1. Introduction

Since the foundation of the Bureau of Mineral Resources in 1948, and through its successors the Australian Geological Survey Organisation and Geoscience Australia, a major effort has been made to assemble continent-wide datasets across Australia. Much of the work has been put into collecting potential field data, notably for gravity and magnetic anomalies, and also a variety of airborne information, including radiometry and airborne electromagnetics. In recent years, the State and Territory Geological Surveys have collected much of the field data, and the continent-wide synthesis has been carried out by Geoscience Australia, with careful stitching together of data grids with very different resolutions.

In addition to the potential field data, a range of seismological information has been assembled for the Australian continent. A number of major seismic refraction experiments were carried out from the 1960s to the 1980s, and these provide an important control on seismic wavespeeds across the continent. There has been little such work since, except for some offshore/onshore experiments mostly in Western Australia. Reflection studies of the whole crust have grown from short experimental spreads in the 1960s to large-scale transects. By the end of 2015, over 16,000 km of reflection profiles with full crustal penetration had been collected (Kennett et al., 2016). The regional earthquake belts to the north and east of Australia, as well as more distant events, have been exploited for passive seismic studies with extensive coverage of the continent using portable seismic instruments. A wide range of techniques have been employed to gain a good representation of the variations of seismic wavespeeds in the crust and mantle components of the lithosphere in the AuSREM model (Kennett and Salmon, 2012).

For the International Geological Congress held in Brisbane, Australia in 2012, a major volume, *Shaping a Nation: a Geology of Australia* (Blewett, 2012), was prepared. In this work and its electronic appendices can be found a wealth of information about the continent with a geological emphasis. In the current book we draw on the latest results for many different types of geophysical measurements, and aim to present a wide range of material in a common format to provide a uniform perspective and synthesis at the continental scale.

The original datasets have been assembled at different resolutions, which makes comparisons difficult. We have therefore endeavoured to present the results for the entire Australian continent in forms that provide a common basis for presentation and comparison.

For the larger datasets, such as topography and the potential fields, we have used a spectral stabilisation approach (Chopping and Kennett, 2015) to place all the different datasets on a common geographical grid with 1.2 km spacing. This approach is described in detail in the Appendix. Using this procedure we are able to represent diverse fields with a common basis of 4096 x 4096 points that is both practical for plotting, and very suitable for spectral manipulation. In consequence, we are able to construct and display a variety of useful secondary fields to aid in cross-comparisons between different geophysical properties. We are also in a position to examine the interrelations between different fields by exploiting spectral relationships.

For seismological results and other datasets acquired on a much sparser grid, we use plotting grids with a constant spacing of 0.125º, or 0.5º where that is the resolution of the original product.

Images have been developed using a number of different classes of software, but all have been brought into the same format with a common framing. Each of the continental-scale geophysical figures uses the same geographic projection for the Australian continent:

> Lambert conformal equal-area with reference latitudes of 18ºS and 36ºS, and reference meridian 135ºE

As far as possible, the different classes of geophysical images are plotted at fixed scales, so that direct comparisons can be made between different fields. In all maps a 500 km scale bar is included. For each class of geophysical data, a common scale large image is provided. Discussions of relations to geological features are illustrated with images using overlays of geological provinces or major crustal boundaries, which are often at a smaller scale.

The Australian continent is unique as it is the only single nation continent. This has facilitated the collection of the suite of geophysical data across the entire continent that is presented in this work. This extensive data suite enables us to gain some perspective on the relationship between the deep and surface features of the continent.

Although the work is focused on Australia, we hope that the insights it provides into the character of a continent and how continental structures are built up over time will be of value those working beyond Australian shores.

Structure of the Book

In Chapter 2 we provide an overview of the continental setting of Australia. We start with the physiographic and plate tectonic environment, and then present the surface geology. We also summarise information on Crustal Age and the distribution of sedimentary basins.

Nearly all of the surface area of Australia has been covered using airborne radiometry. Considerable efforts have been made to bring the multifold surveys into a common framework and these results form the basis of Chapter 3, where we present ternary radiometric images and specific results for the distribution of potassium (K), thorium (Th) and uranium (U).

Chapter 4 is devoted to magnetic studies based on the extensive collection of aeromagnetic data. Magnetic anomalies are presented in various ways and we also discuss the character of magnetisation and its relation to Curie depth. The other main potential field, gravity, is covered in Chapter 5, with discussion of both the absolute gravity field and the anomaly patterns (both Bouguer and free-air).

Chapter 6 introduces the earthquake distribution across Australia and the considerable neotectonic activity within what is commonly regarded as very stable continent. We also summarise the available information on the current stress field. The next two chapters are linked in theme and describe what has been learnt from seismological studies about the structure beneath Australia from crustal studies (Chapter 7) and work on the lithospheric mantle (Chapter 8). Chapter 9 describes the 3-D density structure beneath the continent derived by inversion of gravity observations, both at the surface and from satellites.

Chapter 10 presents a continent-wide model for electrical conductivity structure derived from geomagnetic measurements. Extensive deployments are progressively covering the continent with a dense network of magnetotelluric stations in the AUSLAMP project, but this has yet to reach the stage of an improved continental-scale conductivity model. Chapter 11 presents information about the thermal state of the continent inferred from the temperature distribution in boreholes, and efforts to exploit other geological and geophysical information to counter the patchy distribution of direct sampling.

The next two chapters build on the full suite of geophysical data presented in Chapters 3–11:

In Chapter 12 we consider the relationships between the different fields, notably the relations between gravity and magnetics, and gravity and topography. we introduce a number of ancillary fields that have the merit of enhancing trends in the geographic distribution. Use is made of binary and ternary colour images to enhance the visual impact of the relations between fields. The relation between the depth to base of magnetisation and temperature is also discussed. The chapter concludes with estimates of the thermal and compositional state of the lithospheric mantle derived from the combination of gravity data and 3-D seismic models.

In Chapter 13 we look at the relationships between the distribution of known resources across the Australian continent and the nature of the various geophysical fields. The results highlight some interesting relations between composite field attributes and resource distribution that may be of value in assessing future resource potential.

Chapter 14 presents the exploitation of the radiometric map of Australia to develop a measure of the local weathering intensity across the continent. This information is then integrated with a broad range of other topographic and geophysical information to extend the limited direct information on regolith depth to a model for the full continent.

Many of the datasets we present are available in the Geoscience Australia Common Earth Model, and can be visualised in three dimensions with the EarthSci Viewer freeware system from www.ga.gov.au.

Such visualisation can go well beyond what is readily presented on a simple page. As an example of what can be achieved, Figure 1.1 shows the surface geology of Australia draped over land and marine topography.

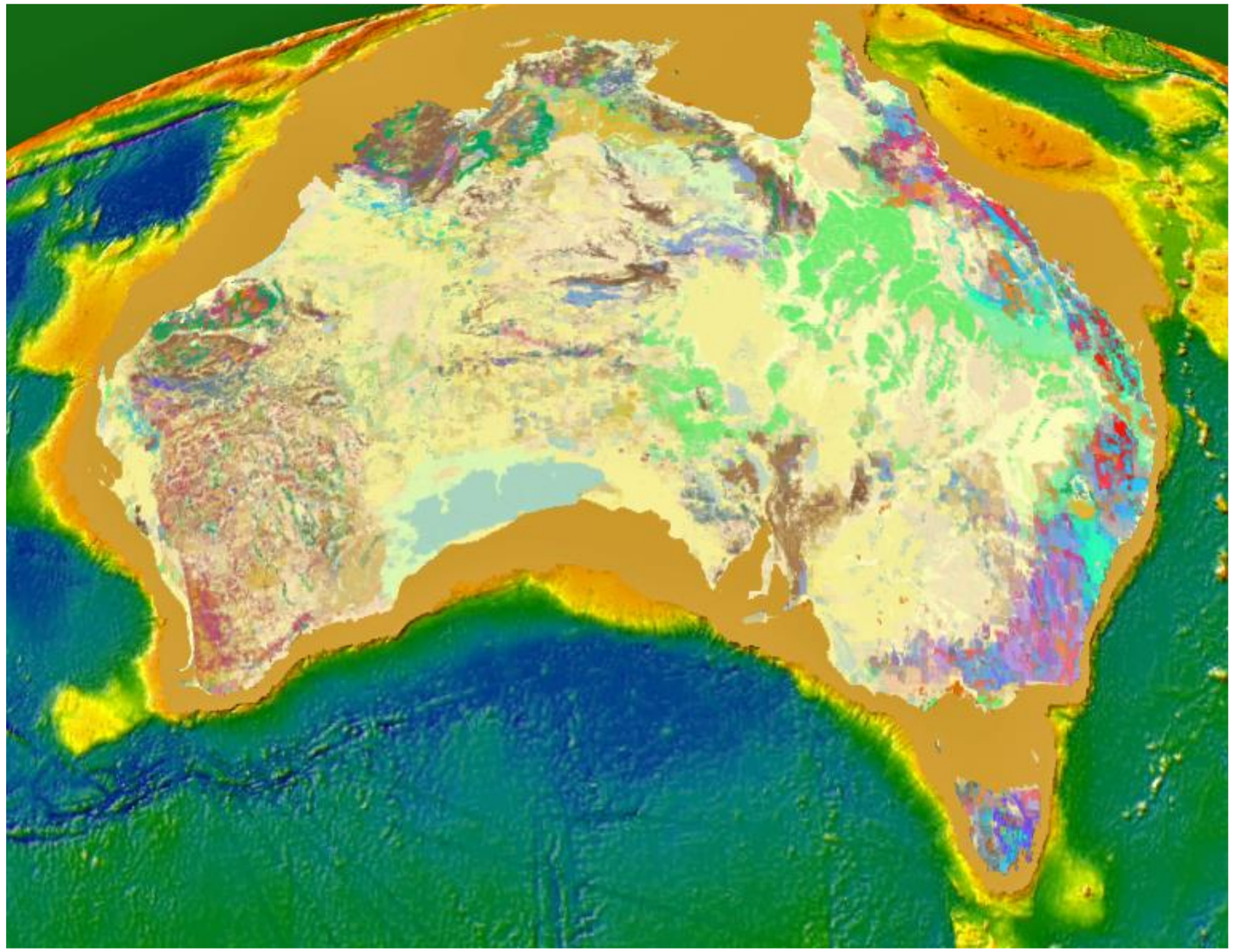

Figure 1.1: The geological structure of Australia draped over land and marine topography.

Image created using the Geoscience Australia EarthSci visualisation software.