Reviews

CECIL, L.D., J.R. GREEN and L.G. THOMPSON, *eds.* 2004. *Earth paleoenvironments: records preserved in mid- and low-latitude glaciers.* Dordrecht, etc., Kluwer Academic Publishers. 250 pp. ISBN 1-4020-2145-3 hardback £56/ €80/US$88; ISBN 1-4020-2146-1 (ebook).

Ice cores have played a major part in the context of climatic change. The Vostok (Antarctica) core has become almost legendary in demonstrating the important connection between temperature changes and changing greenhouse-gas concentrations, albeit as an amplifier. Greenland, with its higher-resolution records, has demonstrated, among many other things, the ability for climate to change rapidly, although its relevance to modern change may be debatable. Most other cores, although data from the subpolar cores have been used equally with the polar ones in paleoreconstructions (e.g. Mann and others, 1999), have been overshadowed as a consequence. The fear of melt and its effect on the ice-core record seem to have left those I like to call the high-polar mafia in contempt of us lesser mortals who work in warmer climes. As the introduction to this volume points out, Wally Broecker was inspired by one of Lonnie Thompson's cores to call him one of the great modern explorers, principally because of the value of the data in showing that important climatic changes also occur in the tropics. One cannot doubt that the mid- and low-latitude cores, as far as the ice-core community is concerned, help to fill in the gap between the two polar regions. This gap of course, as some of the authors in this volume stress, is where most of the planet lives. This is where this volume can bring some of these cores in from the cold, as one sees only very rare reference to the tropical cores in the ice-core literature.

The high-elevation cores are usually won with extreme difficulty by small teams of scientists who do not have the kind of resources that the deep-core teams have. The Greenland cores, for example, are analyzed and interpreted by very large scientific teams from several nations. One volume of the *Journal of Geophysical Research* (Hammer and others, 1997**),** considering just two cores, has 47 papers. This volume, by contrast, has 11 papers with 21 authors. Even the mode of core logistics cannot be compared. On the great ice sheets, transport to the core site is usually by large aircraft. Get on at one end, get off at the other and begin setting up the camp and start drilling. There is even dancing at the end of the day for some of the rugged souls. Low-latitude, high-elevation transport is often without vehicles. Pull it up and then pack it down. Some of the field exercises show astonishing ingenuity and a complete and essential absence of weak hearts.

Don't get me wrong. I do not mean that the cores from the non-polar areas are beyond criticism. In fact, I think that the harder push for funding and the efforts to get the cores from the ice and back into storage result in a more limited breadth of the research field. At times, I think the researchers overstate their case and over-interpret the data in a quest to impress their polar colleagues. What one cannot deny is the availability of the data. They are there for posterity when the glaciers may not be. This is because modern warming is causing dramatic recession of the glaciers. Some authors suggest that these ice bodies need to be cored soon as they may not be there in the future.

The idea for the book apparently grew out of a session at an American Geological Union meeting in Boston, held in June 1999. It is a collection of some of the papers from that meeting, with others that were requested and submitted afterwards specifically for this volume.

The book is divided into three main sections.

Part I consists of two chapters, one an introduction and the other a 'methods' paper.

Lonnie Thompson introduces the volume. He points to the retreating nature of the mid-latitude glaciers. While many glaciologists might consider this low-key, it is the feature of glaciers that makes the greatest impact on the public. Glaciers 'before, during and after' have always evoked strong responses from the media, as they need very little explanation: glaciers melt so it is getting warmer. Thompson also pleads for more research before these glaciers disappear. It is an effective plea for funding, although I have always had problems reconciling glaciers that have existed for tens of thousands of years with their disappearance in the near future. This is because it implies that the climate now is warmer than it has been since the last ice age (or in the case of glaciers like Guliya, Tibetan Plateau, for over 700 ka). He presents a brief survey of the lessons learned from the astonishing number of high-elevation glaciers that his group at the Ohio State University have cored over the last 30 years. He stresses their importance as water reservoirs that are rapidly disappearing, some in areas dependent on them for late-summer water resources. He also draws attention to the need to improve both the temporal and spatial resolution, and also improve the integration of the data between cores.

J.R. Green, L. DeWayne Cecil and S.K. Frape, '*Methods of mid- and low-latitude glacial record collection, analysis, and interpretation*'. This chapter describes ice-core methodology. It brings together, perhaps for the first time in a volume of this nature, all the demands of field operations and laboratory analysis. However, it is a bit thin and could have done with better, or perhaps more, references (e.g. Dansgaard, Hammer and Langway are all missing). In a section on site selection, many priorities are listed but they do not include a requirement for location at the top of the flowline. Insufficient reference is made to transport, sampling and storage. Drilling cores is one thing, but how you get them down from several thousand metres above sea level in a tropical region remains a mystery to me. The processing section could have been a bit longer, with more on the University of Maine/New Hampshire method of sophisticated sample-melters. In this system the outside of an ice section, being somewhat less clean, is channelled off for the more robust stable-isotope samples. The analysis section could have done with more credits, and atomic absorption is missed as an analytical method. I would have liked to see more on the measurement of boreholes – vertical stain rates and closure rates. It was measurements like these that led Paterson (1977) to conclude that ice-age ice was softer than interglacial ice. One must admit, perhaps, that the environmental challenges demand equipment is kept to an absolute minimum.

Part II considers the climate and environmental change record over the last 200 years.

U. Schotterer, W. Stichler and P. Ginot, '*The influence of post-depositional effects on ice core studies: examples from* *the Alps, Andes, and Altai*'. This chapter deals with post-depositional effects in snowpacks and how they need to be considered when interpreting ice-core data. The effects, drawn from research in the Swiss Alps, the subtropical and tropical Andes, and the Mongolian and Siberian Altai, include drifting snow, sublimation and meltwater percolation. They present comparisons between analyses of snowfalls at the surface and at depth. Once buried, the layers are subjected to such post-depositional events as meltwater percolation. The effect on the seasonal stable-isotope structure in the snowpack is minimal but can be completely destructive in the case of the seasonal record of ion concentrations. These effects are particularly important in the various studies presented in this book, where many of the ice-core studies are conducted in areas subjected to strong snow scour and melt. They are also relevant to those working with ice cores from subpolar glaciers.

K.J. Kreutz, C.P. Wake, V.B. Aizen, L.D. Cecil, J.R. Green and H-A. Synal, '*Event to decadal-scale glaciochemical variability on the Inilchek Glacier, central Tien Shan*'. The sampling and analytical methodology is well described. The authors use snow chemistry data to determine air-mass trajectories. Based on snow pits dug at different elevations, they find there is no elevation effect on the stable isotope of hydrogen (δD), concluding that snowfall is generally from clouds with horizontal cloud bases (much as found in the Canadian Eastern Arctic; Koerner and Russell, 1979). This is important as it means an ice core drilled from a site down the flowline is not 'contaminated' by ice deposited at elevations above the drill site.

C.P. Wake, P.A. Mayewski and S. Kang, '*Climatic interpretation of the gradient in glaciochemical signals across the crest of the Himalaya*'. The gradient referred to in the title is steep, with much higher fluxes north of the divide where they recommend that future studies of changing atmospheric circulation patterns and dust transport should be located. Pollutant signals appear to be difficult to detect due to high washout to the south and the complicating effect of high natural dust fluxes to the north.

M. Schwikowski, '*Reconstruction of European air pollution from Alpine ice cores*' brings the picture back to Europe. This is the kind of chapter I prefer in a volume of this kind. It is a review of the work done in the European Alps and is adequately referenced. The method of site selection is covered and three sites are used in the discussion. The methods used for ice-core dating are described and illustrated. The base technique is counting annual layers using seasonal variations of parameters that are elaborated on. The accuracy of this time-scale is improved by using methods applicable to most cores; they include stratigraphic markers like volcanic and dust layers, fall-out from nuclear weapons tests and Chernobyl, radioactive decay of ^{210}Pb, and the trend in methane concentrations determined initially from the Greenland cores. These are plotted on a depth time-scale, which serves to illustrate the importance of applying a multi-parameter approach to this important exercise. The chapter then proceeds to use these cores to trace atmospheric pollution since the industrial revolution in Europe. Sulphates, various forms of organic and inorganic carbon, lead and other metals are some of the pollutants considered. Each 'group' is dealt with separately which makes the whole presentation flow smoothly.

W. B. Whalley's *Glacier research in mainland Scandinavia* is a good review of glacier mass balance records in this area and their importance with respect to climate modelling. It is well referenced and considers glacier extent, mass balance and ice coring in Scandinavian glaciers. As an introduction to any of these aspects in these glaciological sub-disciplines, it is a good guide.

Part III deals with the last 200–500 years.

M.E. Davis and L. Thompson, '*Four centuries of climatic variation across the Tibetan Plateau from ice-core accumulation and records*'. The Tanggula Mountains on the Tibetan Plateau act as a climatic divide where the monsoon dominates to the south but much less so to the north. Dust, δ^{18}O and deuterium excess records behave differently between sites north and south of this divide. Future studies of ice cores in both regions should lead to a better understanding of variations in the northern extent of the monsoon. In many ways, this and similar papers in this volume (like that of Wake and others) illustrate the sharp spatial variations of climate that occur in the areas that these types of ice core represent. This is very different from the much broader spatial variations that occur on the two great ice sheets. This is, of course, to be expected, as tropical ice cores must come from the high elevations of mountainous regions where spatial variation reaches a maximum. It does mean, however, that one core may represent only a small area and justifies the higher spatial density of ice coring needed in this kind of work.

Yao Tandong and Yang Meixue, '*Climatic changes over the last 400 years recorded in ice collected from the Guliya ice cap, Tibetan Plateau*'. This paper deals, firstly, with the derivation of annual layer thickness with depth according to the theoretical approaches of Nye, Reeh and Raymond. This leads, secondly, to the main consideration, which is the accumulation record. The authors find what seems to me to be an extraordinarily good correlation in the accumulation rate among cores quite distant from each other. Ice cores show good correlation between El Niño–Southern Oscillation events and negative precipitation anomalies in the Guliya core. However, there are numerous typographical errors in the paper (one in an equation) and several unedited misspellings.

P.F. Schuster, D.L. Naftz, L. DeWayne Cecil and J.R. Green, '*Evidence of abrupt climate change and the development of an historic mercury deposition record using chronological refinement of ice cores at Upper Fremont Glacier*'. This paper has one of the longer introductions in this book, dealing with methods of drilling and sample cleaning. However, there are slight discrepancies between text and diagrams where the authors claim that there is no reduction in concentrations from the outer to the inner parts of the ice core they discuss. To my eyes, there seems to be a slight trend in the figure. This is important, as the subject is historic trends of mercury in the ice, and hence atmosphere. I found the age determinations too descriptive and simplistic, with long sections on recognition of volcanic layers as time markers. None the less, the historic chemistry profiles, especially of mercury, are of great interest, showing the peaking of concentrations up to a maximum in the 1980s and a decrease since then. It would have been valuable to compare the levels of mercury with those in the Arctic. Common to this volume, the references show very little awareness of the subpolar Canadian and Svalbard cores. This is a pity as most of these ice cores have many things in common, in the post-depositional sense, with subpolar cores.

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D.L. Naftz, D.D. Susong, L. DeWayne Cecil and P.F. Schuster, '*Variations between* δ^{18}O *in recently deposited snow and on-site air temperature, Upper Freemont Glacier, Wyoming*'. This chapter deals with the development of a transfer function between air temperature, *T*, and the stable isotopes of oxygen, δ^{18}O. This is done by comparisons between measurements of air temperature and snow accumulation/deflation on the one hand and snow-pit measurements of stratigraphy and δ^{18}O of pit layers on the other. The authors conclude that the best site for the automatic weather station is on the glacier and that snow deflation, which removes complete surface snow layers during the year, strongly biases the overall $\delta^{18}O/T$ relationship. This is because snow deflation occurs mainly in the winter, thereby biasing the proxy temperature to summer. This also is important in subpolar regions of the Canadian High Arctic, this time because there is only slight snowfall in winter.

L.D. Cecil, '*Summary*' Like any summary or conclusions at the end of peer-reviewed papers, this is the chapter one should read after the introduction. It allows the reader to get a view of what is going to be covered and in which region of the Earth's surface. Each chapter is discussed briefly, not necessarily in the same order as they are presented in the book. There is also an attempt to pull some common facts together. This is difficult when one considers these cores come from vastly different regions of the planet, but the attempt is reasonably successful.

The promotional text on the back of the cover claims the text 'forms an ideal supplement in courses dealing with climate and global environmental change, glaciology and natural resources management'. I feel this is a slight overstatement. An ideal text is usually written by one author who reviews all the literature and separates this into a series of chapters, each with its own central theme. This book, instead, is a mixture of original papers and reviews of work in specific regions, not exclusively based on ice-core results. As a result, it is somewhat of a mixed bag. If each chapter had been a review of work done with ice cores in a specific region, the book would have been closer to the stated goal. There are gaps too. I am a stalwart of the value of ice layers as a summer temperature proxy. By the very nature of their location, some melt must occur in the cores discussed in this book. However, this proxy is ignored. Similarly, although I am aware that some of these researchers have used the varying concentration and assemblages of pollen in ice cores as a climate proxy, this approach also receives no mention.

Unfortunately the quality of the publication often does a disservice to the authors. Although the book contains a long list of reviewers, I can hardly believe some of the papers were reviewed at all. There are numerous typos: for example 'Glen' in one chapter is consistently written as 'Glan'. There are diagrams with no text on the axes, sentences left unfinished and a repeated paragraph. In one case, the dates on the diagrams are different to those in the text, in another the text on the diagram is far too small, and there are numerous pages that are half blank in the middle of chapters. I also wish the chemists would use a consistent system of units. We find ueqiv Kg, mmol/l, ppbv, ng/g, mg/L, etc. At least they don't use chains, rods, poles and perches!

Even with all these criticisms, I think the book can be a valuable acquisition for libraries. Despite its deficiencies, it puts together for the first time a collection of papers dealing with ice-core research in areas that receive scant mention or reference from researchers in the well-known field of ice-core research on the two great ice sheets. It therefore shows ice cores in a quite different light, drawing inferences, particularly from chemistry, that are quite new to the global field of ice cores.

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