



Copyright

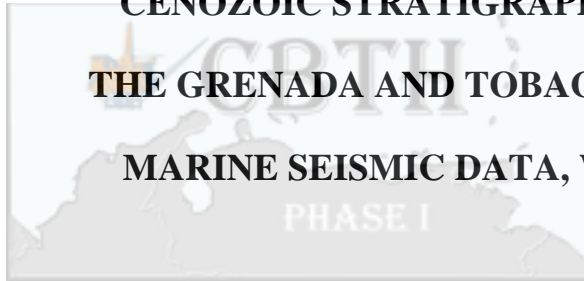
by

Trevor John Aitken

2005



**CENOZOIC STRATIGRAPHIC AND TECTONIC HISTORY OF
THE GRENADA AND TOBAGO BASINS AS DETERMINED FROM
MARINE SEISMIC DATA, WELLS, AND ONLAND GEOLOGY**



by

Trevor John Aitken, B.S.

Thesis

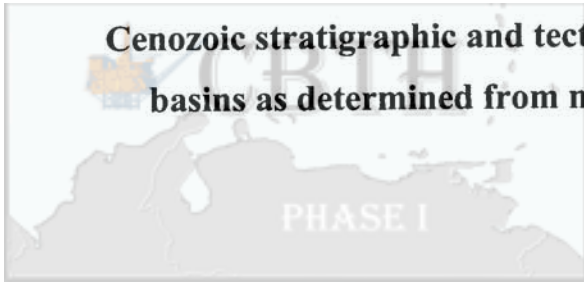
Presented to the Faculty of the Graduate School of
The University of Texas at Austin
in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science in Geological Sciences



The University of Texas at Austin

May, 2005



**Cenozoic stratigraphic and tectonic history of the Grenada and Tobago
basins as determined from marine seismic data, wells, and onland
geology**

**Approved by
Supervising Committee:**



Paul Mann, Supervisor



Gail L. Christeson, Co-Supervisor



Ron J. Steel



Paul L. Stoff

CARIBBEAN BASINS, TECTONICS AND HYDROCARBONS
UNIVERSITY OF TEXAS INSTITUTE FOR GEOPHYSICS
PHASE I



Dedication

To my girls, wife Anne and daughters Grace and Holland. You will always be the reason
for my accomplishments in life.





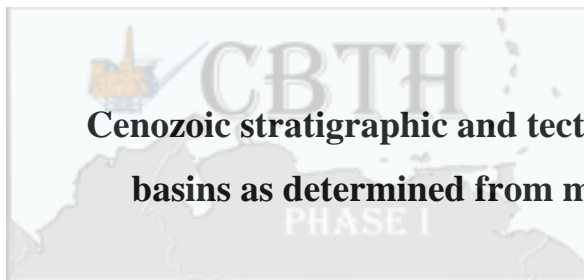
Acknowledgements

I would like to thank my master's thesis committee for their support and helpful reviews: Paul Mann (advisor), Gail Christeson (co-advisor), Ron Steel (committee member), and Paul Stoffa (committee member). I would like to thank especially Alejandro Escalona, who constantly shared his geological expertise in the southern Caribbean with me. I would also like to thank Steffen Sastrup for mentoring me as a seismic data processor and for his helpful review of Chapter 2. I would also like to thank Luc Lavier for suggesting the flexural subsidence model used for the early opening of the Grenada and Tobago basins. This research was made possible by the BOLIVAR project, partially funded by NSF Grant EAR-0003588 awarded to G. Christeson and P. Mann at UTIG. Additional financial support was provided by the Jackson School of Geosciences of the University of Texas at Austin, and by a UTIG Gale White Fellowship awarded to Trevor Aitken in the fall of 2004. Most importantly, I would like to acknowledge and thank my loving wife, Anne, who has been supportive in all my endeavors.



May 4, 2005

Abstract



Cenozoic stratigraphic and tectonic history of the Grenada and Tobago basins as determined from marine seismic data, wells, and onland geology

Trevor John Aitken, M.S. GeoSci

The University of Texas at Austin, 2005

Supervisor: Paul Mann

This thesis presents an integrated stratigraphic and tectonic evolution of the Grenada and Tobago basins using multi-channel seismic data collected in May, 2004, (BOLIVAR cruise), along with GULFREX seismic data collected by Gulf Oil Company in 1975.

These reflection data, combined with UTIG OBS refraction data also collected with the BOLIVAR study in 2004 and with a compilation of previously published, onland geologic data in the southeastern Caribbean, constrain a multi-stage, Cenozoic tectonic history for the southern Lesser Antilles arc and flanking Grenada and Tobago basins. A new tectonic model for the Grenada and Tobago basins is based on three seismic megasequences. The striking similarity in the two basins' half-graben structure, smooth

basement character, deep-marine seismic facies, and similar Paleogene sediment thickness suggest that the two basins formed as a single, Paleogene forearc basin related to the now dormant Aves Ridge. This single forearc basin continued to open through flexural subsidence during the early to middle Eocene probably because of slow rollback of the subducting Atlantic slab. The Grenada and Tobago basins began to be divided during the early to middle Miocene, when the thinned crust of the forearc was inverted as a result of: 1) oblique convergence between the Caribbean plate and the passive margin of South America; and 2) intrusion of the Neogene Lesser Antilles arc. Observed transpressional shortening of the basins decreases from southwest to northeast. Total shortening in the southern Grenada basin varies from 5 km in the southern part of the study area to 1 km in the northern part of the study area. Shortening structures include inverted Paleogene normal faults, folds, and shale diapirism. The late Miocene to Recent period is characterized by divided depositional histories of the Grenada and Tobago basins. The Tobago basin is characterized by a 4-km-thick wedge of Plio-Pleistocene clastic sediments inferred to represent the distal progradation of the proto-Orinoco River. The Grenada basin becomes increasingly isolated from further continental sediment input by uplift of coastal Venezuelan ranges and the Neogene Lesser Antilles volcanic ridge.



Table of Contents

CENOZOIC STRATIGRAPHIC AND TECTONIC HISTORY OF THE GRENADA AND TOBAGO BASINS AS DETERMINED FROM MARINE SEISMIC DATA, WELLS, AND ONLAND GEOLOGY	ii
Acknowledgements.....	v
List of Tables	xi
List of Figures	xi
CHAPTER 1: INTRODUCTION	1
1. Introduction.....	1
2. Motivation for this thesis	4
3. Objectives of this thesis	5
CHAPTER 2: PROCESSING OF BOLIVAR SEISMIC REFLECTION DATA	6
1. Seismic data acquisition.....	7
2. Seismic reflection data processing.....	9
3. Pre-processing of seismic data.....	9
3.1 Raw data QC.....	10
3.2 Geometry definitions	10
3.3 Channel and trace editing.....	10
3.4 Filter.....	11
3.5 Spherical correction	11
3.6 Multichannel deconvolution	11
3.7 Trace amplitude balance	11
3.8 Brute stacks.....	13
4. Modeling of seismic data.....	13
4.1 Seafloor picks.....	13
4.2 CMP sort of all offsets	13

4.3 Multiple attenuation using Pradmus	13
4.4 Velocity analysis.....	14
5. Imaging	17
5.1 Mutes.....	17
5.2 CMP stack with NMO	17
5.3 Migration.....	17
5.4 Time variant band-pass filter	18
5.5 AGC gain	18
5.6 Final output	18
5.7 Depth conversion	18

**CHAPTER 3: CENOZOIC STRATIGRAPHIC AND TECTONIC HISTORY OF THE
GRENADA AND TOBAGO BASINS AS DETERMINED FROM MARINE SEISMIC
DATA, WELLS, AND ONLAND GEOLOGY 20**

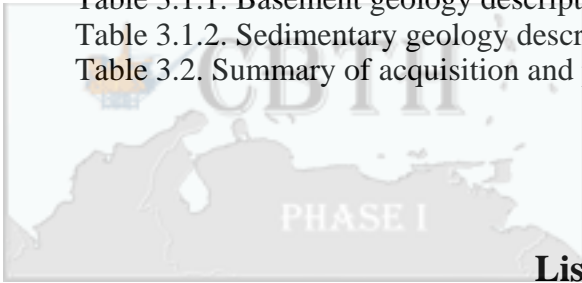
Abstract.....	20
1. Introduction.....	21
1.1 Objectives of this chapter.....	25
2. Tectonic setting of the southern Grenada and Tobago basins	25
2.1. Plate tectonic evolution.....	25
2.2. Crustal provinces of the eastern Caribbean	27
2.2.1 Venezuelan basin	27
2.2.2 Aves Ridge.....	32
2.2.3 Grenada basin.....	33
2.2.3 Grenada basin.....	34
2.2.4 Lesser Antilles arc.....	34
2.2.5 Tobago basin.....	35
2.2.6 Barbados accretionary prism.....	36
2.2.7 Araya-Paria peninsula-Northern Trinidad Range	36
2.3. Previous models for the Grenada basin	36
3. Data and Methodology.....	42
3.1. BOLIVAR data	42

3.2. Gulfrex data	46
3.3. Published seismic data & well data	46
3.4. Methodology	47
4. Seismic character of megasequences in the Grenada and Tobago basins	49
4.1 Megasequence 1 – Paleogene widening of the forearc	49
4.1.1 Acoustic basement	52
4.1.2 Paleogene sedimentary rocks.....	53
4.2 Megasequence 2 - early to middle Miocene	54
4.3 Megasequence 3 – late Miocene to Recent.....	56
4.3.1 Megasequence 3: Grenada basin.....	56
4.3.2 Megasequence 3: Tobago basin.....	57
5. Structural restorations	58
6. Isochron maps	63
7. Discussion.....	68
7.1. Origin of basement in the Grenada and Tobago basins	68
7.2. Slab rollback and flexural subsidence model for forearc extension	68
7.3. Lesser Antilles arc divides the two basins’ depositional histories.....	75
7.4. Closing of the Grenada basin.....	76
7.5. Basin model	77
8. Conclusions.....	79
Vita.....	89



List of Tables

Table 3.1.1. Basement geology descriptions	30
Table 3.1.2. Sedimentary geology descriptions	31
Table 3.2. Summary of acquisition and processing parameters.....	45



List of Figures

Figure 1.1. Major crustal provinces of the Caribbean region	2
Figure 1.2. Geosat marine gravity map with BOLIVAR seismic reflection lines	3
Figure 2.1. MCS setbacks and offsets diagram for BOLIVAR (EW-0404).....	8
Figure 2.2. Example of pre-processing before and after image.....	12
Figure 2.3. Velocity analysis windows with and without NMO correction	16
Figure 2.4. Examples of unmigrated Pradmus stack, F/K and F/X migration.....	19
Figure 3.1. Regional map of Caribbean region.....	22
Figure 3.2. A. Regional map of study area	28
Figure 3.2. B. Regional gravity map showing the various basement provinces.....	29
Figure 3.3. Correlation of well and outcrop data from the study area with seismic.....	33
Figure 3.4. Previous models of Grenada backarc basin opening.....	37
Figure 3.5. Seismic line BOL30	40
Figure 3.6. Fence diagram combining BOLIVAR and Gulfex seismic lines.....	43
Figure 3.7. Seismic facies of megasequences and their interpretations.....	50
Figure 3.8. Fault restoration of Tobago basin using BOL30	59
Figure 3.9. Fault restoration of Grenada basin using BOL30.....	60
Figure 3.10. Fault restoration of Grenada basin using BOL37.....	61
Figure 3.11. Megasequence 1 isochron map.....	64
Figure 3.12. Megasequence 2 isochron map.....	65
Figure 3.13. Megasequence 3 isochron map.....	66
Figure 3.14. Grenada/Tobago basin restoration to illustrate their common origin.....	69
Figure 3.15. Cenozoic plate reconstructions and cross-sections.....	72

