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Preface

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The modern scientific study of the magnetic field of the Earth, most notably by Gilbert, began abruptly in the late 16th century because of its importance for navigation. It soon became clear that the geomagnetic field changed slowly over time, the secular variation, which prompted Halley in the early 18th century to propose a mobile interior. The liquid iron outer core and solid inner core were discovered by seismology early in the 20th century, and the dynamo theory gained acceptance: fluid motion in the outer core generates the magnetic field and is responsible for the secular variation. Meanwhile, David and Brunhes had discovered that some rocks were magnetized in the opposite direction to that of the Earth's present magnetic field, now known to be a result of past complete reversals of polarity of the geomagnetic field. However, both dynamo theory and palaeomagnetism have been painfully slow to develop, each taking most of the 20th century. Dynamo theory is inherently complicated—very few simple models generate their own magnetic field—and realistic simulations had to await the advent of very large supercomputers. Inferring the past magnetic field from magnetized rocks and artefacts has also proved extraordinarily tricky. Polarity reversals were not accepted by the wider geophysical community until the 1960s and the development of plate tectonic theory, and even now estimates of the field's strength are rare and sometimes unreliable.

The Discussion Meeting on which this issue is based was prompted by rapid recent developments in both theory and observation. Large scale numerical simulations of the geodynamo, developed by G. A. Glatzmaier and others, have provided the first three dimensional models for comparison with observation. Parallel advances with 2.5-dimensional simulations by C. A. Jones and others have provided important support in elucidating the physical mechanisms underlying these dynamo models. Meanwhile, palaeomagnetism has advanced to the stage of returning detailed records of the geomagnetic field in transition from one polarity to the other, and of the sometimes extreme variations in the last 100 000 years. Several authors have shown how it is now possible to obtain reliable, continuous records from sediments. These new data demonstrate that the geodynamo fluctuates rapidly and appears to be unstable on a geologically short time-scale. Furthermore, there are hints that the solid, rocky mantle controls the geomagnetic field to some extent, through its influence on the outer boundary of the liquid core.

These recent advances provide the forum for a discussion between theorists and observationalists. In this issue, the theory is reviewed by Jones. He pulls no punches: current models are still nowhere near the true parameters for the Earth's core, the main problem being the low fluid viscosity, which Zhang & Gubbins suggest may produce the instability responsible for excursions, rapid falls in intensity followed by wayward geomagnetic directions. Sarson explains how a 2.5-dimensional dynamo model reverses, and Hide returns to the Faraday disc dynamo to discuss superchrons, long intervals when the Earth had no reversals. Observational papers cover the full range of current research: Jackson *et al*. report on the remarkable rediscovery of many 'lost' magnetic measurements in European archives from the 17th to the 19th century; Constable *et al*. have researched archaeomagnetic and lake sediment data from the prehistoric period; Laj *et al*. give a new record of palaeointensity variations with millennial scale resolution for the last 75 000 years, including an excursion, from North Atlantic sediments; Channell & Kleiven describe geomagnetic behaviour near polarity transitions; and Clement assesses the fidelity of transition records. Selkin & Tauxe give new results for the intensity over the last 30 million years; they call into question most previous intensity measurements and come to the remarkable conclusion that the present field is considerably stronger than its long-term average. The magnetic measurements are only half of the story: accurate dating is equally important and dating errors have prevented the identification of excursions worldwide until recently. Frank gives a fascinating account of how radiocarbon dates link with geomagnetic intensity through the field's influence on the incoming cosmic radiation. The new face of geomagnetism is represented in the interpretational papers. Roberts & Glatzmaier and Kono *et al*. explore secular variation generated by their dynamo models; Coe *et al*. examine a reversal from a dynamo simulation; and Bloxham discusses the very long-term effects of changing boundary conditions resulting from mantle convection. Hoffman and Love give, respectively, analyses of reversal transition and secular variation palaeomagnetic data in the full light of modern theory.

We hope this issue provides not only a collection of current research papers, but also the flavour and excitement of current geomagnetic research.

D. Gubbins
D. V. Kent
C. Laj

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