Paleomagnetism of the Atlantic, Tethys and Iapetus oceans

Rob Van der Voo

Cambridge University Press, 1993.
411 pp., hardback, \$89.95 ISBN 0-521-41941-7

It can be convincingly argued that no property of rocks has contributed more to the advance of earth science in the last 40 years than natural remanent magnetisation (NRM). In the decade to 1965, the revelation that NRM directions varied systematically with age within each continent but that the records differed from one continent to another, decisively reopened the century-old debate on the mobilism of continents. In the decade to 1975, the establishment of the magnetic polarity timescale was the crucial element of two fundamentally important advances: the demonstration of sea-floor spreading and plate tectonics, and the establishment of magnetostratigraphy as a precise and widely applicable chronostratigraphic tool for the study of sedimentary rocks. Subsequent years have seen the consolidation of the methodology and databases, demarcation and quantification of displacement of exotic terranes, and the emergence of other applications. Some of these have been of specialist character (e.g. Holocene chronostratigraphy using palaeosecular variation of NRM directions, and the cooling histories of sedimentary basins or of batholithic intrusions). Others are more global and fundamental, touching on the origin and behaviour of the geomagnetic field itself.

How curious, then, that NRM and its uses are so superficially understood by most earth scientists and that it finds such a small niche, if any, in first-degree curricula. Why is it that, in the light of the pervasive contributions such as I have mentioned, palaeomagnetism is so widely perceived as an imprecise science at best, and at worst as depending too much on art to be treated as seriously as its usefulness ought to demand?

Rob Van der Voo's book offers answers to these conundrums; indeed they form one of the major themes of his book. There are many sources of imprecision in paleomagnetism; some are evident and quantifiable while others remain obscure. Van der Voo shows they impede but do not prevent clear unambiguous discoveries of geological significance. Paleomagnetism thus has a contribution to make to an extraordinarily wide range of geological problems in igneous, sedimentary and metamorphic rocks. The point is demonstrated in this book via synthesis and commentary on palaeomagnetic studies of the circum-Atlantic and circum-Tethyan continents.

Following introductions, the foundations are laid in Chapters 2–4. First the geocentric axial dipole field model is defined and justified, and the methods of calculating remanence directions and palaeomagnetic poles are summarised. The elements of the needed geological framework (stratigraphic and tectonic) are then described and the standard palaeomagnetic methods reviewed.

For the potential user of palaeomagnetic information the heart of the book is Chapters 5–8: a series of essays on pieces of the world tectonic mosaic. Chapter 5 is concerned with how each of the present-day major continents nucleated in the Phanerozoic. Particularly useful here is discussion of different geometrical models of apparent polar wander and of plate motion. This and the variable reliability of data, e.g. between Laurasia and Gondwana, illuminate discussion of the assembly of Gondwana and Pangea. Emphasis in this chapter is on the pre-Jurassic for which sea-floor record is not available to provide further constraint.

Chapter 6, by contrast, takes models for the evolution of the Atlantic based on marine geophysics, and seeks to enhance and discriminate between them using land-derived data. In Chapter 7 on Tethyan history the 'balance of power' between palaeomagnetic and other data is different again: the process of delineating individual tectonic blocks is an iterative one between geologic and palaeomagnetic approaches. Van der Voo skilfully weaves into this story the classic cases in the Cretaceous of Italy and elsewhere, in which palaeomagnetism and stratigraphy combine to produce uniquely precise chronological frameworks.

These three chapters demonstrate what can be achieved when the study area is big and not severely deformed, or when other data help define the framework. But what if these aids are absent or weak? In Chapter 8, Van der Voo treats a series of case histories to show what can and cannot reasonably be deduced. The conclusions are 'of a kind' with those reached earlier in the book, e.g. worthwhile estimates can be made of the changing width of Iapetus as of Tethys, but controversy remains about timing and of rates at critical moments.

The writer of a monograph such as this faces a daunting task to present the virtually indigestible in digestible form, and considerable thought and effort has clearly been put into achieving this by employing a personalised style of writing and by interspersing illustrations of classic palaeomagnetic study-locations. Reporting numerical results, often from geographically unfamiliar locations, does not make easy reading; and the proper scholarly decision to maintain thorough referencing throughout the text does not help the flow. In spite of this, the book will be invaluable to professional and academic geologists worldwide who need to judge the current state of relevant knowledge, and what paleomagnetism may

and may not contribute to the understanding of Earth history. I recommend it strongly to such readers: it deserves to sell well.

What also emerges from this book is another possible answer to the conundrum with which I began this review. It is that the rigour that is sometimes lacking in palaeomagnetic methodology derives from its imperfect linkage to mainstream petrology. After all, NRM is 'only' the sum of a set of rather particular rock properties. 'Rock magnetism', the research discipline that links NRM to petrology, is, save for brief mention, beyond the scope chosen by Van der Voo. Its potential importance however is alluded to: 'Microscopic observations...do not generally represent the important smaller grains which carry the more stable magnetization. Scanning or scanning-transmission electron microscopy must be used to obtain images of these...' However, in a rare lapse of perspective (p.65) he generalises that 'Rock magnetic ... information ... does not contribute to our knowledge about the reliability of a palaeopole. ... Any magnetic mineral can be secondary or primary ...' These are statements that are worth challenging. The goal must be to distinguish the actual remanence-carriers among the host of petrologically similar and hitherto indistinguishable non-remanence-carrying ferromagnetics, and to devise ways of experimenting on those remanence-carriers alone in order to understand, as well as merely measure, these treasured properties with the needed discrimination and precision. Success would enable paleomagnetism to broaden the scope of tectonic and historical geology, by extending to earlier periods the levels of precision and rigour already brought to Mesozoic and Cenozoic chronostratigraphy. □

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Gold and other precious metals from ore to market

Claudia Gasparrini

Springer-Verlag, 1993. 336 pp.,
hardback, DM 228.00, ISBN 3-540-54976-5.

Following a general introduction in which the author emphasises her attention to focus primarily on the precious metals and to give only a more superficial cover of base metals, the opening two chapters provide brief and rather deprecatory reviews of the state of the art of the processing sector and provide the author's own observations on the 'poor planning of precious metal recoveries'. Much of the blame is laid at the door of poor communication between earth scien-

tists and metallurgists which the author believes can be attributed to the way in which the relevant subjects are taught at university level. Chapter 3 provides a useful and succinct review of the physical and chemical parameters that can affect the recovery of metals from their ores ranging from bulk-ore chemistry and the physical characteristics of the host rock to mineral chemistry, grain size, and mineral assemblages. *Methods and techniques utilised in the study of ores* (Chapter 4) relate to ore microscopy, electron microprobe and SEM studies and emphasise the need for a consistent and logical approach to such work. Chapter 5, *General Principles of Mineral Processing*, although not intended to be an in-depth review, at least ensures that all readers have a basic understanding of the various physical and chemical processes commonly employed in the mining industry.

Subsequent chapters focus on the specific metals. Chapter 6, on gold, provides a fairly comprehensive review of the nature and composition of gold and gold-bearing minerals, well illustrated with colour photographs. The second part of the chapter is devoted to gold metallurgy and its recovery. There is some duplication of information but nevertheless it remains a coherent section. Brief case histories and comments on relative processing techniques provide a useful dimension but sometimes tend to be rather superficial, leaving the reader wanting more solid facts. Silver is tackled in the same way and to the same extent whereas the later chapters on uranium (Chapter 10) and the base metals (Chapter 11) are intentionally more succinct. Chapter 11 in particular, merely provides 1–2 page overviews of a wide range of metals—Be, B, C, Mg, Al, K, Ti, Cr, Mn, Fe, Co, Ni, Cu, Pb, Zn, As, Nb, Ta, Mo, Sn, Sb, Ba, REE, W, Hg and Bi. Concluding sections on mineral exploration (Chapter 12) and 'Conclusions' are somewhat perfunctory and do not add materially to the volume. A short glossary of minerals, rocks and geological terms is appended.

In concept and content this is an unusual, perhaps unique book, the strengths of which are its good documentation of ore minerals and their interrelationships, particularly so for gold and silver, and also its attempts to highlight the extreme relevance of detailed mineralogical studies to mineral processing. It could perhaps have benefitted from a more thorough consideration of the principles and practice of processing in relation to specific mineralogical problems and the case histories presented, although the reader's attention is directed to relevant publications. In appearance the book is a superbly produced and well-illustrated volume, with numerous high-quality colour photomicrographs, but a number of computer-generated line diagrams have not reproduced very well. Overall the volume achieves most of the author's stated objectives and certainly provides an excellent

introduction to the interface of mineralogical studies and mineral processing.□

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Foreland basins and fold belts

Edited by R W Macqueen and D A Leckie

American Association of Petroleum Geologists Memoir 55, 1992. 460 pp., hardback, \$79 (AAPG members), \$110 (nonmembers). ISBN 0-089181-334-9.

This book addresses the geology of foreland basins and fold belts in regards to hydrocarbon resources. It is the fifth volume of a five-volume series published under the American Association of Petroleum Geologists' World Petroleum Basins project initiated in 1983. The intent was to devote each volume to one major class of basin and, in each volume, to discuss one extensively explored 'type' basin while additional summary papers would discuss other basins of similar type. In addition to this volume on foreland basins, others in the series cover divergent/passive margin basins, cratonic basins, active margin basins and interior rift basins.

In keeping with the objective of the series, this book discusses the geological and hydrocarbon details of the Western Canada foreland basin (the 'type' basin) and includes five similar basins that are compared with the type basin. The editors have selected the Zagros, Eastern Venezuela, North Slope Alaska, US Rocky Mountains and Ouachita foreland basins to compare with the Western Canada basin. There are three distinct parts to the book. Firstly, 10 chapters discuss the type basin in great detail, covering over two-thirds of the volume. Secondly, five synthesis chapters summarize the five other foreland basins. The third part comprises a chapter that gives an overview and synthesis of the entire volume.

The editors state that they picked the Western Canada foreland basin as the type example because it is reasonably mature in regards to hydrocarbon formation and concentration and there is a 'phenomenal' wealth of publicly accessible data covering over 100 years of exploration. Indeed, the details presented in the book are considerable. Exhaustive descriptions are given in regard to the tectonics and structure, including lithospheric implications, stratigraphy, sedimentary and thermal history, hydrocarbon formation, and even the history of petroleum development of this extensive foreland basin and fold belt. Certainly the size and geographical extent of the basin

make it attractive as a type example. At one time it extended for more than 6000 km, from the Arctic to the Gulf of Mexico, was over 1600 km wide, and a thickness of sediment in excess of six kilometres was deposited in the basin. With the exception of the Ouachita foreland basin of late Palaeozoic age, all other basins discussed in the book are Mesozoic and Cenozoic features.

This book is a good reference book for anyone interested in basin formation along the margins between active plates and cratons. The relationships of overthrusting, lithospheric loading and cratonic erosion with tectonic events and sea-level fluctuations are discussed in detail. The editors meet their objective of comparing a type example with other basins of similar type. In addition, the book liberally includes well-drafted illustrations, many colour plates and several tip-outs.□

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The geology of the Belingwe Greenstone Belt Zimbabwe

Edited by M J Bickle and E G Nisbet

Geological Society of Zimbabwe, Special Publication 2. A A Balkema, Rotterdam/Brookfield, 1993.

Opinions on the nature of the Archaean crust of the Earth have swung between extremes; that it was rather like or very unlike what it became in the Phanerozoic; that plate-tectonic processes operated in much the same way as they did later in the Earth's history, or they did not. The gap that arose between the many theoretical models and the results of mapping on the ground, widened as the boot-and-hammer geologist became more of an endangered species. Hence an account of fairly detailed field and laboratory work from southern Africa, carried out sporadically over a period of some 20 years, is to be welcomed.

Situated on the Zimbabwe craton of central southern Africa, the Belingwe Greenstone Belt has a geochronology which embraces a time interval from 3.6 Ga to 2.5 Ga, a quarter of the age of the Earth and longer than the whole of the Phanerozoic. The concerned inquirer can understand, if he absorbs the 222 pages, what the rock units, their stratigraphy, structure, metamorphism and geochemistry are really like in this huge span of Precambrian time. Much of the discussion about 'Greenstone Belts' and the 'Granite Greenstone terrains', for the two

terms are more or less synonymous, has centred around the questions 'Are they relics of oceanic crust?' or 'Were they laid down upon a continental basement?' By now, however, we may suspect that these are not necessarily the right, or the only questions to ask.

Attention has long been focused upon several characteristics of the GSBs, which in combination set them apart from other formations. These are well documented in the Belingwe memoir, as follows:

- The presence of komatiites, ultramafic, high Mg extrusives (often with pillow structure) which are much more abundant than in the Phanerozoic. The Belingwe komatiites are surprisingly fresh, with low grades of metamorphism and with clusters of huge spine-like olivine crystals forming the 'spinfex texture' (aptly named after a prickly Australian grass, and taken to indicate quenching).
- The presence of stromatolites, fossilized algal mats, which are some of the earliest preserved life forms, in limestones.
- The presence of banded sedimentary ironstones (BIFs) which at Belingwe are locally associated with the extrusives.
- The presence of voluminous, bimodal volcanic successions; at Belingwe there is an andesitic volcano of modern dimensions.
- There is a wide variety of thin and thick clastic sediments. Of particular interest at Belingwe is a well-established conglomerate which, in part, separates the old basement Shabani gneiss complex (3.5 Ga) and the Chingezi complex (2.9 Ga) from the two overlying GSBs, and which also separates the older of these (Mtshingwe, 2.8 - 2.9 Ga) from the younger (Ngezi, 2.6 Ga).

The metamorphic grade is low, seldom above greenschist, and the rocks are weakly deformed. The overall structure, as in many GSBs, is synclinal. Shear deformation is evident, and this may or may not be associated with the subsequent emplacement of plutons (for which A M McGregor coined the term 'gregarious batholiths' in this terrain). The plutons often punctuate GSBs to give them a characteristic 'bitten apple' outline in plan. Characteristic gold mineralisation of this GSB as with others, tends to be associated with the shearing.

In a useful introductory review entitled 'Archaean geology—some of the problems' the authors encapsulate the big greenstone question as follows: 'Distinction between the "autochthonous" continental or the "allochthonous oceanic" models is a crucial step in tectonic interpretation of granite-greenstone terrains.' 'Are greenstone sequences typically disordered, allochthonous and bounded by thrusts or are they autochthonous sequences?' And they add, cogently, 'This problem may have different answers in different places....'.

As a general conclusion the authors are firmly in favour of a 'well-defined sedimentary and volcanic stratigraphy, including

the komatiites.... deposited on an even older granite-greenstone continental crust.' They tentatively recognize a rifted, depositional basin in an extensional regime, in at least part of their interpretation of the palaeoenvironment. More recent work by Kusky and Kidd, and Scholey, published since the memoir was written, has reinforced the opinion that, whatever the initial origin of the GSB, there was an element of translation in its emplacement.

Recognition of the existence and importance of continental crust in association with the GSBs found support from the neighbouring territory of Botswana when the first satellite imagery became available in the early '70s. Litherland recognized the 'schist belts' (GSBs) as relics within a vastly greater areas of layered, now gneissose, continental material. This shifted the balance away from 'greenstones plus granites' towards 'greenstones in a continental context'. He also suggested that there was a broad stratigraphic continuity between the GSBs of the Zimbabwe craton, as the authors of the Belingwe now believe. However, one wonders if this could be accounted for by similar evolutionary processes in isolated basins.

So far so good: but as is usual in studies of these formations, we arrive at another series of questions: such as:

- 'Were the 'nappes', recognized further south towards the Limpopo mobile belt by earlier workers, operative here?'
- 'Do the GSBs have a real, distinctive identity, and is this specific to the Archaean?'
- 'To what extent are the rocks of the GSBs to be regarded as 'oceanic' albeit in what appears to be a 'continental context?'
- 'Why is their grade of metamorphism so low?'
- 'What light do they throw on the Earth's early, evolutionary history?'

At a recent symposium in London (September 1993) Professor Bickle, one of the authors of the Belingwe Memoir, addressed himself again to the question of 'the elusive oceanic crust' without being convinced that it had in fact been recognized. Others (Robert Shackleton and Brian Windley) were confident that the final solution is to be seen in the 'Canadian model', where much more extensive mapping, has shown that the GSBs were emplaced in stabilised continental masses as accretionary prisms, by plate-tectonic processes.

In southern Africa at least, the assessment of the original extent and exact nature of the supposedly accreted material, and of the tectonic processes which put it in place, still depends upon careful consideration and evaluation of the data and the binding constraints; these are provided in the Belingwe memoir. Throughout, the authors' descriptions are meticulously detailed, clearly expressed and objectively presented. Any one who wishes to make a well-informed

judgement will find the volume fruitful reading. (This reviewer noticed only one surprising mistake, presumably in the printing, the omission from Table 2.1 'Major geological units: Belingwe area' of the Matshingwe Group).

The volume is well produced, abundantly illustrated (although some of the field photographs are a bit 'grey'), and as an attractive, hardback book will be a valuable addition to any geological library. □

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Pacific Neogene, environment, evolution and events

(papers from the Fifth International Congress on Pacific Neogene Stratigraphy and meetings of IGCP Project 246)

Edited by R Tsuchi and J C Ingle

University of Tokyo Press, 1992. 257 pp., \$94.50, hardback. ISBN 4-13-068206-7

There are few books which provide a geologically thematic overview of a region as extensive as the Pacific Ocean. The most recent described the palaeo-oceanography and biogeography of the Miocene Pacific (Geological Society of America Memoir 163, 1985). Pacific Neogene provides a timely up-date of recent research and, to a certain extent, complements the earlier publication.

The 257 pages of this hardcover book contain 15 papers selected from the 82 papers and posters presented at the Fifth International Congress on Pacific Neogene Stratigraphy and associated meetings of the IGCP Project 246, held in Japan in October 1991. The three subtitle topics are retained as three discrete parts within the book, of which the first, Palaeoenvironment of the Pacific, is well represented by eight papers in 144 pages. The second part, Tectonic Evolution of the Pacific, is unfairly represented by only two papers in 16 pages. Pacific Neogene Events In Time And Space forms the theme for the third part, and is better represented by five papers in 79 pages.

In Part 1, biostratigraphic evidence for palaeoenvironmental reconstruction is based on palynomorphs (Heusser, core material Sea of Japan); diatoms (Koizumi, core material Sea of Japan; Barron, onshore and core material California); planktonic foraminifera (Ibaraki, onshore coastal Peru; Gasperi and Kennett, core material western equatorial

Pacific); molluscs, larger foraminifera and palynomorphs (Hornibrook, onshore New Zealand). Non-biostratigraphic evidence used in this first section is derived from lithofacies variations (Garrison, onshore California and Peru), oxygen, carbon (Gasperi and Kennett; Raymo) and strontium (Raymo) isotope data. These contributions, with the exception of that of Hornibrook, provide isolated, unidisciplinary insights to the palaeoenvironment of scattered localities of the circum Pacific. In welcome contrast, Hornibrook presents an integrated, multidisciplinary review of marine palaeoclimates of New Zealand, from which the reader is able to obtain a more comprehensive insight into climatic change in that region since the Paleocene. The possible influence of the tectonic uplift of the Tibetan Plateau on climatic changes in the Pacific Neogene is succinctly reviewed by Raymo.

The two contributions on the tectonic evolution of the Pacific (Part 2) focus only on the western flanks. An account of the palaeomagnetically derived deformation of the Neogene sediments of central Japan during the Tertiary (Hirooka) is rather insignificant when compared with the explanation of the influence of an Indonesian 'seaway' on the surface water circulation between the tropical Pacific and Indian Oceans (Nishimura).

Part 3 includes a description of Neogene molluscan assemblage variations of northeast Asia (Gladenkov, Sakhalin-Chukotka region); late Neogene planktonic foraminiferal lineage responses to temperature changes (Wei, core material southwest Pacific); and planktonic foraminiferal zonation differences between the southwest Pacific and Indian Ocean (Srinivasan and Sinha, core material). Within this section, the descriptions of larger foraminiferal (Adams), marine molluscs, planktonic and larger foraminiferal (Tsuchi) distributions in the Pacific Neogene provide two of the too-few pan-Pacific regional contributions within the entire book.

The Neogene marine environments, evolution and events, within an area as immense as the Pacific, are naturally complex, and it would take a book many times the size of this one to tackle the subject comprehensively. Unfortunately, only a few of the papers are truly regional in scope; the other papers could reside quite appropriately in specialist journals where their Pacific Neogene aspect would have been accessed through any of the numerous referencing techniques currently available (Gasperi and Kennett have recently republished their results in *Marine Micropalaeontology*, vol. 33, no. 3, October, 1993). The book is, nevertheless, a valuable reference for geologists concerned with the Neogene history of the Pacific. The four 'time-space' charts, presented as Appendix 2, display climatic, palaeo-oceanographic, biotic, palaeobiogeographic, tectonic and other

events for the interval between the late Oligocene and early Pleistocene in the four geographic quadrants of the Pacific. Appendix 2 places the contributions of the various authors in context, and is so vital to the overall success of the aim of the book, that it should have been promoted to a position at the front.□

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Quaternary of the Thames

D R Bridgland

Chapman and Hall, 1994. 441 pp., hardback, UK£79.00. ISBN 0-412-48830-2

The River Thames has an important place in British Quaternary science. It has left an extensive suite of terrace gravels that record a depositional history dating back to the early Pleistocene. The geographical distribution of these deposits shows that both the extent of the catchment, and the course of the river and its tributaries have changed considerably during the Quaternary. In the early Pleistocene, the headwaters may have lain in the English Midlands or in Wales, and the river entered the North Sea in East Anglia. The modern course of the Lower Thames through London was established following blockage of its earlier route by ice and glacial debris during the Anglian glaciation. The present mouth of the Thames is of even more recent vintage, resulting from flooding of the valley during the Holocene sea-level rise.

The deposits of the Thames are primarily cold-climate gravels, typically arranged in a 'staircase' of terraces on the valley sides, recording successive periods of downcutting and aggradation. At many sites the gravels include lenses of fossiliferous 'interglacial' sediment dating from the temperate phases of the Quaternary, as well as flint artefacts recording the presence and cultural development of man. It is this combination of palaeontological and archaeological evidence, put into a chronological context by their relative positions within the terrace 'staircase' and their relationship to the Anglian glacial deposits, that make the Thames deposits so important. Indeed, they must represent the most complete Quaternary record in onshore Britain.

The Thames is without doubt the most intensely studied river in the British Isles, with researches dating back to the nineteenth century. There is a formidable literature on the deposits, which is daunting to the student or researcher. To summarise our understanding of the Thames in one volume is an heroic task, but one in which the author of 'Quaternary of the Thames' has

succeeded most admirably.

This book is the seventh volume in the Geological Conservation Review Series initiated by the UK's Nature Conservancy Council in 1977. In essence, the aim of the series is to provide a record of localities designated (or considered for designation) as Sites of Special Scientific Interest. This particular volume does very much more than this.

The opening chapter starts with a short introduction to the history of research and the classification of the Thames deposits, and a description of the history of the river throughout the Quaternary. This is followed by a discussion of the Pleistocene chronostratigraphical framework and its considerable problems, models of river terrace formation, and the succession and schemes of correlation for the Thames deposits. The later chapters discuss the succession in greater detail, on a regional basis. There are chapters on the Upper Thames, the Middle Thames, the Lower Thames, and the deposits of the early Thames in north Essex. Each of these chapters commences with a useful introductory section, before proceeding to a description of the various designated or candidate sites. Nearly 40 sites are described; these have been well chosen to demonstrate important stratigraphical relations, types of deposit, or crucial evidence for dating the Thames sequence. The discussion of each site is exhaustive. Every strand of argument in the published literature is described, and the number of references cited is awesome. To give an idea of the depth and completeness of the discussion, the account of the Swanscombe site, famous for its human skull and associated Palaeolithic implements, occupies more than 20 A4 pages of text. This treatment is far more detailed than most readers will require, but those impatient for the gist of things need only look at the brief 'Highlights' and 'Introduction' which come at the beginning of each site description, and the 'Conclusions' at the end. These, together with the clear and appropriate diagrams, quickly inform the reader of the significance of the sites, and how they fit into the overall story of the Thames.

Despite over a century of work on the Thames terraces, correlation of the deposits remains controversial. Thus, one of the most important and valuable aspects of the book is that for the first time (as far as I am aware), the author has presented a complete correlation scheme for the deposits of the entire Thames system. This is presented as clear long-profile diagrams at various points throughout the book, and as a useful summary diagram in the introductory chapter, which also includes a table putting the terrace deposits into the chronological context of the deep-sea oxygen isotope stages. The correlation favoured by the author retains one or two problems, but the majority of the difficulties inherent in previous schemes seem to have been solved, and I have little

doubt that, at last, this version is substantially correct.

Although the book does not purport to be a field-guide, it describes some of the most important Quaternary localities in southern England, and readers will wish to visit these sites. Despite the laudable intentions of the legislation behind Sites of Special Scientific Interest, it is regrettable that the public has no legal right of access to them. All the more reason, then, to give details of ownership and some indication of how one might obtain permission for access; currently, there is merely a standard paragraph in the prefatory pages, inviting one to enquire from English Nature. Certainly each site should have been provided with a reasonably detailed location map, a graphic

section of the succession displayed and a photograph showing a general view, no matter how unprepossessing it might be. This would help the reader get a feel for those localities he or she might never be able to see first-hand. My only other serious criticism concerns the scant treatment of the Holocene, which, to fully justify the title of this book, deserves considerably fuller discussion than it is given. 'Pleistocene of the Thames' would have been a much more appropriate title.

The book is printed on heavy paper, and both text and illustrations are clear. It is strongly bound between stout covers, and is generally a first-class product which is a pleasure to handle and use. But the price is high by anyone's standards, and is well out-

side the reach of the average student. This is a great pity, for this book should be standard reading in Quaternary teaching courses; I know of few better introductions to the study of river terrace deposits and to the Pleistocene succession in southern England. Perhaps the author might be persuaded to produce a summary account, minus the detail of the sites, but with more on the Holocene; it would sell well. Nevertheless, I hope this book will find its way into the libraries of teaching departments, and onto the bookshelves of all serious workers on the Quaternary. It is destined to become a standard reference for many years to come.□

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