Preface

Starting with Clairaut in 1743, the theory of the earth as an equilibrium figure had, for two centuries, been considered one of the best ways to determine the earth's flattening. During that time, the theory of equilibrium figures had always been an essential part of physical geodesy.

This situation changed only in the last decades, for two reasons:

1. The artificial satellites provided a direct and extremely accurate determination of the flattening, which did not presuppose hydrostatic equilibrium; the satellite results even seemed to contradict the hypothesis of the earth's being in hydrostatic equilibrium.

2. The extremely important and influential theory of Molodensky postulated that geodesy be restricted to the earth's surface and its external gravitational field; the internal earth's structure, including the internal gravity field, should be left to geophysics.

Now we witness a change in the opposite direction. The formerly neat boundary between geodesy and geophysics begins to dissolve for various reasons: geodetic measurements are essential for plate tectonics, earth rotation and earth tides; the theory of rotation and tides, which presuppose an equilibrium figure as a reference, is left to geodesists, and generally, geodynamics requires a close interaction between geodesy and geophysics. This turn of the tide is also shown by the remarkable book (Lambeck, 1988), which is almost exactly complementary to the present monograph.

The Geodetic Reference System 1980 uses an equipotential ellipsoid as a reference surface; thus the question of suitable mass distributions for such an ellipsoid arises naturally. Similarly, recent excellent global models for the earth's irregular gravity field, as determined by a combination of satellite data and terrestrial gravimetry, call for the search for mass anomalies that produce these irregularities: this is the gravitational inverse problem.

Finally isostasy, a stronghold of physical geodesy until the advent of artificial satellites, has become indispensable now as a tool for removing trend in methods such as least-squares collocation. New developments in isostasy, especially inverse problems, promise to make isostasy again an important tool for a geophysical study of the lithosphere.

This roughly delineates the content and the intent of the present book. Whereas the author's book "Advanced Physical Geodesy" (1980) treated physical geodesy essentially in the spirit of Molodensky, the present book is on what may be called "non–Molodenskian geodesy". This expression is by no means derogatory: the fact that there is a non–Euclidean geometry speaks for the greatness of Euclid, and one of the first "Non–Molodenskians" was M.S. Molodensky himself when he studied earth rotation around 1960 ...

This is expressed by the somewhat provocative subtitle "Theoretical Geodesy and the Earth's Interior", whereas the title "The Figure of the Earth" is to indicate that the book tries to continue a great geodetic tradition, starting with Clairaut, which always maintained that the gravity field, external and internal, and its source, the density distribution inside the earth, are inseparably interrelated.

The character of the book is theoretical: emphasis is on physical concepts and their mathematical treatment rather than on computational methods and results. It has the didactic style, and the selection of material, of a textbook: it has no pretension whatsoever to encyclopedic completeness. We have attempted a detailed and rather slow-paced treatment, sometimes at the cost of repetitions and wordiness, and sometimes regarding the same subject from different points of view.

The style of the book is also meant to show to the reader how in fact scientific thinking works: it is not always strictly deductive but frequently uses ideas from other fields and reasoning by analogy. Motivations and heuristic arguments have been considered essential elements of the presentation. It is an open-ended book also in the sense that it presents not only solutions but also indicates open problems for future research.

It is intended that the book leads the reader up to current research topics and facilitates reading the vast contemporary literature of which a sample is given in the list of references. This list is rather long but it is by no means complete: it reflects the limitations of the subject of the book and, above all, the limitations of its author. There is no doubt that there are important omissions, but none of them is intentional.

The book combines, in a unified treatment, classical material (Chapter 2) with work that is virtually unknown to the English-speaking community (Chapter 3 and the last section of Chapter 7), systematic derivation of results available only in very condensed articles (e.g., Chapter 4), work that the author has previously published only in report form (Chapters 5 and 6 and sec. 8.2) and perhaps also some material published for the first time in this book such as sec. 4.3 and sec. 8.3.2 and a simple approach to a convergence problem that has intrigued mathematicians (sec. 4.1.5).

The book is intended for graduate students and researchers in geodesy, geophysics, and astronomy. Little beyond a general science and mathematics background is required, although a basic knowledge of elementary physical geodesy will be helpful.

The nucleus of the book was a special course given to members of the geodetic staff at the Technical University at Graz in summer 1988. The author's own research incorporated in the book has been possible only through his long-time cooperation with The Ohio State University, which is gratefully acknowledged.

The book was reproduced from a LaTeX script carefully prepared by Ruth Hödl, and the figures were drawn by Konrad Rautz using AutoCAD. Valuable help such as proofreading, correction of mistakes and suggestions for improvement, was also provided by Gerhard Kraiger, Norbert Kühtreiber and Herbert Lichtenegger. The author wishes to express his thanks to all who have contributed to the book.

Graz, March 1990

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