GeoGuide

Frances M. Williams

Understanding Ethiopia

Geology and Scenery

Springer

GeoGuide

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This book is dedicated to the memory of Dr. Bill Morton, friend and colleague, whose contribution to the understanding of Ethiopia's geology was tragically cut short.

Foreword

To venture is to enlarge one's life. To venture into Ethiopia is to encounter a cornucopia of unmatched physical and cultural diversity. Poised high and commanding above the Nile plains to the west, the Red Sea littoral to the east and the Kenyan savannah to the south, Ethiopia's castellated plateaus have been home, rallying ground and refuge to a two thousand year-long succession of ruling emperors (and empresses!). Ethiopia, today an increasingly powerful influence in Africa, has an ancient name worthy of the birthplace of *Homo sapiens*, expressive of its hospitality to the Queen of Sheba and possibly the Ark of the Covenant, and a refuge for early followers of the prophet Muhammad. Yet the kaleidoscopic human history of Ethiopia has been conditioned by a far older history, that of its landscape. For as the author of this book rightly remarks, "In Ethiopia geology lies behind almost every experience".

The spectacular landscape of Ethiopia has been moulded and sculpted by forces inside the earth which continue to act today: volcanoes simmer in the lowlands, earthquakes episodically open chasmic fissures in Afar, and the Rift Valley continues slowly but inexorably to widen in response to ongoing continental drift. At the same time, great rivers impressed on the highlands continue to roar and cut deep into their awesome canyons: the Abay (Blue Nile), Tekeze, Omo and Shebeli. This is nature alive on the grand scale!

Frances Williams' love affair with Ethiopia stems from close to half a century's acquaintance with the land and its people. She has travelled it from east to west, north to south and peak to gulf. As a field scientist, photographer, linguistic artist, and convivial and sensitive companion, she now expresses in this gem of a book her knowledge of not only the geological tapestry of Ethiopia, but also its archaeology and ancient human cultures. With clarity and, in the best sense, simplicity, she communicates the drama of the moulding of Ethiopia's geology, both for the novice and for those advanced but still learning!

Between these covers, the traveller, on the move or at home, can savour and more fully appreciate the remarkable and complex choreography of Ethiopia's geological evolution. The first section of the book, after introducing some essential geological concepts, describes its 600 million year-long story: from an initial, crunching continental collision; then successively through glaciation near the South Pole, gentle flooding by tropical seas, violent flooding by gigantic white-hot lava flows; and lastly and still ongoing, the uplifting of the high plateaus while at the same time they are being rifted apart. The second section devotes fifteen chapters to the various geological regions of Ethiopia, well illustrated with colourful maps, informative diagrams and photographs that display an artist's eye.

For the artistry of geology teaches us that ultimately "It is the beginning and the end that shadows the civilisations that pass upon the surface".

Paul Mohr
Author of a 1962 "Geology of Ethiopia"

Acknowledgments

So many people have helped me while preparing this book that it is hard to know where to begin expressing my thanks. I will therefore do so where my association with Ethiopia began, with the Department of Geology (now the Department of Earth Sciences) at Addis Ababa University. Thank you to all its staff and students, past and present, for giving me the opportunity to work in your department all those years ago, for opening my eyes to your wonderful country and for continuing to give me encouragement and support throughout this project.

During my trips to Ethiopia over the past ten years, my travel has been arranged by Mr. Tony Hickey and his team at Ethiopian Quadrants. Thank you to Tony and all the Quadrants staff, especially to W/o Manalebsh Tilahun and W/o Etagegnehu Buli for organising unconventional itineraries, and to everybody for being smiling and welcoming whenever I come to your office. My very special thanks go to long-distance drivers Ato Mesfin Debrework, Ato Fuad Ahmed, Ato Kassahun Ejeta and Ato Kassaye Yohannes who never demurred about going off the beaten track to follow the strange whims of a geologist and for whose driving skills I have unceasing admiration.

Ato Bedassa Gubena kindly arranged logistics for trips to Lake Tana, and to the Semien Mountains where Ato Yalew Tafete was an indefatigable and knowledgeable guide. Chief Warden Ato Maru Biadglegn and his team at the Semien Mountains National Park headquarters at Debarek provided valuable logistical support.

Dr. Yirmud Deneke and the staff of the Awash Falls Lodge have always given me a warm welcome and provided assistance during my visits to Awash National Park.

Many chapters of the book have benefitted enormously from careful review and critical comments by people who are more expert in particular areas than I am. My heartfelt thanks go to Professor Ernesto Abbate, Ato Tadesse Alemu, Professor Mohamed Abdelsalam, Emeritus Professor Michael Beyth, Ms. Morgan Blades,

Dr. Tadewos Chernet, Professor Alan Collins, Professor Giacomo Corti, Associate Professor Derek Keir, Professor Henry Lamb, Professor Paul Mohr, Mr. Robert Neil Munro, Professor Dr. Jan Nyssen, Mr. Peter Purcell, Mr. Keith Rawolle, Mrs. Jan Rawolle, Professor Solomon Tadesse and Dr. Jacques Varet for taking time to read chapters and make constructive comments—and for saving me from some potentially embarrassing errors. I am alone responsible for any errors which remain.

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Professor Ernesto Abbate, Professor Mohamed Abdelsalam, Ms. Morgan Blades, Dr. Seifu Kebede, Professor Henry Lamb, Dr. Daniel Mège and Mr. Peter Purcell allowed me to use information from unpublished reports or gave me access to pre-publication material, and Dr. Atalay Ayele of the Institute for Geophysics and Space Research, Addis Ababa, provided the unpublished earthquake map of the Horn of Africa. Mr. Emile Farhi, Dr. Thomas Wanner, Dr. David Haberlah, Ms. Jutta Von dem Bossche and Dr. Ernst Hirsch kindly translated Italian and German texts into English for me. Dr. Yohannes Lemma Didana introduced me to GeoMapApp and instructed me in its use.

Professor Solomon Tadesse arranged my visits to the mines at Adola and Kenticha. My thanks go to him, to Ato Million Mered, Dr. Zerihun Deseta and Ato Abdela Kedir for permitting me to visit, and to Ato Ebisa Dugasa, W/t Meseret Seife, Ato Amsali Yizengau and Ato Mulugeta Abraham for showing me around the mining operations.

The Geological Survey of Ethiopia has provided assistance and support throughout the project, and a great deal of material in the form of maps and reports. I especially appreciate them for providing me with a complete coverage of the 1:250,000 geological maps of Ethiopia and the accompanying notes, which have given a wealth of information. W/o Tenaye Hailu and Ato Girma Tefera patiently downloaded all this material and spent considerable time searching out other references that I required. Ato Tadesse Alemu and Dr. Girma Woldetensae provided valuable information and useful guidance, particularly for my trip to western Ethiopia.

My warm thanks go to the people of Ethiopia, for their friendliness and courtesy, and for unfailingly offering assistance, guidance and hospitality during my travels around their country.

The Department of Earth Sciences, University of Adelaide, granted me an honorary position and provided me with a home in which to work on the final compilation of this book, as well as use of their facilities and their logistical and moral support.

Special thanks go to my husband Emeritus Professor Martin Williams who read through all the chapters and never ceased to give encouragement.

Last but not least, this project would never even have been dreamed of had not Dr. Johanna Schwartz of Springer DE suggested it. Thank you to her, and to Springer, for initiating the project and for bringing it to light.

Digital elevation models for Figs. III.1, 9.1, 12.1, 12.4, 13.1, 15.1, 15.2, 16.3, 19.1, 20.3, 20.6 and 23.1 were obtained using GeoMapApp http://www.geomapapp.org (W.B.F. Ryan, S.M. Carbotte, J.O. Coplan, S. O'Hara, A. Melkonian, R. Arko, R.A. Weissel, V. Ferrini, A. Goodwillie, F. Nitsche, J. Bonczkowski, and R. Zemsky (2009), Global Multi-Resolution Topography synthesis, Geochem. Geophys. Geosyst., 10, Q03014).

Each of the geological maps was constructed using a number of sources, but most are based initially on the 1:2,000,000 Geological Map of Ethiopia (2nd edition) published by the Geological Survey of Ethiopia, with details modified using the regional 1:250,000 geological maps, information from published reports, and my own observations.

Figures 12.2, 17.3, 19.4, 20.4 and PHOTO 19.7 are based on Google Earth imagery.

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About the Author

Frances M. Williams taught geology at Addis Ababa University from 1969 to 1976. During that time, she travelled throughout Ethiopia, exploring its geology with her students, mapping volcanoes and investigating the effects of earthquakes. Now relocated to Australia, she visits Ethiopia frequently and has authored and co-authored a number of guidebooks and brochures on localities of geological interest.

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Introduction

I first fell in love with Ethiopia before even setting foot in the country. It was early morning on a September day in 1968, and I was on the last leg of my journey to a new job in a country about which I knew almost nothing. As I gazed out of the plane window, I was mesmerised! Little round houses clustered into tiny villages, with wisps of smoke rising from their roofs, a peaceful landscape of patchwork fields that plunged without warning into vast gorges with silvery threads of river meandering in their depths, a sudden steep mountain range and—joy of joys—a beautiful, perfectly circular volcano with a deep blue lake nestling in its crater. I knew at once that this was going to be a very special place for me.

And so it has remained, though there have been many changes since those early days. At the time of writing this book, 2015 in the Gregorian calendar and 2007 in the Ethiopian, the rate of change in Ethiopia is unprecedented. New roads are being constructed, new hotels and lodges opening, new dams and industries being built, and every city and town is throwing its tentacles into the surrounding countryside. Places that were almost inaccessible when I first lived in Ethiopia can now be reached by tarmac road. Comfortable, even luxurious, hotels and lodges have sprung up in places where camping used to be the only option. Progress is both inevitable and desirable but, if allowed to proceed unchecked, may come at a high price. As a geologist, I am keenly aware that there is a very real danger of Ethiopia's important and sometimes unique geological features being overlooked and destroyed in the rush to develop. One of the aims of this book is to bring to the attention of the people of Ethiopia, to visitors to the country and to those responsible for determining her future development, the value of her geological features and heritage. Once lost, these can never be restored.

My primary aim, however, is to share with the reader the thrill of understanding something of Ethiopia's geology. A knowledge of geology, even if only a

smattering, will surely enhance the experience of anyone who travels in the country, be they visitor, resident or those who travel vicariously via armchair. In Ethiopia, geology lies behind almost every experience. Her spectacular scenery is determined by geological processes. Geology has made possible the construction of the wonderful rock churches of Lalibela, provided niches for the hidden churches of Tigray and supplied building material for the magnificent obelisks of Axum. Her wildly varying climate, from the fresh coolness of the highlands to the fierce heat of the Afar desert, her lakes and rivers where travellers may enjoy a relaxing swim or the excitement of white water rafting, and the mountains and canyons which make every journey in Ethiopia an adventure, are all products of her geology.

Geology has also played its part in the history of Ethiopia, providing her with a formidably mountainous interior, bounded by great escarpments and faced by inhospitable desert, which have assisted her fiercely independent and resourceful inhabitants to discourage invaders and enable her to be the only country in Africa that was not colonised by a European power.

This book does not set out to be a comprehensive treatise on the geology of Ethiopia. To produce such a work would be a marathon task requiring several volumes. There is a vast amount of specialist literature available to those who wish to delve into details. Rather, it attempts to convey in non-technical language a sense of wonder, founded upon a basic understanding. It is hoped that both geologists and non-geologists will find the book informative and enjoyable. I have tried to assume no prior geological knowledge on the part of the reader and to this end have restricted the use of technical geological terms as far as possible. Since it is impossible to avoid them entirely, I have provided an explanation wherever such terms are used in the text and a glossary to explain them at the end of the book.

Neither is the book intended as a tourist guide. Even if it were, change is too rapid for this to be practicable. New roads appear and existing ones are re-routed. Places once accessible become so no longer as private developments engulf them, for example the shores of the crater lakes at Debre Zeit. The reverse occurs as new roads are constructed, as is the case in northern Afar. Potential landmarks such as hotels appear and disappear. Even the geology itself is not static, particularly in a land as geologically active as Ethiopia. Fissures appear; volcanoes erupt; hotsprings and fumaroles come and go; and lakes may shrink, grow or disappear altogether. Although the book describes many specific localities of geological interest, the above reasons render it difficult to give detailed routes and directions to them. The maps shown in the book are intended as sketch maps only and not for navigation. A reasonably good map of the country will enable you to locate most

of the places mentioned, and Ethiopia is a land of helpful and friendly people, and knowledgeable guides, who will be more than happy to assist you to find your way.

In the book, I have tried to answer the questions that have continually come to my own mind during my travels in Ethiopia and those which have been put to me by fellow travellers. Why is Ethiopia so mountainous? Why are there so many deep gorges? What caused the Rift Valley to form and why does it have so many volcanoes? What causes the colourful hotsprings at Dallol and the spectacular lava lake of Erta Ale? How were people able to carve out the wonderful rock churches of Lalibela and produce the great obelisks of Axum? Why is Afar such an extraordinary and inhospitable desert of lava and salt? There are hundreds of such questions, and many of them have no definite answer. In attempting to provide answers, and at the same time produce a coherent and exciting story, I have tried to base my narrative on the most recent and/or most widely accepted thinking, without confusing the reader with technical details or by giving equal space to alternative interpretations. This has not been easy, and it is certain that many of my statements will be challenged by those who have studied the topics in detail and made different interpretations. My defence is that my purpose is not to provide a rigorous scientific text but to paint a broad picture which will engage rather than confuse the reader. A list of references is given at the end of the book, which the interested and determined reader may consult for further detail in order to form his or her own opinion.

The book is arranged in three parts. In order to make sense of what follows, the reader will find it helpful to have an overall picture of how the earth works and how geological time is measured. The first part, in Chaps. 1–3, aims to provide this as briefly and simply as possible, and to introduce some of the rock types that we will meet in the following pages. It concludes in Chap. 4 with a summary of Ethiopia's present-day physiography and geology. The second part, in Chaps. 5–8, outlines the geological story of Ethiopia, since her oldest rocks formed more than half a billion years ago to the present time. The third part, which comprises the bulk of the book in Chaps. 9–23, brings this story alive by travelling through the country and observing how it has shaped her rocks, scenery and even the history of her people. Chapter 24 gives a brief insight into the significance of earthquakes in Ethiopia, Chap. 25 attempts to bring everything together, and Chap. 26 speculates upon what may happen in the future. Maps, diagrams and photographs are provided to enable the reader, whether in the country or not, to locate himself or herself both physically and geologically. For those readers who are not in the country, I hope that these may help you to feel that you are!

A Note About Ethiopian Place Names

There is no standard system for the transliteration of Ethiopian place names. Even the name of the capital city is spelled in at least four different ways (Addis Ababa, Addis Abeba, Adis Abeba, Adis Abbaba), depending on which map one looks at.[1] Throughout the book, I have used the spelling which is most familiar to me, or which most closely resembles the Amharic or local ethnic phonetic. The names should be easily recognisable to those who would spell them differently. A more challenging complication is that many places have more than one name—an Amharic one and an ethnic one—and each of these can sometimes vary depending upon who your informant is! Current movement is towards the replacement of Amharic names in non-Amhara regions by their traditional ethnic ones. This is particularly so in the case of the Oromia region and can cause much confusion, particularly as many maps have not been updated. Again, I have used the name which is more familiar to me, and where appropriate given the alternative name in brackets.

The names of geographical features such as lakes, mountains and rivers can be even more problematic. Asking passers-by for the name of such a feature can often result in a variety of answers. Sometimes, the same feature is named differently by different groups of people or may not have a name at all. It is just a "river" or a "lake". An example of this is Lake Hayk in the Ethiopian highlands north of Dessie—"hayk" is simply the Amharic word for "lake". I have tried to name such features as correctly as possible and apologise for any misunderstandings.

There is even some confusion over the name of the country itself. Even today, many people still refer to her as Abyssinia, and historical texts frequently use the two names interchangeably. In fact, the name of Ethiopia for the country was not formally recognised internationally until after the establishment of the United Nations in 1945. The Ethiopia of the Bible is a Greek translation of the original Hebrew name of Cush. This is particularly misleading, since the land of Cush did not correspond geographically to present-day Ethiopia.

Finally, throughout the book, I have followed the practice of referring to Ethiopia in the female gender, as Ethiopians do in recognition of the fact that she is their motherland.

[1]The town of Wukro in northern Ethiopia holds the record for different transliterations of its name—with fourteen versions!

Part I
Setting the Scene

Since I want this book to be enjoyed by readers who have no geological background, I have tried to condense a few essential concepts into three short chapters. Chapter 1 explains the basics of how the earth works and where Ethiopia fits into the big scheme of things. Chapter 2 introduces the concept of geological time and the terms which are used to describe it, and Chap. 3 introduces the main rock types that we will meet during our journey around Ethiopia.

In Chap. 4, we will come to Ethiopia herself and take an overall look at her present topographic regions and how these relate to her geological make-up.