilling or so called sand wedges hypothesis. There is no place here to present the writers' reasoning, but one must stress that it is done excellently and deserves to be followed.

The hypothesis that the fossil polygons are the ice-wedge casts and that they had originated in the fissure ice is evidenced by: the presence of the relict permafrost in Central Alaska, the actual development of the fissure ice in gravel in Northern Alaska, and the fact that annual mean temperature in Central Alaska was at the Wisconsin time considerably lower than at present and it had never been higher than –6°C. Secondary infilling after melting of fissure ice is proved by deformations near the surface of contact and chiefly in the form of down-turned beds, a random texture of the infilling material and the texture of the adjacent sediments close to the fissures as well.

Paleoclimatic conclusions

The fossil polygons with the secondary infilling material replacing the former fissure ice provide the authors with the very basis for climatic reconstruction since the time of the formation of frost fissure in the late Wisconsin up to the present. Fissure ice develops at present in numerous areas under conditions of very low temperatures and poor precipitation. It is Northern Alaska which has furnished most of comparative material, as it is the area, especially near Barrow, where polygons of fissure ice develop very intensively.

Barrow is situated in the area of continuous permafrost which still develops. The mean annual temperature is –12°C and the minimal temperatures measured at the top of permafrost varies from –15°C to –25°C. The mean value of annual precipitation appears to be

110 mm, and half of it comes in the form of rain falling chiefly in July, August and September.

The present lowermost limit of snow is about 1800 m. However, at the Wisconsin time it was about 1350 m, as could be concluded from the bases of cirques on the Granite Mountain, adjacent to the Donnelly Dome area. Assuming the vertical temperature gradient of 0,68°C per 100 m, the Wisconsin depression of mean annual temperature was –3°C. It means that a mean annual temperature for the Donnelly Dome area at the Wisconsin time was –5,8°C.

The development of fissure ice in Alaska takes place at present exclusively in the areas where the maximal mean annual temperature is not higher than –6°C to –8°C. Thus, evidently, the mean annual temperature at the time of the formation of fissure ice in the Donnelly Dome area could not have exceeded the value of –6°C at maximum.

The melting of fissure ice, secondary infilling, and formation of the fossil polygons had to be produced as the result of a rising of temperature. This fact has faced the authors with the alternative: either the temperature rose to the actual value, i.e –2,8°C, or it rose even more, until the mean annual temperature was at least 0°C, rather above it.

The authors reject the first possibility viewing the fact that the permafrost in Central Alaska did not disappear totally. It exists at present among other places in the Fairbanks area, where numerous ice-wedges are to be seen. Péwé et al. admitting the rise of the mean temperature until at least 0°C, argue that the degradation of permafrost and melting of permafrost and melting of fissure ice went selectively. The permafrost and fissure ice had been preserved almost intact in the fines, vanishing in coarse material, as was the case of gravel in the Donnelly Dome area.

At the same time they support the hypothesis that the Holocene climatic amelioration was relatively short, from 7500 to 3000 years before present, which corresponds to the post--Wisconsin warming period, recorded world wide.

The value and importance of this paper

The reviewer followed very attentively the course of research undertaken by the author and their reasoning which was aiming towards ascertaining of the conclusions presented in the paper. He could not find, however, more than one question which may be open to further discussion and where another interpretation seems to be possible. It concerns the degree of the rise of the temperature at the post-Wisconsin time and the selective degradation of permafrost and fissure ice. The Soviet scientists have stated that the fissure ice develops commonly in permafrost consisting of fines, but the formation of fissure ice in gravel and still coarser material takes place exclusively under the most severe climatic conditions. Similar opinion is shared by Péwé, when speaking of frost fissures developing in beach gravel in Northern Alaska.

Consequently, there is no doubt that the inverse process, i.e. the degradation of permafrost and the melting of fissure ice, was taking place similarly; it means that with the rise of temperature the degradation took place in areas consisting of coarse material and vanishing of permafrost and ground ice in silts had needed considerably higher temperatures. This line of reasoning favours the authors' hypothesis of selective degradation. The authors, however, did not determine inductively the value of the mean annual temperature necessary to the degradation of permafrost. The conclusion that it is at least 0°C is based on statements elaborated elsewhere. It is very probable that the value mentioned above could be right for Central Alaska, but this conclusion is not based on facts determined in Alaska.

The shapes of fissure ice casts, being quite different from the familiar wedge forms,

give rise, at the first glance, to some doubts as to their origin. The doubts, however, disappear as a result of persuasive and exhaustive reasoning in which the first place is taken by the close connection with distinct polygonal pattern and the minute analyses of texture and structure as well as of the filling material at the adjacent sediments. Thus, instead of possible doubts, there appear reflections on the need of more accurate research of fossil polygons elsewhere, including Poland. One has to pay greater attention to sections disclosing irregular outlines, which by far do not look like "nice wedges". Detailed textural and structural analyses are needed too, which results from the fact that the material infilling the fissures in the Donnelly Dome area is almost identical with the adjacent sediments, and this differentiation has been reached thanks to such analyses.

The paper by Péwé, Church and Andresen is to be considered as an excellent model for comparative research. This opinion is evidenced, firstly, by the right choice of the investigated area in the region of discontinuous permafrost, at the place where the degradation of the permafrost occurs, but not too far from the areas in which permafrost and fissure ice still exist. The interpretation of traces of events occurring during Wisconsin and later in Central Alaska was facilitated by the possibility to relate the ancient processes to the ones which still take place in Northern Alaska. These studies are evidently more certain than comparative research, where interpretations of fossil traces of the Pleistocene periglacial processes are based on comparisons with actual processes occurring in remote regions and under climatic conditions certainly quite different from those that were dominating during Pleistocene in lower latitudes. This paper, by Péwé and co-writers, may be considered as an important link in comparative research necessary for reconstruction of periglacial events occurring during Pleistocene.

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