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Preface to Astronomical (Milankovitch) calibration of the geological time –scale. A Discussion Meeting held at the Royal Society on 9 and 10 December 1998

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Preface

Milutin Milankovitch (1879–1958) is generally recognized as the father of the astronomical theory of the ice ages in its modern form (for his life, see Milanković 1995). It is worth remembering that his theory was not held in high regard at the time of his death. The most authoritative text of the time (Flint 1956) dismissed it more or less totally, citing only one author (Zeuner 1952) in its favour, and 'several astronomers, meteorologists and geologists' against. It was well known that Zeuner was the only significant supporter of the Milankovitch theory in the UK, and the hypothesis only gained widespread acceptance after the publication of a paper by Hays *et al*. (1976), which documented evidence in a marine sequence for Milankovitch pacing of climate. This paper also pointed the way to establishing an accurate time-scale for the ice ages by mapping the history of global ice volume—obtained by the oxygen isotopic analysis of foraminiferal calcite from deep sea sediment cores—onto a template constructed from the Milankovitch model.

The recognition of astronomically related cyclicity in sediments from before the Quaternary ice ages had a history to some extent independent of Milankovitch's theory for the ice ages. A century ago G. K. Gilbert observed rhythmic sedimentary alternations which he interpreted as being related to precessional forcing, and which he viewed as providing a measure of geological time (Gilbert 1895). At the time of Milankovitch's death, pioneering work on the statistical evaluation of analogous cyclicity was being carried out by Schwarzacher (1954, 1964). In this sense, the title of the present issue might be misleading; the use of orbitally controlled cyclicity to measure the passage of distant geological time does not require a belief that Milankovitch cycles are the sole pacemaker for the Quaternary ice ages. At the same time, it is undoubtedly the case that Milankovitch was the true pioneer in providing a basis for the modelling of the climatic response to orbital forcing, both during and before the ice ages.

A belief that a concerted effort should now be made to use astronomical cyclicity to calibrate a substantial portion of geological time, in terms of absolute age on an astronomical calendar, was the driving force behind the organization of this meeting. The contributors to this volume cover all the main scientific components that will be needed in order to achieve this objective; the Meeting on 9–10 December 1998 attracted many other workers active in this area, generating very valuable discussion.

The papers in this issue speak for themselves; one significant additional point to which we would draw attention arose during the day following the Discussion Meeting. As Laskar (this issue) points out, despite the fact that a purely mathematical solution to the orbital calculations is intrinsically limited to a maximum extension into the past of *ca.* 30 Ma, some of the long-period frequencies that may be found in geological records are stable or calculable over much longer intervals. The 406 ka eccentricity cycle is particularly interesting in this respect, and indeed it seems realistic to propose the establishment of a stratigraphic scheme based on this cycle.

An extended, astronomically calibrated geological time-scale will open the door to a spectacular range of scientific rewards. A better understanding of a wide range of climatic, geophysical and evolutionary processes and mechanisms will be possible.

We believe that the calibration of at least the past 100 Ma is feasible over the next few years.

We are extremely grateful to the Royal Society for sponsoring and hosting this Meeting; in thanking our contributors we recognize that they all share our appreciation of the special opportunity that the support of the Royal Society and its excellent staff provided.

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