

introduction of the theory of evolution is particularly thoughtful. The evolutionists of the 1860s "failed to recognize that human societies, by the mere fact of their being human and subject to history, needed to be treated differently from animal species". The statement is worth pondering within the structure of his essay, although unfortunately he scarcely elaborates on any particulars. But he does return to Darwin in the penultimate paragraph, to remind us that Darwin lost his religious faith at the same time as his pleasure in music and pictures and his capacity even to endure the reading of poetry. Although Clark is never explicit, there is an implication that to lose these capacities is to be less than fully human. □

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## Under the weather

A. S. Goudie

**Geomorphic Responses to Climate Change.** By William B. Bull. Oxford University Press: 1992. Pp. 326. £45, \$59.95.

In the literature of geomorphology there are some excellent syntheses, some outstanding texts, but only a few classics based on individual research. Some obvious examples of research classics spring to mind — R. A. Bagnold's *Physics of Blown Sand and Desert Dunes* (Chapman and Hall, 1941) is a timeless and durable example of the genre. Such volumes must stand the test of time, be original and scholarly, and have a significance beyond their own inevitably specialized focus. William Bull's book may well come to join their ranks. Although largely based on work in four geographical locations, its methods and results will open up broader horizons to other workers. It also has the stamp of individuality and personal endeavour.

The book is a departure from other books on climatic influences in geomorphology. Bull does not, for example, pursue the effects of long-term climatic change (that is, during the Tertiary period) in the essentially qualitative way espoused by the German school, nor does he seek to catalogue and classify the nature and origin of the 'bizarre' departures from the humid temperate norm in the way that many French and Anglo-American treatments have tended to. Common terms in the book are

'geomorphic thresholds', 'feedback mechanisms' and 'response times to perturbations'. Bull examines the effects of climatic change on fluvial systems over the past 20,000 to 40,000 years in areas that have a range of current mean annual precipitation from 30 to more than 2,000 millimetres. These areas are in Egypt, Israel, the western United States and New Zealand. Some are monolithologic, others multilithologic.

There are some themes and subjects that recur: the importance of weathering and soil formation as a source and store of debris in systems; the variability of varnish and weathering rind formation under different climatic conditions; the processes by which streams depart from equilibrium and initiate processes that lead to the creation of stream terraces; the function of bedload size and quantity in favouring aggradation; changes in basin plant communities in response to climatic change and their impact on sediment mobility; differences in the timing and number of geomorphic events under different climatic regimes; and the progressive exposure of bedrock outcrops in hot deserts as a powerful self-enhancing feedback mechanism that makes some hillslopes sensitive to climatic perturbations.

The book helps us to understand the past. It may also help us to understand the future, for, as Bull himself writes, "Lessons from histories of landscape change provide insight into future impacts of natural or human-induced climatic change on storm patterns, flood frequency, landslides, stability of valley floors, and agricultural productivity". □

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## Magnetograph

Michael Fuller

**Paleomagnetism: Magnetic Domains to Geologic Terranes.** By Robert F. Butler. Blackwell Scientific: 1992. Pp. 319. £29.50, \$44.95.

ROBERT Butler's aim of showing how palaeomagnetism works is certainly fulfilled by this excellent book, which provides an introduction to the fundamental principles of the subject with plenty of examples of practical applications to tectonics and geochronology.

As with all authors of books on palaeomagnetism, Butler faces the difficulty of deciding how much background to include on the geomagnetic field and rock magnetism. Some basic magnetism

and the geomagnetic field are covered, and there is a very useful appendix on units in magnetism. An admirable balance is struck between keeping the discussion short enough to be practical and covering rock magnetism in some detail. The physics and chemistry of rock magnetism are complicated and to describe them well is not easy.

Butler discusses the various magnetic energy terms, domain states and magnetization processes, and provides a particularly skilful exposition of Néel theory. I would like to have seen some recognition of the importance of domain nucleation in the magnetization of fine particles, but perhaps that is precisely the sort of detail one cannot cover in an introductory work. Nevertheless, Butler covers the important aspects clearly, providing a sound basis for the later discussion of palaeomagnetism.

The section on the nuts and bolts of palaeomagnetic technique is first class. This is the most practical discussion of palaeomagnetism I have seen. Like A. Cox and B.-R. Hart's *Plate Tectonics, How it Works* (Blackwell Scientific, 1986), it succeeds by taking the reader through the procedures in detail. Butler is well versed in the techniques of measurements and analysis and gives an even coverage of both areas.

The rest of the book covers special topics in rock magnetism and applications of palaeomagnetism. The examples described are all of considerable interest and give a good impression of the contribution of palaeomagnetism to the earth sciences. But I missed any mention of the applications of palaeomagnetism to establishing secular variation and transition fields during reversals, in which palaeomagnetic techniques are pushed to the limit. For this reason alone the applications are of particular interest, but they may also be a key to understanding the geodynamo.

Useful derivations are given in an appendix. Here, as elsewhere, the explicit use of rotation matrices is avoided in favour of the formulae of spherical trigonometry, with all the attendant problems of employing the correct quadrants and signs. This is a pity, as rotation matrices are now familiar to most earth scientists from their use in plate tectonics. A great virtue of this book is that Butler's workmanlike discussion of palaeomagnetism in terms of basic physics and chemistry removes any last vestige of an excuse for treatment of the subject as a black art or form of magic — a regrettable attitude of too many otherwise sensible Earth scientists. □

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