Hammering out the meaning of strata

Derek Ager

Great Geological Controversies.
By A. Hallam.
Oxford University Press: 1983. Pp.182. Hbk £15, $35; pbk £7.95, $14.95.

POLITICIANS often complain that the media only see politics as a matter of fights between personalities, but nothing attracts public attention more than a good hard-hitting row. The same is true of science, especially an inexact one such as geology. Certainly one of the best ways to establish one's name in the subject is to be engaged in a hearty controversy. For all the great work done by Sedgwick and Murchison on the Cambrian and Silurian Systems respectively, nothing is so much remembered as their battle over the boundary between them. Do we not perhaps spend too much time on the disputes?

Tony Hallam's latest book is a learned and thorough discussion of several of the most famous geological controversies, at least in Britain. So he takes us through five "case histories": neptunism — vulcanism, catastrophism — uniformitarians, the Ice Age, the age of the earth and continental drift. He finishes with "general considerations" and an excursion into the philosphy of science. Hallam is unfortunate in that the publication of his book coincides with that on *Geology in the Nineteenth Century* (Cornell University Press) by M.T. Greene. Both books cover much the same ground, but in surprisingly different ways. Thus Green is much more preoccupied with the arguments on the European continent on the mode of formation of the Alps, which is hardly mentioned here.

Hallam divides the geological world into the arm-wavers and the nit-pickers: the great generalizers who stand on mountain tops (at least in spirit) and wave their arms about and those who keep their noses and their hammers close to the rocks. The former naturally get the glory and appear in books such as this, but it is the latter who do all the work and whose observations must ultimately be explained. That is why I prefer the views of Cuvier, who recorded what really happened bed by bed in the Tertiary rocks of the Paris Basin to those of Lyell who did not really look at strata in detail at all. Yet it was the latter who, in his day, triumphed and established for himself the status of the great thinker and synthesizer of geology, whilst the former was derided for his extremism.

It is noteworthy in this connection that Hallam proudly claims Cambridge as the leading centre of things geological in the years leading up to plate tectonics. This is true if one only thinks of the geophysical side of Cambridge (before the three departments there merged). But the Geology Department at Cambridge was at that time still plodding away with the meticulous description of Lower Palaeozoic stratigraphy, as it had been for 150 years before.

Similarly, it is worth noting, as Hallam does, that "the prime goal of the founders of the Geological Society [of London] in 1807 was to eschew argument and speculation [as was then going on so actively in Edinburgh] in favour of sober fact-finding". This is not to decry the desirability for grand theorizing but it reminds us that we also need the careful, and many would say the only, real geology.

One theme that emerges clearly from this book is the nationalism of geological controversy. I well remember teaching continental drift to graduate classes in America in the late fifties. They were sceptical, as Hallam indicates was the general atmosphere in the US at that time, but they were not beyond persuasion even before plate tectonics. I think this illustrates the point that in many of these controversies, national, social and political factors played a big part in the scientific attitudes adopted in different countries. It will surprise many prejudiced people, no doubt to read Hallam's assertion that supposedly autocratic and dogmatic German academia was more amenable to new ideas than most other countries. Certainly Protestant Britain went through far more agonies over the Noachian deluge (and later over evolution) than did her Catholic contemporaries. Also our monarchic, aristocratic background increased our fears of revolutionary ideas, both political and scientific, from the continent.

Apart from his fondness for words such as heuristic, Hallam's book is very easy to read. It may follow well-travelled paths, but it does so with a remarkable broad knowledge of the literature. It is full of lengthy but very relevant quotations. One may quibble at times (I wonder, for example, at what Norwegians would think of his statement that Switzerland is the only European country with substantial mountain glaciers) but essentially it is reasonable and well-argued. It presents a careful examination of contrasting views rather than the over-simplified versions we usually find in the literature. Certainly it fully respects the many truths contained within the apparently diametrically opposed opinions. □

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A life of classical physics

John J. Roche

Ludwig Boltzmann. Man. Physicist. Philosopher.
By Engelbert Broda.
(translated by L. Gay and the author)
Ox Bow Press: 1983. Pp.169. $22.50.

THIS brief biography of Boltzmann was a delight to review because of its captivating style, and because of the mirth it frequently provoked. Professor Broda is a professional scientist well known for his writings on the history and philosophy of science. His text, which is a revised translation of a German text first published in 1955, is written in a relaxed and good-humoured manner and conducts us on a brief and somewhat personal survey of the life and times of Boltzmann.

Boltzmann is his hero, "one of the greatest thinkers of all nations and all times". Broda does, nevertheless, engage in a gentle and oblique criticism, which is quite penetrating and revealing. He has gathered together a fascinating collection of vignettes of Boltzmann, culled from friends, family and colleagues. A valuable aspect of this biography is that Boltzmann is largely allowed to speak for himself through a wide selection of well-translated passages. A portrait emerges of a very attractive and sensitive man, a keen pianist, rather unworldly, someone who enjoyed the theatre, liked to travel, and had a considerable penchant for doggerel. Boltzmann was an excellent and humorous teacher, and most of his published books emerged from his teaching. In the 1890s Boltzmann was drawn into a heated and protracted controversy over the positivist opposition to the atomic theory which cast a shadow over his life's work.

Briefly, Boltzmann was born in 1844 in Vienna into a comfortable middle class Austrian family. He studied physics at the University of Vienna, where he received his doctorate in 1866. He worked at different times with Stefan, Loschmidt, Bunsen, Kirchhoff and Helmholtz. He spent six years at various German universities, but the rest of his academic appointments were in Austria. He does not appear to have enjoyed Prussian severity. Boltzmann married Henrietta von Aigentler in 1876, who bore him four children. He committed suicide during an attack of depression while on a summer vacation near Trieste in 1906.

Boltzmann was essentially a late nineteenth century classical physicist. Although he was witness to the birth of a new physics, he virtually ignored it. Boltzmann's work in physics was dominated by a commitment to mechanism and to atomism. In common with a great many physicists of the nineteenth century he combined the skills of an experimentalist with those of a mathematical physicist.

Boltzmann's best known contributions to physics lie in the realm of the kinetic theory of gases and in statistical thermodynamics, which occupied him for forty years. He extended the work of Maxwell and others, generalizing the analysis of the distribution of energy among atoms and molecules. Using similar methods he also generalized the analysis of transport

Ludwig Boltzmann, as drawn by his student Karl Przibran, later Professor of Experimental Physics at Vienna University.

phenomena in non-equilibrium systems, arriving at the famous Boltzmann transport equation. His greatest achievement lay in the discovery of a functional law which related thermodynamic entropy to the statistical distribution of an ensemble of molecules. This law, which was written by Planck in the form $S = k \log W$, is inscribed on Boltzmann's tombstone. Boltzmann also extended the mathematical analysis of entropy to non-equilibrium states which are not covered by the thermodynamic definition. His experimental work included the study of dieletrics and of diamagnetism.

In the late nineteenth century many physicists became impatient with the penetration of metaphysical concepts into physics, and with the din of competing theories in electromagnetism and in thermodynamics. There were two distinguishable responses to this predicament, positivism, led by Ernst Mach, and conventionalism, led by Boltzmann. Positivism dismissed hypotheses of all sorts, metaphysical and physical, as harmful, or as mere mnemonics at best and wished to reduce the laws of physics to a summary of observation-statement.

Largely because of the fierce positivist opposition to the atomic theory, Boltzmann was forced to articulate an alternative epistemology of physics, which combined the ancient mathematical device of 'saving the appearances' with a dash of Kantian idealism. According to Boltzmann, hypotheses are indeed useful but not as candidates for physical 'reality', as we have no access to such reality, but rather as convenient pictures which stimulate and guide research and which can be made increasingly self-consistent. In this manner, at one stroke, Boltzmann undermined the pretensions of metaphysics and of theorists, an defended his right to an atomic 'picture'.

Positivism and conventionalism have competed for the minds if not the hearts of physicists ever since. Conventionalism, for example, is behind the reduction of force, momentum and the electromagnetic field intensities to mathematical constructs, and behind the reduction of Newton's laws to definitions.

It is also responsible for the contemporary preference for using the term 'model' rather than 'theory'. There were many other sides to Boltzmann's philosophy, of course. He was an ardent Darwinian, for example.

Broda laments Boltzmann's lapses of literary style. Indeed, Boltzmann's historical errors, confusing Roger Bacon with Francis Bacon, for example; his description of the Greeks as 'naive' and his definition of metaphysics as 'mental migraine' heralded, perhaps, a decay of style in physics. Faraday, Maxwell or Helmholtz would not have committed such solecisms.

Broda's analysis of Boltzmann's science and philosophy does not represent exacting scholarship, and the translation has peculiarities such as "atomistics" and the "obligate increase in entrophy". The non-specialist, however, will find this a good and informative read. □

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Intelligent steps

Simon Lavington

Towards Fifth-Generation Computers.
By G.L. Simons.
National Computing Centre: 1983.
Pp.225. £10.50, $18.10.

The Fifth Generation:
Artificial Intelligence and Japan's Computer Challenge to the World.
By Edward A. Feigenbaum and Pamela McCorduck.
Addison Wesley/Michael Joseph: 1983.
Pp.288. $15.55, £9.95.

FEW TOPICS in computing excite so much emotion as Artificial Intelligence. Since anyone possessing a brain — artificial or not — is entitled to join the debate, the task of disentangling fantasy from reality is not easy. The dream of artificial intelligence has been with us from the early days of computers, with several respected pioneers expressing the cautious hope that machines would one day exhibit intelligent behaviour. The reality has yet to appear.

Artificial intelligence research concentrated for many years on identifying and reproducing basic mechanisms of learning and problem-solving: laudable aims, but difficult to achieve with the primitive computing tools available and the fragmented nature of the research effort. General theories were slow to evolve, and the few demonstrations of problem-solving to emerge from computer science laboratories hardly seemed relevant to real-life applications.

A shift of emphasis took place in the 1970s, when some of the general techniques of reasoning, notably inference mechanisms, were applied to collections of specific knowledge. The aim was to make the computer appear as an expert assistant. Predigested knowledge, in the form of rules and facts about, say, respiratory diseases, was embedded in a friendly question-answering framework and the so-called Expert System was born. Here at last was a money-making product which hard-nosed industrialists could appreciate. More importantly, there arose the conviction amongst a small but growing band of computer users that information systems could be made 'smart': that dumb database systems could one day be replaced by intelligent knowledge-based systems.

This vision of intelligent knowledge-based systems has not only become the acceptable face of artificial intelligence; it is seen by many as the essential ingredient of future computers. Nowhere is this more firmly believed than in Japan. The Japanese, casting around in 1979 for a policy for long-term economic survival, launched an investigation into the most likely trends for the next generation of computers. The resulting report described their image of the 'fifth generation' computer, and stressed the importance of three functions: problem-solving and inference-making, knowledge-base management, and intelligent interfaces. Soon the 'fifth generation' had become a peg on which anyone felt free to hang opinions and prejudices, hopes and fears, about every aspect of future computer hardware and software.

Although many strands of research were naturally assumed to contribute to the fifth generation, Japan's uncompromising inclusion of artificial intelligence provoked the most comment. The debate then moved smartly out of academia when the huge scale of Japanese investment in fifth generation research became apparent. In the UK, the Alvey Report and its recommended £350 million for information technology research is a direct response to the perceived Japanese challenge. Likewise, the books by Feigenbaum and McCorduck and by Simons take