

The Earth Inside and Out:  
Some Major Contributions to Geology  
in the Twentieth Century

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The Earth Inside and Out:  
Some Major Contributions to Geology  
in the Twentieth Century

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## Preface

The essays in this volume have developed from the proceedings of Section 27 of the International Geological Congress, held at Rio de Janeiro in August 2000. At that meeting – with a view to the arrival of the end of the second millennium – a symposium was held on ‘Major Contributions to Geology in the Twentieth Century’, organized by Dr Silvia Figueirôa, Professor Hugh Torrens, and myself, in our capacity as Members of the IUGS’s International Commission on the History of Geological Sciences (INHIGEO), which was responsible for organizing the symposium.

Established in 1967, INHIGEO has about 170 Members representing 37 countries. Its role is to promote studies on the history of geological sciences and stimulate and coordinate the activities of national and regional organizations having the same purpose. It seeks to bring together, or facilitate communication between, persons working on the history of the geosciences worldwide. To this end, it holds annual conferences in different countries, and its *Proceedings* appear in various forms, according to the publication opportunities that may be available.

It was, then, with pleasure that INHIGEO received an invitation from The Geological Society to offer its papers from the Rio meeting as one of the Society’s Special Publications. Evidently, the time was ripe for a retrospective look at some of the major 20th-century contributions to geology. The present volume follows three other recent Special Publications dealing with historical matters: Blundell & Scott (1998), Craig & Hull (1999), and Lewis & Knell (2001).

The Rio symposium had eight invited papers, and, by invitation, the number has been increased to fourteen, thereby adding to the international character of the present publication as well as the number of papers.

I am most grateful to all those who have contributed to the present collection, to the referees, and to Martyn Stoker for overseeing the volume.

**David Oldroyd**

## References

- BLUNDELL, D. J. & SCOTT, A. C. (eds). 1998. *Lyell: The Past is the Key to the Present*. Geological Society, London, Special Publications, **143**.
- CRAIG, G. Y. & HULL, J. H. (eds). 1999. *James Hutton – Present and Future*. Geological Society, London, Special Publications, **150**.
- LEWIS, C. L. E. & KNELL, S. (eds). 2001. *The Age of the Earth: 4004 BC–AD 2002*. Geological Society, London, Special Publications, **190**.