Static Corrections for Seismic Reflection Surveys

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Raypaths for surface- and datum-referenced processing
Static Corrections for Seismic Reflection Surveys

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Preface

Static corrections, unlike many specialized geophysical subjects, are essential to all three key subdisciplines: data acquisition, data processing, and interpretation. An individual’s knowledge base of the topic is dictated by his or her studies and work experience. At one end of the spectrum are those who work only on marine data, where current procedures require a minimal understanding of static or residual static corrections, apart from a few key areas of the world. The other extreme involves those working in areas where in-depth knowledge is required and is of vital importance to their work. To assist these individuals, an approach used by many companies is to have a resident expert or “guru” who has acquired an extensive knowledge of the subject, usually as a result of exposure to problems from many areas of the world over many years.

The key objective of this reference book is to assemble details of the various facets of static corrections so that more geophysicists can fully appreciate them, their limitations, and how they relate to the near surface and the quality of their final seismic sections. I have included simple explanations of the underlying principles in an attempt to remove some of the mystique of static corrections. The book provides information for those who work on seismic surveys of a variety of scales, from shallow surveys to those associated with mining, oil and gas exploration, to crustal surveys in which the sedimentary section may constitute the near surface.

The basic principles have not changed over the years, although the methods that are fashionable have changed. For example, the use of refraction arrivals to compute times through the weathered layer was common practice up until the 1960s and was then reintroduced as refraction statics in the 1980s. During the 1970s, this technique was out of fashion because residual static corrections were supposed to provide much of the location-to-location time shifts previously obtained from refraction arrivals. In the field of residual static corrections, which is the fine-tuning of datum static corrections, many new algorithms have been proposed over the past 30 years, but much like deconvolution, the approaches used for decades are still in use today.

The methods and techniques used to compute datum static corrections and to analyze residual static corrections can be categorized into three groups: those currently in use, those that have become obsolete, and those considered to be research and development topics. Such divisions are likely to change during the shelf life of this book, and new methods will be developed. Some of the obsolete approaches may get a new lease on life at some future time. Consequently, I have made no attempt to weed out approaches not currently in use but rather have included the vast majority of published methods.

Geophysical surveys in the oil and gas industry are primarily conducted using seismic reflection techniques, but geophysicists working on these surveys must not be so narrowly focused that other geophysical techniques are ignored. A book on static corrections deals with the near surface, which encompasses a depth range usually associated with civil engineering, hydrogeology, and mining surveys in which a wide variety of geophysical techniques are used. Seismic reflection crews have traditionally used seismic techniques to map the near surface, in conjunction with uphole surveys in some areas, with the objective of obtaining sufficient information to compute accurate datum static corrections. However, one must consider the use of other geophysical techniques that are appropriate for specific projects, as these
form part of the geophysicist’s tool kit. Because my personal geophysical knowledge base is primarily seismic, I apologize if my summary of potential field and other nonseismic methods is incomplete.

The geophysical industry has seen rapid growth in the computer power available for seismic data processing in recent years, some of which has counteracted the increase in the number of bits recorded per kilometer or square kilometer. Geophysicists should not use this potential power to solve problems with computer intensive algorithms without sufficient quality control of the basics of data processing. It is important to ensure that the field geometry is faithfully communicated to the data processing system and that the datum static corrections and stacking velocities (equivalent to the velocity–depth model) are optimum.

Many new algorithms start off with the premise that near-surface irregularities do not exist. This is rarely the case for land surveys, and it is also likely to be an incorrect assumption for marine surveys, especially where low-velocity zones occur close to the water bottom. For example, depth migration, whether prestack or poststack, 2-D or 3-D, requires a well-defined velocity–depth model. Ideally, this should be from the surface, but for expediency, it is now generally defined from datum; static corrections are used to convert from the actual recording surface to the assumed recording from datum. I indicate that there are problems with this simplified approach and that it is likely that the velocity–depth model for migration will be generated from the surface at some point in the future. This means that datum static corrections, as they are known today, will no longer be required. Similarly, I show that in the marine environment, near-surface corrections should be corrected by a dynamic rather than a true static solution.

In both of these specific examples, there will continue to be a need to define near-surface layers, and their refinement will probably continue to be with residual static corrections. Hence, the title of this book may be inappropriate at some point in the future. However, all that disappears is the actual computation of datum static corrections; all other aspects of the book should remain relevant.

Throughout the book, there are several topics that are discussed in more than one location. Rather than simply referring the reader to another chapter, I have generally referred the reader to the detailed description and have also included a summary of the topic at the current location. Although this approach does create some duplication of text, it allows the book to be used more effectively as a reference.

Many data examples are included that have already been published, either in technical journals or in brochures. These were chosen at the time to illustrate specific topics and as such are still highly relevant to the topic concerned. I have supplemented these examples with many new ones, together with illustrative model data sets.

In any published work, there is inevitably a delay between collecting the information and the final document being consulted or read by a reader. This can vary from a few hours in the case of a newspaper to many years for an extensive reference book. In this case, most of my references were published prior to mid to late 1994, with a few that were included after the start of the technical review in late 1994. References are included to give credit for work done and to allow the reader to locate more detailed information. The majority of references quoted have been peer reviewed and edited, but this is not the case for the abstracts or extended abstracts published by the Society of Exploration Geophysicists (SEG) and the European Association of Exploration Geophysicists (EAEG), now the European Association of Geoscientists & Engineers (EAGE). Because these have not been edited for technical content, the views expressed are those of the author(s) alone.

The chapters on residual static corrections (Chapter 7) and refraction surveys (Chapter 5) are long. After consulting with my editors, I decided not to split them but to keep them intact so that each chapter refers to a complete subject. We believe
that this is the correct approach for a reference book, provided it is accompanied by a comprehensive table of contents and an extensive index. The index provided can be used as a conventional index and to show a list of the salient points associated with each major topic.

Static corrections have been a key component of my geophysical career, with Geophysical Service International (GSI) and BP Exploration. I must express my appreciation to Clem Blum and Pete Embree who did much to foster my interest in static corrections in the late 1960s and early 1970s. My involvement with static corrections has included computing refraction-based static corrections with an analog field crew in the Libyan desert, developing and implementing crosscorrelation-based residual static correction techniques, developing the computation of refraction-based static corrections on an early field computer, and visiting many field crews around the world to assist in setting up a practical way to compute datum static corrections in their area.

I hope that through this book I am able to transfer some of my accumulated knowledge and experience to my fellow geophysicists. I believe that a companion volume containing a large number of case histories would be a welcome addition to the libraries of many geophysicists. I hope that someone will be able to gather this information together in the not-too-distant future.

In writing this book, I have received assistance from many individuals, companies, and organizations. I acknowledge with thanks the authors, publishers, and contractors who gave me permission to reproduce previously published examples. Many individuals have provided me with information and have assisted in reviewing specific topics in the text. I therefore thank Franklin Boitier, Swavek Deregowski, David Ellis, Guy Flanagan, Freddy Ngian, Sue Raikes, Jean-Marc Rodriguez, and Peter Simpson, with extra acknowledgement of the help given by Clem Blum and Ian Jack. Special thanks are due to my editors Roland Chen and Gene Scherrer for their reviews which required many long hours reading the manuscripts; I also wish to thank Gene, as Series Editor, for his support and understanding. I extend my sincerest appreciation to my wife Gillian and our three children for their patience, understanding, and encouragement. On the production side, I must thank Lynx Information Systems Ltd for their assistance in converting some dyeline prints into a reproducible format, Kathy Walker for changes made to the text for clarity and to bring it up to SEG publication standards, and the support received from Ted Bakamjian, Jerry Henry, and Judy Hastings at the SEG Business Office. And finally, sincere thanks are due to BP Exploration for the support provided to me in writing this reference book.

—Mike Cox
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