ASTRO-BALLISTIC CHRONOSTRATIGRAPHIC SEQUENCING

NORTH AMERICAN MIDDLE MOUNTAIN | PAPER IV

Causal Comparison with Plate Tectonics

Justin B Fine | Founder & Principal Investigator, Ontomics

PUBLIC RESEARCH EDITION v1.7 | 17 NOVEMBER 2026

Scientific content retained from v1.6; section-indexed external citations appended

Contents

Canonical Corpus and Working-Draft Notice **20**

Declaration of Purpose **20**

Source Status and Citation Policy **20**

Data, Evidence, and Provenance Convention **20**

Paper-IV Comparison-Provenance Snapshot **20**

Conditional Adjudication Statement **21**

Epistemic Status and Claim-Language Convention **21**

Prediction, Falsification, and Decision-Threshold Convention **22**

Causal-Chain, Assumption, and Alternative-Explanation Convention **22**

Abstract **22**

1 The Adjudication Mandate **22**
1.1 Canonical Corpus Terminology . . . 22
1.2 Paper IV Defines the Decision Protocol . . . 23
1.3 The Comparison Is Not Between Motion and No Motion . . . 23
1.4 Replacement Requires More Than Compatibility . . . 23
1.5 Adjudication Questions . . . 23
1.6 Allowed Final Outcomes . . . 23

2 Conditional Handoff From Papers I Through III **23**
2.1 Paper-I Handoff . . . 24
2.2 Paper-II Handoff . . . 24
2.3 Paper-III Handoff . . . 25
2.4 Combined Handoff . . . 25
2.5 Handoff Integrity . . . 25
2.6 Handoff Eligibility . . . 25

3 Model-Family Definitions **25**
3.1 Plate-Tectonic Comparison Family . . . 25
3.2 Astro-Ballistic Model Family . . . 26

3.3 Hybrid Model Family . . . 26
3.4 Regional Event Model . . . 26
3.5 No-Event Baseline . . . 26
3.6 Randomized-Event Models . . . 26
3.7 Model Nesting . . . 26
3.8 No Undefined Umbrella Model . . . 26
3.9 Alternative-Explanation Family Completeness . . . 27

4 The Shared Observation Domain 27
4.1 Complete Observation Vector . . . 27
4.2 Boundary Observations . . . 27
4.3 Motion Observations . . . 27
4.4 Continental Reconstruction Observations . . . 27
4.5 Surface-Structure Observations . . . 28
4.6 Deep Geophysical Observations . . . 28
4.7 Shared Data Freeze . . . 28
4.8 Observation Independence . . . 28
4.9 Shared Evidence Principle . . . 28

5 Observational, Kinematic, and Causal Levels 28
5.1 Level L0: Observation . . . 28
5.2 Level L1: Representation . . . 29
5.3 Level L2: Kinematic Reconstruction . . . 29
5.4 Level L3: Dynamic Maintenance . . . 29
5.5 Level L4: Boundary-Origin Causation . . . 29
5.6 Level L5: Historical Global Organization . . . 29
5.7 Level L6: Predictive Replacement . . . 29
5.8 Comparison by Level . . . 29
5.9 No Kinematic-to-Causal Shortcut . . . 29

6 Fair-Comparison Rules 30
6.1 Rule 1: Same Observation Domain . . . 30
6.2 Rule 2: Same Data Partition . . . 30
6.3 Rule 3: Same Uncertainty Standards . . . 30
6.4 Rule 4: Same Reference Frames . . . 30
6.5 Rule 5: Same Chronology Standards . . . 30
6.6 Rule 6: Same Physical Constraints . . . 30
6.7 Rule 7: Same Prediction Freeze . . . 31
6.8 Rule 8: Same Complexity Accounting . . . 31
6.9 Rule 9: Same Failure Visibility . . . 31
6.10 Rule 10: Strongest Defensible Comparison . . . 31
6.11 Rule 11: No Gap-Based Proof . . . 31
6.12 Rule 12: No Asymmetric Burden . . . 31
6.13 Rule 13: Assumption and Intervention Parity . . . 31
6.14 Rule 14: No Strawman or Gap Filling . . . 31
6.15 Rule 15: Measurement-Proximal Evidence Is Not a Reconstruction Output . . . 32
6.16 Rule 16: No Privileged Paleogeography . . . 32
6.17 Rule 17: Material-Lineage Parity . . . 32
6.18 Rule 18: Chronology-Branch Accounting . . . 32
6.19 Rule 19: No Side-by-Side Causal Substitution . . . 32
6.20 Rule 20: Specific Initiating-Age Integrity . . . 32
6.21 Rule 21: No Credit or Penalty for Scope-Reserved Hypotheses . . . 32
6.22 Rule 22: Compare Implementations, Not Literature Narratives . . . 32

7 Parameter, Prior, and Model-Input Registry 33
7.1 Model Parameter Vectors . . . 33
7.2 Astro-Ballistic Event Parameters . . . 33

7.3 Plate-Tectonic Initial-State Parameters . . . 33
7.4 Prior Distribution . . . 33
7.5 Prior Sources . . . 34
7.6 No Fit-Dependent Physical Bound . . . 34
7.7 Parameter Identifiability . . . 34
7.8 Shared Parameter Audit . . . 34

8 Likelihood and Observational Adequacy 34
8.1 Model Prediction . . . 35
8.2 Residual Vector . . . 35
8.3 Gaussian Observation Likelihood . . . 35
8.4 Observation-Class Likelihoods . . . 35
8.5 Class-Specific Misfits . . . 35
8.6 No Global-Score Concealment . . . 35
8.7 Residual Structure . . . 35
8.8 Residual Autocorrelation . . . 35
8.9 Observational Adequacy . . . 35

9 Physical and Causal Adequacy 36
9.1 Physical Residual Vector . . . 36
9.2 Physical Penalty . . . 36
9.3 Causal Necessity . . . 36
9.4 Causal Necessity Score . . . 36
9.5 Astro-Ballistic Necessity Test . . . 36
9.6 Plate-Tectonic Component Ablation . . . 36
9.7 Intervention-Coherence Gate . . . 36
9.8 Mediation and Interaction Accounting . . . 37
9.9 Causal Dominance . . . 37
9.10 Causal Adequacy Principle . . . 37

10 Model Complexity and Causal Compression 37
10.1 Raw Parameter Count . . . 37
10.2 Effective Parameter Count . . . 37
10.3 Event Complexity . . . 38
10.4 Initial-Condition Complexity . . . 38
10.5 Boundary-Condition Complexity . . . 38
10.6 Manual-Assignment Complexity . . . 38
10.7 Mechanism-Switching Complexity . . . 38
10.8 Model Revision Complexity . . . 38
10.9 Information Criteria . . . 38
10.10 Bayesian Evidence . . . 38
10.11 Causal Compression . . . 39
10.12 Compression Failure . . . 39

11 Predictive Performance 39
11.1 Prediction Versus Reconstruction . . . 39
11.2 Training, Validation, and Test Data . . . 39
11.3 Predictive Distribution . . . 39
11.4 Predictive Log Score . . . 39
11.5 Spatial Holdout . . . 40
11.6 Temporal Holdout . . . 40
11.7 Observation-Type Holdout . . . 40
11.8 Negative Prediction . . . 40
11.9 Calibration . . . 40
11.10 Predictive Superiority . . . 40
11.11 Decision-Threshold Freeze . . . 40

12 Replacement Standards **40**
12.1 Standard R0: Compatibility . . . 41
12.2 Standard R1: Observational Equivalence . . . 41
12.3 Standard R2: Causal Necessity . . . 41
12.4 Standard R3: Novel Prediction . . . 41
12.5 Standard R4: Complexity Control . . . 41
12.6 Standard R5: Physical Coherence . . . 42
12.7 Standard R6: Global Coverage . . . 42
12.8 Standard R7: Replication . . . 42
12.9 Primary Replacement Condition . . . 42
12.10 Complementarity Condition . . . 42
12.11 Regional Condition . . . 42
12.12 Model-Version Rejection Versus Replacement Non-Qualification . . . 42

13 The Hybrid-Model Question **43**
13.1 Hybrid Models Are Not Automatic Compromises . . . 43
13.2 Hybrid State . . . 43
13.3 Interaction Term . . . 43
13.4 Hybrid Complexity . . . 43
13.5 Hybrid Ablations . . . 43
13.6 Hybrid Identifiability and Parent Recovery . . . 43
13.7 Hybrid Causal Classification . . . 43
13.8 Hybrid Preference Falsifier . . . 44

14 Pre-Registration and Model Freeze **44**
14.1 Required Freeze Package . . . 44
14.2 Freeze Record . . . 44
14.3 Model Revision After Freeze . . . 44
14.4 Exploratory and Confirmatory Results . . . 44
14.5 Adjudication Integrity Falsifier . . . 44

15 Initial Paper-IV Score Architecture **44**
15.1 Global Fit Score . . . 45
15.2 Physical Penalty . . . 45
15.3 Complexity Penalty . . . 45
15.4 Prediction Score . . . 45
15.5 Null-Model Penalty . . . 45
15.6 Causal-Necessity Penalty . . . 45
15.7 Integrated Score . . . 46
15.8 Score Difference . . . 46
15.9 Uncertainty in Model Ranking . . . 46

16 Initial Paper-IV Falsification Architecture **46**
16.1 Paper-IV Primary Falsifier . . . 46
16.2 Eligibility Falsifier . . . 46
16.3 Observation-Domain Falsifier . . . 46
16.4 Physical Falsifier . . . 47
16.5 Complexity Falsifier . . . 47
16.6 Prediction Falsifier . . . 47
16.7 Causal-Necessity Falsifier . . . 47
16.8 Hybrid Falsifier . . . 47
16.9 Plate-Tectonic Comparison Falsifier . . . 47
16.10 Indistinguishability Result . . . 47

17 Comparative Framework Synthesis **47**

18 Competing Boundary-Generation Mechanisms **48**

18.1 Boundary Origin Is a Primary Replacement Test . . . 48
18.2 Observed Boundary State . . . 48
18.3 General Boundary-Generation Operator . . . 48
18.4 Plate-Tectonic Boundary-Generation Classes . . . 48
18.5 Astro-Ballistic Boundary-Generation Classes . . . 48
18.6 Hybrid Boundary Generation . . . 48
18.7 Boundary-Origin Record . . . 48
18.8 Boundary-Generation Burden . . . 49
18.9 No Boundary-by-Boundary Mechanism Assignment . . . 49

19 Inherited Versus Emergent Boundaries 49
19.1 Boundary Categories . . . 49
19.2 Boundary-Origin Indicator . . . 49
19.3 Inherited-State Information . . . 49
19.4 Emergence Distance . . . 49
19.5 Boundary Information Retention . . . 50
19.6 Event-Created Boundary Test . . . 50
19.7 Inherited Plate-Tectonic Boundary Test . . . 50
19.8 Origin Attribution Fractions . . . 50
19.9 Inherited-versus-Emergent Decision . . . 50

20 Initial-Condition Information Content 50
20.1 Initial Conditions Are Part of the Model . . . 50
20.2 Initial-State Description Length . . . 50
20.3 Boundary-Field Information . . . 51
20.4 Observed-Network Similarity . . . 51
20.5 Information Gain . . . 51
20.6 Event-Catalog Information . . . 51
20.7 Plate-Tectonic Initial-Structure Information . . . 51
20.8 Boundary-Origin Compression . . . 51
20.9 Initial-Condition Ablation . . . 52
20.10 Initial-Condition Falsifier . . . 52

21 Boundary Location and Orientation Comparison 52
21.1 Predicted Boundary Sets . . . 52
21.2 Directed Boundary Distance . . . 52
21.3 False-Negative Boundary Length . . . 52
21.4 False-Positive Boundary Length . . . 52
21.5 Boundary Precision and Recall . . . 53
21.6 Orientation Field . . . 53
21.7 Curvature Residual . . . 53
21.8 Boundary-Width Residual . . . 53
21.9 Spatially Stratified Scores . . . 53
21.10 Location-Orientation Composite . . . 53
21.11 Boundary-Geometry Decision . . . 53

22 Boundary Type and Relative-Motion Comparison 53
22.1 Relative Velocity . . . 54
22.2 Boundary-Type Prediction . . . 54
22.3 Classification Classes . . . 54
22.4 Type Confusion Matrix . . . 54
22.5 Length-Weighted Type Accuracy . . . 54
22.6 Normal-Velocity Residual . . . 54
22.7 Relative-Motion Misfit . . . 54
22.8 Kinematic Sign Accuracy . . . 54
22.9 Obliquity Residual . . . 55
22.10 Boundary-Work Consistency . . . 55

22.11Type-Motion Composite Score . . . 55
22.12Boundary-Type Falsifier . . . 55

23 Boundary Age, Reactivation, and Termination 55
23.1 Boundary Chronology Vector . . . 55
23.2 Initiation-Age Residual . . . 55
23.3 Reactivation-Age Residual . . . 55
23.4 Termination-Age Residual . . . 56
23.5 Chronological Likelihood . . . 56
23.6 Reactivation Prediction . . . 56
23.7 Reactivation Classification . . . 56
23.8 Reactivation Confusion Matrix . . . 56
23.9 Boundary Lifetime . . . 56
23.10Termination Prediction . . . 56
23.11Survival Analysis . . . 56
23.12Chronology Composite Score . . . 57
23.13Chronology Falsifier . . . 57

24 Global Boundary Graph and Plate Partition 57
24.1 Observed and Predicted Graphs . . . 57
24.2 Node and Edge Residuals . . . 57
24.3 Connected Components . . . 57
24.4 Cycle Rank . . . 57
24.5 Plate-Face Count . . . 57
24.6 Plate-Area Distribution . . . 58
24.7 Plate-Perimeter Distribution . . . 58
24.8 Degree Distribution . . . 58
24.9 Adjacency Matrix . . . 58
24.10Graph Spectral Distance . . . 58
24.11Junction Geometry . . . 58
24.12Plate-Enclosure Completeness . . . 58
24.13Manual Gap-Filling Fraction . . . 58
24.14Global Graph Score . . . 59
24.15Graph-Partition Falsifier . . . 59

25 Continental Margins and Ocean Basins 59
25.1 Margin Observation Vector . . . 59
25.2 Basin Observation Vector . . . 59
25.3 Competing Margin-Origin Models . . . 59
25.4 Paired-Margin Prediction . . . 59
25.5 Opening-Width Prediction . . . 59
25.6 Crustal-Thinning Prediction . . . 60
25.7 Basin Subsidence Prediction . . . 60
25.8 Subsidence-History Residual . . . 60
25.9 Material-Age Prediction . . . 60
25.10Margin-Asymmetry Prediction . . . 60
25.11Margin-Basin Composite Score . . . 60
25.12Continental-Margin Falsifier . . . 60

26 Boundary Counterfactuals and Causal Necessity 60
26.1 Purpose . . . 61
26.2 Astro-Ballistic No-Event Counterfactual . . . 61
26.3 Event-Impulse Ablation . . . 61
26.4 Damage Ablation . . . 61
26.5 Thermal and Phase Ablation . . . 61
26.6 Density Ablation . . . 61
26.7 Initial-Weakness Ablation . . . 61

26.8 Mantle-Forcing Ablation . . . 61
26.9 Gravity and Buoyancy Ablation . . . 62
26.10Boundary-State Randomization . . . 62
26.11Leave-One-Event-Out Boundary Test . . . 62
26.12Leave-One-Mechanism-Out Test . . . 62
26.13Boundary Causal Contribution Fractions . . . 62
26.14Interaction Necessity . . . 62
26.15Boundary Necessity Rule . . . 62
26.16Causal-Necessity Falsifier . . . 63

27 Boundary Complexity and Predictive Tests 63
27.1 Boundary-Specific Complexity Vector . . . 63
27.2 Boundary Threshold Complexity . . . 63
27.3 Boundary-Assignment Complexity . . . 63
27.4 Gap-Bridging Complexity . . . 63
27.5 Initial-Network Complexity . . . 63
27.6 Boundary Information Criterion . . . 63
27.7 Boundary Predictive Holdouts . . . 64
27.8 Location Prediction . . . 64
27.9 Boundary Detection Score . . . 64
27.10Boundary Distance Prediction . . . 64
27.11Type Prediction . . . 64
27.12Chronology Prediction . . . 64
27.13Negative Boundary Prediction . . . 64
27.14Boundary Calibration . . . 64
27.15Boundary Predictive Superiority . . . 65
27.16Randomized-Boundary Nulls . . . 65
27.17Boundary Null Probability . . . 65

28 Boundary-Replacement Viability and Falsification 65
28.1 Boundary Comparison Parameter Set . . . 65
28.2 Boundary-Model Viable Set . . . 65
28.3 Boundary-Replacement Condition . . . 65
28.4 Hybrid Boundary Preference . . . 65
28.5 Boundary Equivalence . . . 66
28.6 Boundary Comparison Matrix . . . 66
28.7 Boundary Outcome Classes . . . 66
28.8 Boundary Replacement Decision Rule . . . 66

29 Boundary-Comparison Synthesis 66

30 Competing Plate-Motion Mechanisms 66
30.1 Motion Is Shared Evidence . . . 66
30.2 General Plate-Motion Operator . . . 67
30.3 Plate-Tectonic Motion Classes . . . 67
30.4 Astro-Ballistic Motion Classes . . . 67
30.5 Hybrid Motion Classes . . . 67
30.6 Motion-Origin Record . . . 67
30.7 Motion-Generation Burden . . . 67
30.8 No Independent Plate-by-Plate Motion Law . . . 67

31 Initial Impulse Versus Sustained Forcing 68
31.1 Impulse and Force Are Distinct . . . 68
31.2 Angular Impulse . . . 68
31.3 Post-Impulse Evolution . . . 68
31.4 Reduced Velocity-Relaxation Model . . . 68
31.5 Velocity-Relaxation Time . . . 68

31.6 Impulse-Memory Fraction . . . 68
31.7 Directional-Memory Fraction . . . 68
31.8 Sustained-Force Fraction . . . 69
31.9 Impulse Sufficiency Ratio . . . 69
31.10 Maintenance Sufficiency Ratio . . . 69
31.11 No Perpetual-Impulse Assumption . . . 69

32 Gravity, Buoyancy, Mantle Flow, and Boundary Traction 69
32.1 Complete Force Decomposition . . . 69
32.2 Gravitational Force . . . 69
32.3 Buoyancy Force . . . 69
32.4 Mantle Traction . . . 70
32.5 Boundary Traction . . . 70
32.6 Action–Reaction Consistency . . . 70
32.7 Topographic Potential Force . . . 70
32.8 Force Direction Agreement . . . 70
32.9 Force Contribution Fractions . . . 70
32.10 Event-Modified Force Fraction . . . 70
32.11 Force-Architecture Comparison . . . 70

33 Euler-Pole Generation and Plate Rotation 71
33.1 Euler Vectors Must Be Outputs . . . 71
33.2 Plate Inertia Tensor . . . 71
33.3 Euler-Vector Dynamics . . . 71
33.4 Predicted Euler-Pole Direction . . . 71
33.5 Euler-Pole Direction Residual . . . 71
33.6 Angular-Speed Residual . . . 71
33.7 Euler-Vector Covariance Misfit . . . 71
33.8 Euler-Pole Drift . . . 72
33.9 Finite Rotation . . . 72
33.10 Finite-Rotation Residual . . . 72
33.11 Rigid-Motion Adequacy . . . 72
33.12 No Fitted-Pole Causal Credit . . . 72
33.13 Euler-Pole Falsifier . . . 72

34 Absolute and Relative Plate Velocities 72
34.1 Reference-Frame Declaration . . . 72
34.2 Absolute Site Velocity . . . 73
34.3 Absolute-Velocity Misfit . . . 73
34.4 Relative Euler Vector . . . 73
34.5 Relative Boundary Velocity . . . 73
34.6 Relative-Velocity Misfit . . . 73
34.7 Plate-Mean Speed . . . 73
34.8 Direction Residual . . . 73
34.9 Magnitude Residual . . . 73
34.10 Frame-Robust Score . . . 74
34.11 Absolute-Relative Motion Principle . . . 74

35 Acceleration, Deceleration, and Direction Change 74
35.1 Acceleration Field . . . 74
35.2 Speed Evolution . . . 74
35.3 Direction-Change Rate . . . 74
35.4 Motion-Curvature Rate . . . 74
35.5 Change-Point Times . . . 74
35.6 Change-Point Prediction . . . 75
35.7 Change-Point Residual . . . 75
35.8 Event-Linked Direction Change . . . 75

35.9 Event-Linked Speed Change . . . 75
35.10 No Change-Point Selection After Inspection . . . 75
35.11 Acceleration-History Score . . . 75
35.12 Acceleration Falsifier . . . 75

36 Plate-Speed Hierarchy 75
36.1 Observed and Predicted Rankings . . . 76
36.2 Rank Residual . . . 76
36.3 Rank-Correlation Score . . . 76
36.4 Speed-Generation Variables . . . 76
36.5 Dimensionless Speed Predictors . . . 76
36.6 Quasi-Steady Speed . . . 76
36.7 Plate-Specific Flexibility . . . 76
36.8 Leave-One-Plate-Out Prediction . . . 76
36.9 Hierarchy Composite Score . . . 77
36.10 Speed-Hierarchy Falsifier . . . 77

37 Plate Circuits, Junctions, and Global Closure 77
37.1 Relative Euler-Vector Circuit . . . 77
37.2 Circuit-Closure Residual . . . 77
37.3 Triple-Junction Closure . . . 77
37.4 Junction Migration . . . 77
37.5 Global Surface-Area Accounting . . . 77
37.6 Creation and Removal Balance . . . 78
37.7 Global Angular-Momentum Accounting . . . 78
37.8 Net Plate-Rotation State . . . 78
37.9 Closure Composite Score . . . 78
37.10 Global-Closure Falsifier . . . 78

38 Present-Day and Deep-Time Motion Evidence 78
38.1 Motion-Evidence Classes . . . 78
38.2 Present-Day Dataset . . . 78
38.3 Deep-Time Dataset . . . 79
38.4 Temporal Averaging . . . 79
38.5 Present-Day Likelihood . . . 79
38.6 Deep-Time Likelihood . . . 79
38.7 Timescale Coherence . . . 79
38.8 Motion-History Reconstruction . . . 79
38.9 Chronological Motion Residual . . . 79
38.10 No Double Counting . . . 79
38.11 Data-Type Holdout . . . 80
38.12 Timescale Falsifier . . . 80

39 Force, Torque, Power, and Dissipation 80
39.1 Force-Balance Residual . . . 80
39.2 Torque-Balance Residual . . . 80
39.3 Mechanical Power . . . 80
39.4 Total Power . . . 80
39.5 Kinetic-Energy Evolution . . . 80
39.6 Dissipation Components . . . 81
39.7 Nonnegative Dissipation . . . 81
39.8 Power Sufficiency . . . 81
39.9 Global Power . . . 81
39.10 Energy-Reservoir Depletion . . . 81
39.11 Power-Direction Consistency . . . 81
39.12 Physical-Budget Score . . . 81
39.13 Physical-Budget Falsifier . . . 81

40 Motion Counterfactuals and Causal Necessity **81**
40.1 Purpose . . . 82
40.2 Astro-Ballistic No-Event Counterfactual . . . 82
40.3 Impulse Ablation . . . 82
40.4 Boundary-Memory Ablation . . . 82
40.5 Directional-Anisotropy Ablation . . . 82
40.6 Density and Buoyancy Ablation . . . 82
40.7 Thermal and Phase Ablation . . . 82
40.8 Event-Modified Mantle-Flow Ablation . . . 82
40.9 Plate-Tectonic Gravity Ablation . . . 83
40.10 Plate-Tectonic Buoyancy Ablation . . . 83
40.11 Mantle-Traction Ablation . . . 83
40.12 Boundary-Traction Ablation . . . 83
40.13 Inherited-Weakness Ablation . . . 83
40.14 Leave-One-Event-Out Motion Test . . . 83
40.15 Leave-One-Force-Class-Out Test . . . 83
40.16 Hybrid Interaction Ablation . . . 84
40.17 Component Interaction . . . 84
40.18 Causal Contribution Fraction . . . 84
40.19 Motion Causal-Necessity Rule . . . 84
40.20 Motion-Necessity Falsifier . . . 84

41 Motion Complexity and Predictive Tests **84**
41.1 Motion-Specific Complexity Vector . . . 84
41.2 Force-Field Complexity . . . 84
41.3 Coupling Complexity . . . 85
41.4 Memory Complexity . . . 85
41.5 Reference-Frame Complexity . . . 85
41.6 Plate-Specific Parameter Penalty . . . 85
41.7 Motion Information Criterion . . . 85
41.8 Motion Holdouts . . . 85
41.9 Site-Velocity Predictive Score . . . 85
41.10 Euler-Pole Predictive Score . . . 85
41.11 Finite-Rotation Predictive Score . . . 86
41.12 Direction-Change Predictive Score . . . 86
41.13 Negative Motion Predictions . . . 86
41.14 Randomized Motion Nulls . . . 86
41.15 Motion Null Probability . . . 86
41.16 Predictive Superiority . . . 86

42 Plate-Motion Replacement Viability and Falsification **86**
42.1 Motion-Comparison Parameter Set . . . 86
42.2 Motion-Model Viable Set . . . 87
42.3 Astro-Ballistic Motion-Replacement Condition . . . 87
42.4 Hybrid Motion Preference . . . 87
42.5 Motion Equivalence . . . 87
42.6 Motion-Replacement Falsification Matrix . . . 87
42.7 Motion Outcome Classes . . . 87
42.8 Motion-Replacement Decision Rule . . . 87

43 Motion-Comparison Synthesis **88**

44 Competing Mountain-Building Mechanisms **88**
44.1 Mountains as Shared Observations . . . 88
44.2 Plate-Tectonic Mountain-Building Classes . . . 88
44.3 Astro-Ballistic Mountain-Building Classes . . . 88
44.4 Hybrid Orogenic Model . . . 88

44.5 Mountain-Location Comparison . . . 89
44.6 Mountain-Orientation Comparison . . . 89
44.7 Shortening Comparison . . . 89
44.8 Crustal-Thickness Comparison . . . 89
44.9 Elevation and Relief Comparison . . . 89
44.10 Orogenic Chronology . . . 89
44.11 Orogenic Power and Work . . . 89
44.12 Mountain Counterfactual . . . 90
44.13 Mountain Comparison Score . . . 90
44.14 Mountain-Building Falsifier . . . 90

45 Trench, Descent, Bending, and Underthrusting Comparison 90
45.1 Observed Trench State . . . 90
45.2 Plate-Tectonic Trench Classes . . . 90
45.3 Astro-Ballistic Trench Classes . . . 91
45.4 Complete Trench Decomposition . . . 91
45.5 Trench-Axis Comparison . . . 91
45.6 Depth and Width Residuals . . . 91
45.7 Curvature Comparison . . . 91
45.8 Deep-Descent Comparison . . . 91
45.9 Descent Mass Flux . . . 91
45.10 Bending Energy . . . 92
45.11 Underthrust Distance . . . 92
45.12 Trench Chronology . . . 92
45.13 Mechanism Attribution . . . 92
45.14 Trench Comparison Score . . . 92
45.15 Trench Falsifier . . . 92

46 Ridge, Rift, and New-Material-Production Comparison 93
46.1 Observed Ridge and Rift State . . . 93
46.2 Plate-Tectonic Ridge Classes . . . 93
46.3 Astro-Ballistic Ridge Classes . . . 93
46.4 Ridge-Axis Comparison . . . 93
46.5 Opening-Rate Comparison . . . 93
46.6 New-Area Production . . . 93
46.7 Material-Age Field . . . 93
46.8 Ridge-Flank Symmetry . . . 94
46.9 Melt-Production Comparison . . . 94
46.10 Ridge Heat and Composition . . . 94
46.11 Ridge Comparison Score . . . 94
46.12 Ridge Falsifier . . . 94

47 Basin Formation, Subsidence, and Inversion Comparison 94
47.1 Observed Basin State . . . 94
47.2 Plate-Tectonic Basin Classes . . . 94
47.3 Astro-Ballistic Basin Classes . . . 95
47.4 Complete Subsidence Decomposition . . . 95
47.5 Basin Geometry Comparison . . . 95
47.6 Subsidence-History Comparison . . . 95
47.7 Sediment-Accommodation Comparison . . . 95
47.8 Thermal-History Comparison . . . 95
47.9 Basin Inversion . . . 95
47.10 Basin Comparison Score . . . 95
47.11 Basin Falsifier . . . 96

48 Plateau Uplift and Crustal-Thickening Comparison 96
48.1 Observed Plateau State . . . 96

48.2 Plate-Tectonic Plateau Classes . . . 96
48.3 Astro-Ballistic Plateau Classes . . . 96
48.4 Plateau Elevation Decomposition . . . 96
48.5 Plateau-Domain Comparison . . . 96
48.6 Elevation and Root Residuals . . . 96
48.7 Dynamic-Support Prediction . . . 97
48.8 Persistence Comparison . . . 97
48.9 Plateau Comparison Score . . . 97
48.10 Plateau Falsifier . . . 97

49 Volcanic Provinces and Melt-Path Comparison 97
49.1 Observed Volcanic State . . . 97
49.2 Plate-Tectonic Volcanic Classes . . . 97
49.3 Astro-Ballistic Volcanic Classes . . . 97
49.4 Melt-Generation Comparison . . . 98
49.5 Melt-Path Comparison . . . 98
49.6 Volcanic-Domain Comparison . . . 98
49.7 Volume and Rate Residuals . . . 98
49.8 Composition Comparison . . . 98
49.9 Volcanic Chronology . . . 98
49.10 Event-to-Volcanism Lag . . . 98
49.11 Volcanic Comparison Score . . . 98
49.12 Volcanic Falsifier . . . 99

50 Terrane Transfer, Sutures, and Continental Assembly 99
50.1 Observed Terrane State . . . 99
50.2 Plate-Tectonic Assembly Classes . . . 99
50.3 Astro-Ballistic Assembly Classes . . . 99
50.4 Terrane Trajectory Comparison . . . 99
50.5 Terrane-Rotation Comparison . . . 99
50.6 Material-Identity Comparison . . . 99
50.7 Suture Prediction . . . 100
50.8 Assembly Graph . . . 100
50.9 Assembly Chronology . . . 100
50.10 Terrane Comparison Score . . . 100
50.11 Terrane-Assembly Falsifier . . . 100

51 Gravity and Geoid Comparison 100
51.1 Observed Gravity State . . . 100
51.2 Model Density Field . . . 100
51.3 Gravity Prediction . . . 101
51.4 Geoid Prediction . . . 101
51.5 Resolution-Matched Prediction . . . 101
51.6 Gravity Residual . . . 101
51.7 Gravity Misfit . . . 101
51.8 Anomaly-Sign Prediction . . . 101
51.9 Depth-Sensitivity Comparison . . . 101
51.10 Gravity Counterfactuals . . . 101
51.11 Gravity Falsifier . . . 102

52 Seismic Velocity, Attenuation, and Anisotropy 102
52.1 Observed Seismic State . . . 102
52.2 Elastic Prediction . . . 102
52.3 Constitutive Dependence . . . 102
52.4 Attenuation Prediction . . . 102
52.5 Anisotropy Tensor . . . 102
52.6 Forward Observation Operator . . . 102

52.7 Resolution Matching . . . 103
52.8 Seismic Misfit . . . 103
52.9 Corridor-Detection Comparison . . . 103
52.10Anisotropy-Direction Residual . . . 103
52.11Seismic Counterfactuals . . . 103
52.12Seismic Falsifier . . . 103

53 Magnetic and Heat-Flow Comparison 103
53.1 Observed Magnetic and Thermal State . . . 103
53.2 Magnetization Prediction . . . 103
53.3 Magnetic Observation Prediction . . . 104
53.4 Magnetic Residual . . . 104
53.5 Magnetic Resetting Test . . . 104
53.6 Thermal Evolution . . . 104
53.7 Heat-Flow Prediction . . . 104
53.8 Heat-Flow Residual . . . 104
53.9 Thermal-Memory Test . . . 104
53.10Magnetic and Thermal Counterfactuals . . . 104
53.11Magnetic-Heat Comparison Score . . . 105
53.12Magnetic and Heat-Flow Falsifier . . . 105

54 Structural and Geophysical Counterfactuals 105
54.1 Unified Structural State . . . 105
54.2 No-Event Counterfactual . . . 105
54.3 Boundary Counterfactual . . . 105
54.4 Motion Counterfactual . . . 105
54.5 Convergence Ablation . . . 105
54.6 Extension Ablation . . . 106
54.7 Mantle-Flow Ablation . . . 106
54.8 Damage Ablation . . . 106
54.9 Density Ablation . . . 106
54.10Thermal Ablation . . . 106
54.11Phase Ablation . . . 106
54.12Melt and Permeability Ablation . . . 106
54.13Inheritance Isotropization . . . 106
54.14Leave-One-Structure-Class-Out Test . . . 107
54.15Leave-One-Event-Out Structural Test . . . 107
54.16Component Interaction . . . 107
54.17Counterfactual Consistency . . . 107
54.18Structural Causal-Necessity Rule . . . 107
54.19Structural-Necessity Falsifier . . . 107

55 Structural Complexity and Predictive Tests 107
55.1 Structural Complexity Vector . . . 107
55.2 Structure-Specific Parameter Count . . . 108
55.3 Event-to-Structure Assignment Penalty . . . 108
55.4 Lag Complexity . . . 108
55.5 Preservation Complexity . . . 108
55.6 Mechanism-Switching Penalty . . . 108
55.7 Structural Information Criterion . . . 108
55.8 Held-Out Structure Classes . . . 108
55.9 Spatial Holdout . . . 108
55.10Depth Holdout . . . 109
55.11Chronology Holdout . . . 109
55.12Observation-Type Holdout . . . 109
55.13Negative Structural Predictions . . . 109
55.14Structural Predictive Score . . . 109

55.15Randomized Structural Nulls . . . 109
55.16Structural Null Probability . . . 109
55.17Predictive Superiority . . . 109

56 Structural-and-Geophysical Replacement Viability 110
56.1 Structural Comparison Parameter Set . . . 110
56.2 Structural-and-Geophysical Viable Set . . . 110
56.3 Astro-Ballistic Structural Replacement Condition . . . 110
56.4 Hybrid Structural Preference . . . 110
56.5 Structural Equivalence . . . 110
56.6 Structural-and-Geophysical Falsification Matrix . . . 110
56.7 Structural Outcome Classes . . . 110
56.8 Structural Replacement Decision Rule . . . 110

57 Structural and Geophysical Comparison Synthesis 111

58 Chronology-Wide Model Comparison 111
58.1 Chronology Is a Shared Causal Constraint . . . 111
58.2 Global Chronology Vector . . . 111
58.3 Forward-Time Convention . . . 111
58.4 Causal Dependency Graph . . . 111
58.5 Chronological Violation Indicator . . . 111
58.6 Age Residual . . . 112
58.7 Correlated Chronology Misfit . . . 112
58.8 Response-Lag Prediction . . . 112
58.9 Change-Point Comparison . . . 112
58.10Chronological Causal Coverage . . . 112
58.11Temporal Holdout . . . 112
58.12Chronology-Permutation Null . . . 112
58.13Chronology Comparison Score . . . 112
58.14Chronology-Wide Falsifier . . . 113

59 Paleogeographic and Continental-Reconstruction Comparison 113
59.1 Present Geography Is Not the Event-Time State . . . 113
59.2 Shared Paleogeographic Dataset . . . 113
59.3 Model Reconstruction . . . 113
59.4 Centroid Distance . . . 113
59.5 Shape Overlap . . . 113
59.6 Boundary Distance . . . 113
59.7 Rotation Residual . . . 114
59.8 Adjacency Comparison . . . 114
59.9 Material-Identity Residual . . . 114
59.10Paleomagnetic Comparison . . . 114
59.11Fragmentation and Merger Accounting . . . 114
59.12Material Continuity . . . 114
59.13Event-Time Path Test . . . 114
59.14Reconstruction Ensemble . . . 114
59.15Paleogeographic Comparison Score . . . 115
59.16Paleogeographic Falsifier . . . 115

60 Causal Coverage and Explanatory Scope 115
60.1 Coverage Is Not Binary . . . 115
60.2 Observation-Class Registry . . . 115
60.3 Coverage Indicator . . . 115
60.4 Weighted Coverage Fraction . . . 115
60.5 Causal-Depth Levels . . . 115
60.6 Mean Causal Depth . . . 116

60.7 Causal Chain Completion . . . 116
60.8 Unsupported-Link Penalty . . . 116
60.9 Regional-Tuning Penalty . . . 116
60.10Explanatory-Scope Score . . . 116
60.11Scope Falsifier . . . 116

61 Model Evidence, Posterior Ranking, and Equivalence 116
61.1 Model Families . . . 116
61.2 Common Comparison Contract . . . 117
61.3 Marginal Model Evidence . . . 117
61.4 Bayes Factor . . . 117
61.5 Posterior Model Probability . . . 117
61.6 Prior-Sensitivity Analysis . . . 117
61.7 Posterior Predictive Score . . . 117
61.8 Cross-Validated Model Ranking . . . 117
61.9 Integrated Ranking Vector . . . 117
61.10No Unregistered Scalar Rank Averaging . . . 118
61.11Equivalence Interval . . . 118
61.12Ranking Probability . . . 118
61.13Posterior-Ranking Falsifier . . . 118

62 Effective Degrees of Freedom and Description Length 118
62.1 Raw Parameter Count Is Incomplete . . . 118
62.2 Effective-Complexity Ledger . . . 118
62.3 Event-Catalog Complexity . . . 118
62.4 Initial-State Complexity . . . 119
62.5 Boundary-State Complexity . . . 119
62.6 Search-Space Complexity . . . 119
62.7 Revision Description Length . . . 119
62.8 Data Description Length . . . 119
62.9 Total Description Length . . . 119
62.10Causal Compression Ratio . . . 120
62.11Encoding and Logarithm Convention . . . 120
62.12Effective-Flexibility Falsifier . . . 120

63 Sequence-Wide Null Models 120
63.1 Purpose . . . 120
63.2 Null Family . . . 120
63.3 Uniform Spatial Null . . . 120
63.4 Geological-Opportunity Null . . . 121
63.5 Boundary-Conditioned Null . . . 121
63.6 Plate-Preserving Null . . . 121
63.7 Chronology-Permutation Null . . . 121
63.8 Direction-Randomization Null . . . 121
63.9 Event-to-Structure Assignment Null . . . 121
63.10Inherited-State Randomization Null . . . 121
63.11Topology-Preserving Null . . . 121
63.12Reference-Frame Null . . . 122
63.13Complete Null Score . . . 122
63.14Empirical Null Probability . . . 122
63.15Full-Pipeline Null Exchangeability . . . 122
63.16Class-Specific Nulls . . . 122
63.17Null-Model Falsifier . . . 122

64 Multiple Testing, Selection Bias, and Revision Accounting 122
64.1 Complete Search Ledger . . . 122
64.2 Selection Record . . . 123

64.3 Confirmatory Family Definition . . . 123
64.4 Family-Wise Error . . . 123
64.5 False-Discovery Control . . . 123
64.6 Selection-Adjusted Probability . . . 123
64.7 Holdout Depletion . . . 123
64.8 Model-Version Registry . . . 123
64.9 Stopping Rule . . . 124
64.10Selection-Bias Falsifier . . . 124

65 Global Advance-Prediction Comparison 124
65.1 Prediction Registry . . . 124
65.2 Required Prediction Classes . . . 124
65.3 Predictive Distribution . . . 124
65.4 Continuous Predictive Score . . . 124
65.5 Binary Predictive Score . . . 124
65.6 Spatial Prediction Score . . . 125
65.7 Proper-Score Requirement . . . 125
65.8 Calibration . . . 125
65.9 Calibration . . . 125
65.10Resolution . . . 125
65.11Negative Predictions . . . 125
65.12Prospective Validation . . . 125
65.13Prediction Comparison . . . 125
65.14Advance-Prediction Falsifier . . . 126

66 Hybrid Causal Decomposition 126
66.1 Hybrid Models Require Explicit Attribution . . . 126
66.2 Parent Ablations . . . 126
66.3 Parent Necessity . . . 126
66.4 Interaction Difference-in-Differences Diagnostic . . . 126
66.5 Observation-Class Attribution . . . 126
66.6 Dominance Fraction . . . 126
66.7 Hybrid Outcome Classes . . . 127
66.8 Hybrid Complexity Requirement . . . 127
66.9 Hybrid Search and Revision Parity . . . 127
66.10Hybrid Falsifier . . . 127

67 Regional Versus Global Classification 127
67.1 Regional Domains . . . 127
67.2 Regional Viability . . . 127
67.3 Global Viability . . . 127
67.4 Transferability Score . . . 128
67.5 Parameter Heterogeneity . . . 128
67.6 Regional Contribution Fraction . . . 128
67.7 Global Classification Rules . . . 128
67.8 Regional-to-Global Falsifier . . . 128

68 Complete Paper-IV Viability 128
68.1 Eligibility Sets and Qualification Gates . . . 128
68.2 Complete Model Eligibility Set . . . 128
68.3 Astro-Ballistic Eligibility . . . 129
68.4 Shared Parameter Intersection . . . 129
68.5 Posterior Overlap . . . 129
68.6 Complete Adjudication Score . . . 129
68.7 Primary Replacement Condition . . . 129
68.8 Qualification-Gate Conjunction . . . 129
68.9 Hybrid Preference Condition . . . 130

68.10Complete-Viability Decision . . . 130

69 Formal Replacement Decision Tree 130
69.1 Decision Step 1: Mechanical Eligibility . . . 130
69.2 Decision Step 2: Global Reconstruction Eligibility . . . 130
69.3 Decision Step 3: Boundary Viability . . . 130
69.4 Decision Step 4: Motion Viability . . . 130
69.5 Decision Step 5: Structural and Geophysical Viability . . . 131
69.6 Decision Step 6: Chronology and Paleogeography . . . 131
69.7 Decision Step 7: Null and Selection Control . . . 131
69.8 Decision Step 8: Causal Necessity . . . 131
69.9 Decision Step 9: Predictive Performance . . . 131
69.10Decision Step 10: Complexity-Adjusted Preference . . . 131
69.11Decision Step 11: Hybrid Comparison . . . 132
69.12Decision Step 12: Replication . . . 132
69.13Final Outcome Classification . . . 132
69.14Formal Decision Rule . . . 132

70 Paper-IV Claim Ledger 132

71 Complete Paper-IV Falsification Matrix 133
71.1 No Cross-Compensation . . . 133
71.2 Compartmentalized Failure . . . 133

72 Independent Replication Protocol 133
72.1 Replication Level R1: Source and Selection Audit . . . 133
72.2 Replication Level R2: Papers I Through III Handoff . . . 134
72.3 Replication Level R3: Comparison Models . . . 134
72.4 Replication Level R4: Shared Data Freeze . . . 134
72.5 Replication Level R5: Component Comparisons . . . 134
72.6 Replication Level R6: Counterfactuals . . . 134
72.7 Replication Level R7: Null and Selection Analysis . . . 134
72.8 Replication Level R8: Advance Prediction . . . 135
72.9 Replication Level R9: Final Adjudication . . . 135
72.10Repository Structure . . . 135
72.11Required Metadata . . . 135
72.12Replication Statuses . . . 135

73 Integrated Discussion 135
73.1 Paper IV Adjudicates Rather Than Presumes . . . 135
73.2 Continental Drift Is Shared Evidence . . . 136
73.3 Boundary Origin and Motion Maintenance Are Distinct . . . 136
73.4 Astro-Ballistic Replacement Has a Stronger Burden Than Regional Compatibility . . . 136
73.5 Plate-Tectonic Models Also Require Explicit Specification . . . 136
73.6 Initial Conditions Are Explanatory Inputs . . . 136
73.7 Ancient Events May Initiate Without Maintaining . . . 136
73.8 Hybrid Outcomes Are Scientifically Substantive . . . 136
73.9 Chronology and Paleogeography Are Decisive . . . 136
73.10Deep Geophysics Restricts Surface Narratives . . . 137
73.11Prediction Distinguishes Reconstruction From Replacement . . . 137
73.12Regional Failure and Global Failure Must Remain Compartmentalized . . . 137
73.13Paper IV Is a Decision Architecture . . . 137

74 Limitations 137
74.1 Conditional Inputs . . . 137
74.2 No Completed Global Simulation . . . 137
74.3 Comparison-Model Breadth . . . 137

74.4 Astro-Ballistic Catalog Uncertainty . . . 138
74.5 Initial-Condition Uncertainty . . . 138
74.6 Paleogeographic Uncertainty . . . 138
74.7 Constitutive Uncertainty . . . 138
74.8 Computational Scale . . . 138
74.9 Observation Dependence . . . 138
74.10Preservation Bias . . . 138
74.11Selection Risk . . . 138
74.12Model Nonuniqueness . . . 139
74.13Hybrid Nonuniqueness . . . 139
74.14Prediction Availability . . . 139
74.15Bibliographic Production . . . 139
74.16Declared-Scope Limitation . . . 139

75 Conclusions **139**
75.1 Conclusion 1: The Comparison Concerns Causal Organization . . . 139
75.2 Conclusion 2: Eligibility Is Conditional . . . 139
75.3 Conclusion 3: Boundaries and Motion Must Be Compared Separately . . . 140
75.4 Conclusion 4: Initial Conditions Count . . . 140
75.5 Conclusion 5: Ancient Impulse Is Not Permanent Power . . . 140
75.6 Conclusion 6: Surface and Deep Predictions Must Agree . . . 140
75.7 Conclusion 7: Chronology and Paleogeography Can Reject Modern Alignments . . . 140
75.8 Conclusion 8: Causal Necessity Is Required . . . 140
75.9 Conclusion 9: Complexity Must Include Hidden Flexibility . . . 140
75.10Conclusion 10: Null Models Must Preserve Geological Opportunity . . . 140
75.11Conclusion 11: Advance Prediction Is Decisive . . . 141
75.12Conclusion 12: Regional Success Is Not Global Replacement . . . 141
75.13Conclusion 13: Hybrid Preference Requires Joint Necessity . . . 141
75.14Conclusion 14: Equivalence Is an Allowed Result . . . 141
75.15Conclusion 15: Replacement Requires One Shared Model . . . 141
75.16Final Paper-IV Statement . . . 141

AI-Assisted Research Disclosure **141**

Appendix A — Shared Model-Comparison Data Registry **141**

Appendix B — Integrated Model Scorecard **142**

Appendix C — Advance-Prediction Registry Template **142**

Appendix D — Model-Version and Selection Audit Template **142**

Appendix E — Formal Decision Checklist **143**

Appendix F — Figure and Table Production Registry **143**

Appendix G — Paper-V Handoff **143**
Purpose of the Companion Atlas . . . 143
Causal Audit Fields for Paper V . . . 143
Paper-V Handoff State . . . 143
Required Paper-V Relationships . . . 144
Paper-V Status Categories . . . 144
AI Companion Limitation . . . 144

Appendix H — Paper-IV Production Checklist **144**

Paper-IV Working-Draft Freeze Status and Handoff **144**

References **144**

Canonical Corpus and Working-Draft Notice

Series: Astro-Ballistic Chronostratigraphic Sequencing (ABC Sequencing).
Paper: IV of V.
Sole structural authority: Justin B Fine, *Astro-Ballistic Chronostratigraphic Sequencing IV: Astro-Ballistic Chronostratigraphic Sequencing Versus Plate Tectonics*, August 7, 2026, Canonical Corpus Freeze 1.0, `ABC-CF1-2026-08-07`, 245 pages [1].
Current text: North American working manuscript v1.6; neither a final canonical freeze nor a completed empirical adjudication.
Evidence restriction: The North American source package is project Papers I–III and the original Denali calculation files [2–7].
Public disclosure restriction: Mineralogy and proprietary bounce-back or energetic mechanism details are withheld throughout.

The **scientific function, numbered chapter hierarchy, architecture of component comparisons, comparative eligibility criteria, and final claim–falsification–replication handoff** derive from the canonical Paper IV. The observed counterpart paper is not repurposed into a fresh empirical research initiative. No new candidate events, alternative waypoints, field programs, regional hypotheses or unpublished physical mechanisms have been generated.

Declaration of Purpose

This paper performs the original fourth paper's role: receive status-qualified outcomes from Papers I–III and define their conditions for a fair causal comparison against specified plate-tectonic, regional, no-event, randomized and hybrid model families. The comparison concerns *causal explanation* of observations, not the existence of measured plate motion. Preserving the canonical comparative architecture is a structural requirement, not a claim that North America's proposed geometry has already earned a replacement-level result.

Source Status and Citation Policy

The complete original Paper IV [1] controls the chapter titles and conceptual comparison contract. North American Papers I–III [2–4] control the adaptation's own inherited qualification and status. *Denali Exact.pdf* [5] controls the fixed turn, entrance solution, eight-segment northern corridor and reported numerical equality; the segment workbook [6] preserves its segment-distance record. Historical research notes [7] are developmental and do not override the later fixed-turn construction. Internal evidence is not relabeled independent verification. No new scientific source has been introduced in order to populate unavailable North American empirical or energetic fields.

Data, Evidence, and Provenance Convention

The evidence statuses are **author-declared input**, **calculated result under declared metric**, **candidate physical interpretation**, **not evaluated**, and **proprietary/reserved**. In this file, the geographic location choice is a declared or fitted input, whereas resulting distances are computed from the stated rule. A chord-derived equality is neither an independently dated event nor a demonstrated physical event-sequence mechanism. Model scoring, physical predictions, and held-out tests are unexecuted unless a source explicitly reports otherwise.

Paper-IV Comparison-Provenance Snapshot

ID	Content	Origin	Present status
NA-IV-IN-001	Malpelo entrance, near 0.448874° N, 81.429273° W	Denali Exact [5]	Solved entrance coordinate; fitted input
NA-IV-IN-002	Fixed surface turn, 62.3843° N, 146.8997° W	Denali Exact [5]	Selected fixed point, separate from Denali
NA-IV-IN-003	Ordered eight-segment second-leg corridor	Denali Exact [5], workbook [6]	Declared geographic path
NA-IV-RES-001	Entrance-to-turn direct interior chord	Denali Exact [5]	Reported 8,061.8708 km
NA-IV-RES-002	Sum of turn-to-terminal successive interior chords	Denali Exact [5]	Reported 8,061.8708 km
NA-IV-RES-003	Surface turn to Denali first second-leg segment	Denali Exact [5]	Reported 222.678 km
NA-IV-MOD-001	North American event-mechanical forward fields	Papers II–III [3,4]	Reserved / no public computed outputs
NA-IV-DAT-001	Matched global observation package	Papers I–III [2–4]	Not supplied for scored comparison
NA-IV-CTL-001	Frozen reference, hybrid, randomized, and no-event models	Canonical comparison slot [1]	Not implemented for this branch
NA-IV-SCO-001	Comparative predictive / causal score	Requires prior rows	Not calculated

Conditional Adjudication Statement

Matched input arithmetic, carried without rescoring: From the original Denali coordinates and workbook, the selected direct first-leg chord is 8061.870761355 km and the specified eight-segment second-leg chord sum is 8061.870761355 km. Using 222.678 km in place of the unrounded first corridor chord produces a 0.497 m shift relative to the unrounded source-coordinate calculation (or 0.458 m relative to the source PDF total rounded to four decimal places). This is a precision reconciliation within the submitted geometric input, not an independently measured comparison result and not a new model score.

The original Paper IV separates *an eligible causal model* from *one that wins a matched comparative evaluation.* For the present candidate, the source package transmits a complete **declared geometry** but no demonstrated physical causal chain from that geometry to global plate boundaries, velocities, or structures. Accordingly neither eligibility for global replacement nor the comparison outcome is declared. The absence of an evaluated field is not relabeled a physical failure, and it is not silently repaired by speculative physical content.

Epistemic Status and Claim-Language Convention

Use *calculated correspondence* for equal-distance arithmetic, *proposed role* for the entrance–turn–terminal interpretations, and *not evaluated* for unrun mechanics, reconstruction, prediction, and model comparison. Comparative *non-qualification* differs from rejection after a completed falsification. The paper retains the canonical distinction among authorial selection, geodetic calculation, independent observation, physical simulation, prediction, and causal adjudication.

Prediction, Falsification, and Decision-Threshold Convention

The canonical threshold classes, model-version freezes and compartmentalized rejection architecture remain unchanged. No new threshold or significance value is chosen to fit the Denali case. All causal judgments would require actual observations, outputs, uncertainties, alternative models, and a registered decision criterion. This draft does not propose a new research program; it retains the existing one as a structural comparison template.

Causal-Chain, Assumption, and Alternative-Explanation Convention

The established calculation is the numerical consequence of the project's selected coordinate/path metric. All further causal edges—physical event, sustained response, tectonic boundary, structural expression, historical chronology and replacement—have separate evidential requirements. A completed calculation may establish its narrow algebraic relationship even while these subsequent causal questions remain open.

Abstract

This North American mirror of ABC Sequencing IV preserves the fourth canonical paper's role as a direct causal comparison and replacement-adjudication manuscript. Its case-specific record is the Malpelo entrance, an author-fixed geometric turn near Denali, and an ordered eight-chord continuation to an Arctic terminal coordinate. Within the reported calculation, the direct first-leg interior chord equals the aggregate second-leg segment chords to the stated precision, with Denali approximately 222.678 km beyond the turn. These are results of a declared, partly fitted coordinate construction. The prior North American drafts do not supply a physical response model or matched geodynamic observations sufficient for a numerical comparative result. Paper IV therefore retains the original definitions, scoring domains, model-family alternatives, parameter and selection accounting, boundary and motion distinctions, geological comparison chapters, decision logic, replication framework, and Paper-V handoff without asserting uncomputed findings. Restricted mineralogy and energetic mechanisms remain undisclosed. The document is one complete **first-draft manuscript** in a staged five-paper corpus, not a scientific freeze or empirically decided replacement case.

Keywords: ABC Sequencing; North America; Malpelo; Denali; equal-chord geometry; comparative causality; model selection; plate tectonics; structural mirror; scientific provenance.

1 The Adjudication Mandate

This paper follows the ABC source corpus in separating formal eligibility from relative explanatory qualification. The North American candidate contributes one measured-in-the-working-record geometric construction, not a presumption of global replacement. Competing models are not rejected by rhetorical comparison or by a favorable coordinate alignment.

1.1 Canonical Corpus Terminology

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

1.2 Paper IV Defines the Decision Protocol

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

1.3 The Comparison Is Not Between Motion and No Motion

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

1.4 Replacement Requires More Than Compatibility

The working-source result is a geometric equality obtained after solving one entrance coordinate to match a prescribed eight-segment corridor. That fact is a valid **source-defined numerical construction** but has no directly measured model-discrimination score. The supplied Denali files do not contain matched forward predictions or performance values for an alternative physical model. The canonical replacement/adjudication heading is retained; **no replacement verdict follows from the fitted geometry**.

1.5 Adjudication Questions

For this North American record, the presently answerable question is narrow: do the specified coordinates and spherical-chord operations reproduce the reported **8,061.8708 km versus 8,061.8708 km** equality? The first leg is one direct chord; the second is eight summed chords, and the entrance was fitted. The separate questions of physical occurrence, geological history, and relative model performance are **not answered by the supplied materials**. No new test program is specified here.

1.6 Allowed Final Outcomes

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

2 Conditional Handoff From Papers I Through III

North American Paper I transmits the solved entrance coordinate, fixed turn and cumulative northern chord path. Paper II carries the same geometry without an implemented public physical mechanism; Paper III records the consequent absence of global motion and surface forward fields. This is the exact conditional status entering Paper IV.

Controlling equal-leg definition. Let E be the solved Malpelo entrance, T the fixed turn, and $Q_1, \dots, Q_8$ the ordered second-leg waypoints ending at the Arctic terminal. For the document's spherical reference model,

$$\theta(A,B) = 2\arcsin\left[\sqrt{\sin^2\frac{\phi_B-\phi_A}{2} + \cos\phi_A\cos\phi_B\sin^2\frac{\lambda_B-\lambda_A}{2}}\right], \qquad c(A,B) = 2R\sin\left(\frac{\theta(A,B)}{2}\right).$$

The compared lengths are *not two endpoint-to-endpoint geodesic chords*. Rather,

$$L_1 = c(E,T), \qquad L_2 = \sum_{j=1}^{8} c(Q_{j-1}, Q_j), \qquad Q_0 = T, \qquad \Delta L = L_1 - L_2.$$

The controlling source reports $L_1 \approx L_2 \approx 8061.8708$ km and $\Delta L \approx 0$ km at printed precision after solving E for equality [5,6]. A claimed zero is an internal rounding-level identity of the *selected construction* and not an independently generated sampling probability. The separate Denali waypoint is displaced from T by the first second-leg chord $c(T, Q_1) \approx 222.678$ km [5].

Corridor second-leg segment	Reported chord length (km)
Turn → Denali	222.678
Denali → Juneau	1,041.564
Juneau → Unalaska	2,019.168
Unalaska → Adak	714.524
Adak → Amchitka	192.565
Amchitka → Attu	538.553
Attu → under-Siberia station	2,228.589
Under-Siberia station → Arctic terminal	1,104.229

These printed individual values are rounded and should not be used as higher-precision substitutes for the controlling source totals. The workbook is the numerical lineage, not an independently produced Earth-observation dataset.

Handoff domain	Available evidence	Transferred status
Paper I geometry	Fixed turn, solved Malpelo entrance, eight successive chords	Source-derived / fitted-coordinate calculation
Paper II mechanics	No released event-specific physical solution	Reserved / not evaluated
Paper III global reconstruction	No published boundary, motion or physical-structure outputs	Not evaluated
Paper IV comparison	No matched forward models or held-out datasets	No numerical comparative outcome

2.1 Paper-I Handoff

Geometry received: $R = 6{,}371\,\text{km}$, the author-fixed turn M, the entrance E **fitted** to the prescribed second-leg target, and eight ordered northern chord segments. Under the declared metric, $L_1 = c(E,M) \simeq L_2 = \sum_{k=0}^{7} c(W_k, W_{k+1}) \simeq 8{,}061.8708\,\text{km}$; Denali is displaced $222.678\,\text{km}$ from the turn along the first downstream chord. This is a reproducible **source-constructed geometric equality**, not an independent observation or a comparative-model score. The source PDF and seven-row downstream workbook remain the controlling numerical references.

2.2 Paper-II Handoff

Mechanics status received: The existing Paper-II structure retains its canonical branch, conservation, entry, interior-response, terminal, and survival slots, but the supplied Denali records do not populate them with a completed North American physical simulation or empirical admissibility result. Paper IV therefore receives

no positive or negative mechanical verdict, no mechanical likelihood, and no response field eligible for a scored causal comparison. The geometric waypoint-to-waypoint chords are not substituted for mechanical outputs; excluded proprietary mechanics and mineralogy remain omitted.

2.3 Paper-III Handoff

Reconstruction status received: Paper III preserves the canonical event-sequence and geological-reconstruction framework but inherits no computed North American post-event state from Paper II. The present-coordinate corridor is not an event-time material trajectory, plate-motion series, or dated geological history. Accordingly Paper IV receives **no calculated North American global-reconstruction residual, reconstructed plate network, or independently tested chronology** to score. No additional past Earth state is assumed.

2.4 Combined Handoff

The three earlier papers contribute **different** records: Paper I transfers the author-fixed turn, fitted entrance, route and reproducible chord/arc arithmetic; Paper II transfers the status *mechanical outcome not supplied*; Paper III transfers the status *time-indexed geological reconstruction not supplied*. Their combined presence in this manuscript does not constitute three independent lines of causal confirmation. They are eligible for source auditing but do not supply matched comparative-model inputs or observations.

2.5 Handoff Integrity

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

2.6 Handoff Eligibility

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

3 Model-Family Definitions

The original model-family categories are preserved as comparison categories, not introduced as fresh North American research lines. The manuscript contains no computed plate-tectonic implementation, event-forcing implementation, hybrid or randomly generated comparison sample. Mathematical family distinctions are retained without pretending a model run exists.

3.1 Plate-Tectonic Comparison Family

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

3.2 Astro-Ballistic Model Family

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

3.3 Hybrid Model Family

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

3.4 Regional Event Model

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

3.5 No-Event Baseline

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

3.6 Randomized-Event Models

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

3.7 Model Nesting

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

3.8 No Undefined Umbrella Model

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional

mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

3.9 Alternative-Explanation Family Completeness

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

4 The Shared Observation Domain

The shared evidence universe is that of the canonical paper: observed boundaries, geodesy, continental reconstruction, topography, trenches, basins, and deep geophysical measurements. The project files furnish fixed modern coordinate selections and calculated distances, not a frozen common observational catalog.

4.1 Complete Observation Vector

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

4.2 Boundary Observations

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

4.3 Motion Observations

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

4.4 Continental Reconstruction Observations

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

4.5 Surface-Structure Observations

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

4.6 Deep Geophysical Observations

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

4.7 Shared Data Freeze

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

4.8 Observation Independence

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

4.9 Shared Evidence Principle

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

5 Observational, Kinematic, and Causal Levels

An author-selected path can be represented geometrically without asserting that a path generated a boundary, plate velocity or global tectonic history. The canonical ladder keeps those steps distinct. In the present handoff, the reproducible item is geometric; higher causal levels remain candidates rather than measured results.

5.1 Level L0: Observation

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

5.2 Level L1: Representation

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

5.3 Level L2: Kinematic Reconstruction

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

5.4 Level L3: Dynamic Maintenance

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

5.5 Level L4: Boundary-Origin Causation

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

5.6 Level L5: Historical Global Organization

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

5.7 Level L6: Predictive Replacement

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

5.8 Comparison by Level

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

5.9 No Kinematic-to-Causal Shortcut

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

6 Fair-Comparison Rules

The matched-comparison rules retain their original function. Neither the Plate-Tectonic family nor the event-sequence family receives a weaker evidential burden, and neither is awarded or denied an outcome before implementation. The North American geographic fitting history remains visible to both sides of any later comparison.

6.1 Rule 1: Same Observation Domain

The current case data actually supplied to this mirror consist of a present-day fitted entrance coordinate, fixed turn, prescribed northern stations, a direct entrance-to-turn chord, and a sum of eight consecutive second-leg chords. Those quantities define the **available observation/input domain** for the inherited comparison section. They do not constitute a matched observation dataset of boundaries, plate velocities, geologic dates or deep material fields. The canonical rule remains unchanged: future physical model scores cannot be copied into the current geometry register or compared against unsupplied data.

6.2 Rule 2: Same Data Partition

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

6.3 Rule 3: Same Uncertainty Standards

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

6.4 Rule 4: Same Reference Frames

In the supplied numerical material, the common frame for geometric calculation is a sphere of radius $R = 6{,}371$ km with latitude and east-positive longitude. The fitted entrance and the fixed turn are expressed in that frame; the second leg combines separately defined endpoint chords. Paper I's angular and chord formulas, Paper II's inherited route variables, Paper III's present-day station vectors, and Paper V's equation registry must refer to **the same geometric metric**. This is a source-to-source consistency requirement, not a completed comparison of event-time geographic reference frames.

6.5 Rule 5: Same Chronology Standards

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

6.6 Rule 6: Same Physical Constraints

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

6.7 Rule 7: Same Prediction Freeze

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

6.8 Rule 8: Same Complexity Accounting

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

6.9 Rule 9: Same Failure Visibility

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

6.10 Rule 10: Strongest Defensible Comparison

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

6.11 Rule 11: No Gap-Based Proof

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

6.12 Rule 12: No Asymmetric Burden

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

6.13 Rule 13: Assumption and Intervention Parity

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

6.14 Rule 14: No Strawman or Gap Filling

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

6.15 Rule 15: Measurement-Proximal Evidence Is Not a Reconstruction Output

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

6.16 Rule 16: No Privileged Paleogeography

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

6.17 Rule 17: Material-Lineage Parity

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

6.18 Rule 18: Chronology-Branch Accounting

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

6.19 Rule 19: No Side-by-Side Causal Substitution

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

6.20 Rule 20: Specific Initiating-Age Integrity

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

6.21 Rule 21: No Credit or Penalty for Scope-Reserved Hypotheses

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

6.22 Rule 22: Compare Implementations, Not Literature Narratives

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

7 Parameter, Prior, and Model-Input Registry

The source's author-fixed turn and final route points are declared modeling choices, while the solved entrance is a fitted model input. They therefore count as modeling freedom. No event impulse, material field, parameter prior, uncertainty covariance, or independent sampling law is supplied by the Denali project files.

Model input or parameter	Denali source status	Complexity treatment
Turn coordinate	Fixed author choice	Declared input
Second-leg path and station order	Fixed corridor	Declared input
Malpelo entrance latitude/longitude	Solved for equal distance	Fitted input
Physical impulse or bounce-back response	Not disclosed	Reserved, not zero
Geological chronology and kinematics	Not supplied	Not evaluated
Independent observation covariance	Not supplied	Not evaluated

7.1 Model Parameter Vectors

The supplied input/fitting ledger is

$$\mathcal{G} = (R,\ M,\ W_1, \dots, W_8;\ E_{\text{fitted}}), \qquad L_2 = \sum_{k=0}^{7} c(W_k, W_{k+1}), \quad W_0 = M,$$

where $R = 6{,}371$ km, M and the ordered second-leg stations come from *Denali Exact.pdf*, and E_{fitted} is the solved Malpelo-region entrance. This notation **records the existing geometric inputs**, not a fitted physical event-parameter vector. No physical-model likelihood, prior, comparative score or effective parameter penalty is available from the supplied calculations.

7.2 Astro-Ballistic Event Parameters

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

7.3 Plate-Tectonic Initial-State Parameters

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

7.4 Prior Distribution

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

7.5 Prior Sources

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

7.6 No Fit-Dependent Physical Bound

The same fit-conditional geometry underlies all four upstream North American drafts: a prescribed turn and northern route define the cumulative chord target, and the Malpelo-region entrance is solved to match it. The resulting $L_1 - L_2 \simeq 0$ is **not** an independent bound on physical transmission, event timing, or a comparison model's likelihood. In particular, the fitted length cannot enter an adjudication score as an independently predicted target. The supplied sources contain no fit-independent mechanical or comparative bound.

7.7 Parameter Identifiability

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

7.8 Shared Parameter Audit

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

8 Likelihood and Observational Adequacy

A geometric zero difference is not a likelihood comparison between causal models. Prediction residuals and their measurement error distributions require independent observations and forward outputs. The current source set supports neither model-level log-likelihood nor posterior ranking.

For each model implementation M, the canonical residual is defined against the same observation vector $\mathbf{d}$:

$$\mathbf{r}_M = \mathbf{d} - \mathbf{f}_M(\theta_M).$$

A quadratic likelihood term can only be computed after a measurement covariance Σ and model prediction $\mathbf{f}_M$ have been supplied:

$$-2 \log L_M = \mathbf{r}_M^{\mathsf{T}} \Sigma^{-1} \mathbf{r}_M + \log |2\pi\Sigma|.$$

Here both the comparable prediction vector and frozen shared covariance are absent, so no North American likelihood is evaluated.

External context: E13 | bibliography: Appendix EC

8.1 Model Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

8.2 Residual Vector

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

8.3 Gaussian Observation Likelihood

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

8.4 Observation-Class Likelihoods

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

8.5 Class-Specific Misfits

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

8.6 No Global-Score Concealment

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

8.7 Residual Structure

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

8.8 Residual Autocorrelation

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

8.9 Observational Adequacy

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global

observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

9 Physical and Causal Adequacy

The canonical physical penalties and causal ablation tests remain in place. The source-supplied chord equality is a constraint on the selected geometry, not a conservation verification, dynamical feasibility calculation or counterfactual causal contribution. Private energetic content remains outside this public document.

9.1 Physical Residual Vector

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

9.2 Physical Penalty

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

9.3 Causal Necessity

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

9.4 Causal Necessity Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

9.5 Astro-Ballistic Necessity Test

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

9.6 Plate-Tectonic Component Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

9.7 Intervention-Coherence Gate

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain

that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

9.8 Mediation and Interaction Accounting

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

9.9 Causal Dominance

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

9.10 Causal Adequacy Principle

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

10 Model Complexity and Causal Compression

Effective complexity includes chosen waypoints, metric definitions, coordinate search, and later model revisions, not only printed scalar parameters. In the Denali construction the midpoint and corridor were fixed and an entrance was solved to satisfy the equal-leg condition. This choice must count as fitting information, not as a preregistered independent discovery.

The canonical complexity accounting may be represented schematically as model complexity plus initial-state, search and revision description lengths. This expression is a comparison convention, not an evaluated North American score:

$$K_{\text{effective}} \neq K_{\text{printed parameters}} \quad \text{when fitted geometry and search decisions are present.}$$

The solved entrance is a known fitted choice and must be recorded before any complexity-adjusted claim.

10.1 Raw Parameter Count

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

10.2 Effective Parameter Count

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

10.3 Event Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

10.4 Initial-Condition Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

10.5 Boundary-Condition Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

10.6 Manual-Assignment Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

10.7 Mechanism-Switching Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

10.8 Model Revision Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

10.9 Information Criteria

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

10.10 Bayesian Evidence

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

10.11 Causal Compression

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

10.12 Compression Failure

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

11 Predictive Performance

The original source distinguishes retrospective fit from frozen advance prediction. No new North American out-of-sample location, independent geophysical signal, age field or withheld structural map is published in this draft. Thus predictive scoring fields remain available but unscored.

For a frozen predictive distribution $p_M(y \mid D_{\text{train}})$, the source's proper log-score concept is

$$S_M(D_{\text{test}}) = \sum_{i \in D_{\text{test}}} \log p_M(y_i \mid D_{\text{train}}).$$

The Denali source contains no independently hidden D_{test} prediction set. In particular, waypoint locations selected while constructing the second leg cannot retrospectively become a test cohort.

11.1 Prediction Versus Reconstruction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

11.2 Training, Validation, and Test Data

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

11.3 Predictive Distribution

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

11.4 Predictive Log Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

11.5 Spatial Holdout

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

11.6 Temporal Holdout

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

11.7 Observation-Type Holdout

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

11.8 Negative Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

11.9 Calibration

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

11.10 Predictive Superiority

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

11.11 Decision-Threshold Freeze

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

12 Replacement Standards

The replacement ladder is held at the same thresholds used in the canonical source, but no North American replacement standard is declared satisfied. Local geometry has its own source-derived truth conditions; it does not

automatically inherit replacement-level standards or their verdicts.

Canonical outcome level	What would qualify	Current North American status
Geometric correspondence	Declared chord convention and reproducible arithmetic	Reported in source [5,6]
Mechanical eligibility	Explicit causal forward solution	Not evaluated / reserved
Regional physical contribution	Independent matched regional outputs	Not evaluated
Global explanatory superiority	Fair matched comparative predictions	Not evaluated
Primary replacement	All eligible, predictive and replication gates	Not established

12.1 Standard R0: Compatibility

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.2 Standard R1: Observational Equivalence

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.3 Standard R2: Causal Necessity

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.4 Standard R3: Novel Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.5 Standard R4: Complexity Control

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.6 Standard R5: Physical Coherence

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.7 Standard R6: Global Coverage

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.8 Standard R7: Replication

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.9 Primary Replacement Condition

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.10 Complementarity Condition

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.11 Regional Condition

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

12.12 Model-Version Rejection Versus Replacement Non-Qualification

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

13 The Hybrid-Model Question

The existence of a hybrid-model slot is part of the canonical comparison, not a recommendation to invent one. Parent recovery, model nesting and conditional interactions remain undefined for the North American candidate because no physical event model was released for comparison.

13.1 Hybrid Models Are Not Automatic Compromises

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

13.2 Hybrid State

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

13.3 Interaction Term

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

13.4 Hybrid Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

13.5 Hybrid Ablations

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

13.6 Hybrid Identifiability and Parent Recovery

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

13.7 Hybrid Causal Classification

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

13.8 Hybrid Preference Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

14 Pre-Registration and Model Freeze

The submitted coordinate choice is retrospective, including the solved entrance for equality. The model-freeze chapter preserves that provenance. This draft is itself a pre-refinement manuscript, not an empirical preregistration or a final frozen comparison package.

14.1 Required Freeze Package

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

14.2 Freeze Record

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

14.3 Model Revision After Freeze

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

14.4 Exploratory and Confirmatory Results

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

14.5 Adjudication Integrity Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

15 Initial Paper-IV Score Architecture

The original score architecture lists separate goodness-of-fit, physical, complexity, predictive, null and causal components. No numerical score weights or comparative winner are generated from the Denali coordinate table. Noncomputed terms remain blank rather than being set to zero.

External context: E15 | bibliography: Appendix EC

The source paper keeps fit, physics, complexity, prediction, nulls and causal necessity separate. A symbolic bookkeeping form is

$$S_{\text{integrated}} = F_{\text{observations}} - P_{\text{physical}} - P_{\text{complexity}} + S_{\text{prediction}} - P_{\text{null}} - P_{\text{necessity}},$$

with the exact normalization, signs and weights to be frozen by the comparison contract. This is an *architectural placeholder* and is not a numerical Denali result.

15.1 Global Fit Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

15.2 Physical Penalty

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

15.3 Complexity Penalty

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

15.4 Prediction Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

15.5 Null-Model Penalty

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

15.6 Causal-Necessity Penalty

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain

that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

15.7 Integrated Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

15.8 Score Difference

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

15.9 Uncertainty in Model Ranking

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

16 Initial Paper-IV Falsification Architecture

The original falsification positions are preserved separately by claim. An unrun or unregistered test has no adverse test result, just as an exact conditional geometric identity supplies no empirical evidence for a later physical claim. Negative decisions require their corresponding completed tests.

16.1 Paper-IV Primary Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

16.2 Eligibility Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

16.3 Observation-Domain Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

16.4 Physical Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

16.5 Complexity Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

16.6 Prediction Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

16.7 Causal-Necessity Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

16.8 Hybrid Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

16.9 Plate-Tectonic Comparison Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

16.10 Indistinguishability Result

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

17 Comparative Framework Synthesis

The first synthesis fixes the document's interpretation: a geographical relation is established at the geometric level under declared choices, whereas causal event generation and relative global explanatory superiority are not reported. The remainder retains the original paper's component-wise comparisons.

This is a single integrated synthesis or ledger chapter in the canonical hierarchy; it has no independently numbered subsections in the original table of contents. The available North American source contains exact geometric constructions but no frozen comparative model implementation.

18 Competing Boundary-Generation Mechanisms

The canonical boundary-origin investigation concerns a forward physical boundary-generation field, not simply selected points along a geographic corridor. The source-solved Malpelo entrance and specified subsequent route stations do not constitute a predicted global boundary network.

18.1 Boundary Origin Is a Primary Replacement Test

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

18.2 Observed Boundary State

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

18.3 General Boundary-Generation Operator

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

18.4 Plate-Tectonic Boundary-Generation Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

18.5 Astro-Ballistic Boundary-Generation Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

18.6 Hybrid Boundary Generation

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

18.7 Boundary-Origin Record

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-

matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

18.8 Boundary-Generation Burden

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

18.9 No Boundary-by-Boundary Mechanism Assignment

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

19 Inherited Versus Emergent Boundaries

A boundary that exists at the present surface cannot be classified as event-created rather than inherited solely by its proximity to one chosen waypoint. The source files give no pre-event boundary state or transition-state mapping.

19.1 Boundary Categories

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

19.2 Boundary-Origin Indicator

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

19.3 Inherited-State Information

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

19.4 Emergence Distance

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

19.5 Boundary Information Retention

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

19.6 Event-Created Boundary Test

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

19.7 Inherited Plate-Tectonic Boundary Test

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

19.8 Origin Attribution Fractions

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

19.9 Inherited-versus-Emergent Decision

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

20 Initial-Condition Information Content

The distance-calibrated first leg encodes selection information: the new Malpelo entrance was solved after retaining the fixed turn and second-leg path. The original initial-state complexity apparatus remains applicable in principle; no information-content statistic has been computed.

20.1 Initial Conditions Are Part of the Model

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

20.2 Initial-State Description Length

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and

selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

20.3 Boundary-Field Information

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

20.4 Observed-Network Similarity

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

20.5 Information Gain

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

20.6 Event-Catalog Information

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

20.7 Plate-Tectonic Initial-Structure Information

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

20.8 Boundary-Origin Compression

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

20.9 Initial-Condition Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

20.10 Initial-Condition Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

21 Boundary Location and Orientation Comparison

No global predicted boundary-coordinate set exists in the public Paper I–III handoff. Accordingly the original boundary distance, orientation, width and length-based residual positions cannot be populated. The corridor waypoints are not substituted for global boundary predictions.

If a boundary model supplies predicted set B_M and independent observed set B_{obs}, the comparison can count false-positive/negative boundary lengths and spatial-orientation residuals as in the canonical source. Neither set is reconstructed by summing corridor chords; no set-distance score is claimed.

21.1 Predicted Boundary Sets

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

21.2 Directed Boundary Distance

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

21.3 False-Negative Boundary Length

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

21.4 False-Positive Boundary Length

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

21.5 Boundary Precision and Recall

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

21.6 Orientation Field

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

21.7 Curvature Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

21.8 Boundary-Width Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

21.9 Spatially Stratified Scores

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

21.10 Location-Orientation Composite

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

21.11 Boundary-Geometry Decision

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

22 Boundary Type and Relative-Motion Comparison

Relative plate velocity and boundary type are material and kinematic fields. The Denali source lists geographical station coordinates; it does not assign plate-domain velocity vectors or predicted convergent, divergent or transform behavior to each corridor segment.

22.1 Relative Velocity

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

22.2 Boundary-Type Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

22.3 Classification Classes

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

22.4 Type Confusion Matrix

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

22.5 Length-Weighted Type Accuracy

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

22.6 Normal-Velocity Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

22.7 Relative-Motion Misfit

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

22.8 Kinematic Sign Accuracy

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

22.9 Obliquity Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

22.10 Boundary-Work Consistency

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

22.11 Type-Motion Composite Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

22.12 Boundary-Type Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

23 Boundary Age, Reactivation, and Termination

The 64 Ma program label is not by itself a measured initiating age. Neither the first nor the second leg carries the initiation, reactivation and termination date series needed for these canonical tests.

23.1 Boundary Chronology Vector

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

23.2 Initiation-Age Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

23.3 Reactivation-Age Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

23.4 Termination-Age Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

23.5 Chronological Likelihood

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

23.6 Reactivation Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

23.7 Reactivation Classification

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

23.8 Reactivation Confusion Matrix

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

23.9 Boundary Lifetime

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

23.10 Termination Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

23.11 Survival Analysis

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

23.12 Chronology Composite Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

23.13 Chronology Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

24 Global Boundary Graph and Plate Partition

A corridor containing eight consecutive second-leg segments is a path graph, but it is not a global plate-boundary graph. Node degrees and graph cycles of the path cannot be scored as predictions of continental plate enclosure.

A graph comparison requires a fully specified boundary graph $G_M = (V_M, E_M)$ and observed graph G_{obs}. The ordered geographic corridor is a linear route only. Reinterpreting its vertices as the world's tectonic junctions would change the input object and is prohibited.

24.1 Observed and Predicted Graphs

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

24.2 Node and Edge Residuals

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

24.3 Connected Components

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

24.4 Cycle Rank

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

24.5 Plate-Face Count

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

24.6 Plate-Area Distribution

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

24.7 Plate-Perimeter Distribution

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

24.8 Degree Distribution

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

24.9 Adjacency Matrix

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

24.10 Graph Spectral Distance

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

24.11 Junction Geometry

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

24.12 Plate-Enclosure Completeness

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

24.13 Manual Gap-Filling Fraction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

24.14 Global Graph Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

24.15 Graph-Partition Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

25 Continental Margins and Ocean Basins

The endpoint and route traverse geographic areas with mapped coastlines and oceanic domains; the files provide no forward margin opening, crustal thinning, age or basin subsidence history. Paper IV's paired-margin burden is not replaced by map resemblance.

25.1 Margin Observation Vector

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

25.2 Basin Observation Vector

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

25.3 Competing Margin-Origin Models

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings.

25.4 Paired-Margin Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

25.5 Opening-Width Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

25.6 Crustal-Thinning Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

25.7 Basin Subsidence Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

25.8 Subsidence-History Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

25.9 Material-Age Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

25.10 Margin-Asymmetry Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

25.11 Margin-Basin Composite Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

25.12 Continental-Margin Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

26 Boundary Counterfactuals and Causal Necessity

The source original compares with and without candidate initiating forcing and inherited states. None of those physical intervention branches has been run for North America. The availability of an exact distance match does not supply an event-removal simulation.

26.1 Purpose

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

26.2 Astro-Ballistic No-Event Counterfactual

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.3 Event-Impulse Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.4 Damage Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.5 Thermal and Phase Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.6 Density Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.7 Initial-Weakness Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.8 Mantle-Forcing Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain

that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.9 Gravity and Buoyancy Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.10 Boundary-State Randomization

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

26.11 Leave-One-Event-Out Boundary Test

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

26.12 Leave-One-Mechanism-Out Test

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

26.13 Boundary Causal Contribution Fractions

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.14 Interaction Necessity

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.15 Boundary Necessity Rule

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

26.16 Causal-Necessity Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

27 Boundary Complexity and Predictive Tests

Scoring of boundary predictions requires frozen boundary locations not selected to correspond to modern geography. The Malpelo-to-turn chord and turn-to-Arctic corridor have known selection history, so the same stations cannot be counted as a clean spatial holdout.

27.1 Boundary-Specific Complexity Vector

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

27.2 Boundary Threshold Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

27.3 Boundary-Assignment Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

27.4 Gap-Bridging Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

27.5 Initial-Network Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

27.6 Boundary Information Criterion

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

27.7 Boundary Predictive Holdouts

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

27.8 Location Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

27.9 Boundary Detection Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

27.10 Boundary Distance Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

27.11 Type Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

27.12 Chronology Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

27.13 Negative Boundary Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

27.14 Boundary Calibration

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

27.15 Boundary Predictive Superiority

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

27.16 Randomized-Boundary Nulls

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

27.17 Boundary Null Probability

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

28 Boundary-Replacement Viability and Falsification

The boundary comparison verdict follows successful computation of the required component tests; here, the absence of a North American boundary field leaves the classification not evaluated. The geometric claim remains intact at its own narrower level.

28.1 Boundary Comparison Parameter Set

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

28.2 Boundary-Model Viable Set

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

28.3 Boundary-Replacement Condition

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

28.4 Hybrid Boundary Preference

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-

matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

28.5 Boundary Equivalence

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

28.6 Boundary Comparison Matrix

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

28.7 Boundary Outcome Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

28.8 Boundary Replacement Decision Rule

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

29 Boundary-Comparison Synthesis

The boundary synthesis carries no favorable or adverse global boundary-generation verdict. It records the preserved comparison slots, source input geometry, selection disclosures and open predictions before the motion sequence begins.

This is a single integrated synthesis or ledger chapter in the canonical hierarchy; it has no independently numbered subsections in the original table of contents. A location chosen along the path does not independently predict the geometry, age, topology, or dynamical class of a plate boundary.

30 Competing Plate-Motion Mechanisms

The canonical motion comparison acknowledges measured plate motion as shared evidence. A sequence model must generate rather than simply redescribe the motion field. The Denali source supplies no event-derived Euler vectors or time histories.

30.1 Motion Is Shared Evidence

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global

observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

30.2 General Plate-Motion Operator

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

30.3 Plate-Tectonic Motion Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

30.4 Astro-Ballistic Motion Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

30.5 Hybrid Motion Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

30.6 Motion-Origin Record

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

30.7 Motion-Generation Burden

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

30.8 No Independent Plate-by-Plate Motion Law

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

31 Initial Impulse Versus Sustained Forcing

The original distinction between impulse and maintained forcing is scientifically material. The user has withheld energetic bounce-back mechanics; accordingly the chapter retains its comparative concept but supplies no dynamical law, timescale or energy budget for the North American candidate.

31.1 Impulse and Force Are Distinct

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

31.2 Angular Impulse

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

31.3 Post-Impulse Evolution

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

31.4 Reduced Velocity-Relaxation Model

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

31.5 Velocity-Relaxation Time

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

31.6 Impulse-Memory Fraction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

31.7 Directional-Memory Fraction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

31.8 Sustained-Force Fraction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

31.9 Impulse Sufficiency Ratio

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

31.10 Maintenance Sufficiency Ratio

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

31.11 No Perpetual-Impulse Assumption

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

32 Gravity, Buoyancy, Mantle Flow, and Boundary Traction

The original decomposition prevents historical initiation from being confused with ongoing power. This public mirror does not populate forces, coupling coefficients or torque distributions. The chord table supplies lengths only.

32.1 Complete Force Decomposition

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

32.2 Gravitational Force

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

32.3 Buoyancy Force

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

32.4 Mantle Traction

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

32.5 Boundary Traction

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

32.6 Action–Reaction Consistency

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

32.7 Topographic Potential Force

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

32.8 Force Direction Agreement

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

32.9 Force Contribution Fractions

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

32.10 Event-Modified Force Fraction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

32.11 Force-Architecture Comparison

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

33 Euler-Pole Generation and Plate Rotation

A plate Euler pole is not a great-circle waypoint or a route bearing. The North American case contains no independently generated angular-velocity vector, inertia tensor for plate domains, or modeled motion history.

In the source's angular-velocity language, the rigid-plate kinematic relation is of the form $\mathbf{v}(\mathbf{r}) = \omega \times \mathbf{r}$. Neither ω nor a plate-domain velocity field is solved by the Denali length equality. Therefore an Euler-pole prediction or angular-velocity residual is not reported.

33.1 Euler Vectors Must Be Outputs

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

33.2 Plate Inertia Tensor

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

33.3 Euler-Vector Dynamics

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

33.4 Predicted Euler-Pole Direction

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

33.5 Euler-Pole Direction Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

33.6 Angular-Speed Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

33.7 Euler-Vector Covariance Misfit

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar,

interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

33.8 Euler-Pole Drift

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

33.9 Finite Rotation

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

33.10 Finite-Rotation Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

33.11 Rigid-Motion Adequacy

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

33.12 No Fitted-Pole Causal Credit

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

33.13 Euler-Pole Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

34 Absolute and Relative Plate Velocities

A coordinate pair denotes location, not plate velocity. Without time-indexed site positions and a chosen frame, absolute and relative plate speed misfit terms have no numerical evaluation here.

34.1 Reference-Frame Declaration

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

34.2 Absolute Site Velocity

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

34.3 Absolute-Velocity Misfit

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

34.4 Relative Euler Vector

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

34.5 Relative Boundary Velocity

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

34.6 Relative-Velocity Misfit

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

34.7 Plate-Mean Speed

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

34.8 Direction Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

34.9 Magnitude Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

34.10 Frame-Robust Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

34.11 Absolute-Relative Motion Principle

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

35 Acceleration, Deceleration, and Direction Change

A static geometric corridor cannot supply accelerations, long-time speed changes or kinematic change points. The canonical time-history test remains structurally present without a fabricated event-linked motion record.

35.1 Acceleration Field

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

35.2 Speed Evolution

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

35.3 Direction-Change Rate

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

35.4 Motion-Curvature Rate

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

35.5 Change-Point Times

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

35.6 Change-Point Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

35.7 Change-Point Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

35.8 Event-Linked Direction Change

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

35.9 Event-Linked Speed Change

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

35.10 No Change-Point Selection After Inspection

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

35.11 Acceleration-History Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

35.12 Acceleration Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

36 Plate-Speed Hierarchy

Ranking present-day plate speeds is different from summing station-to-station distances. No calculated North American plate-speed ranking is present; the rank score and leave-one-plate-out prediction are unexecuted.

36.1 Observed and Predicted Rankings

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

36.2 Rank Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

36.3 Rank-Correlation Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

36.4 Speed-Generation Variables

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

36.5 Dimensionless Speed Predictors

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

36.6 Quasi-Steady Speed

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

36.7 Plate-Specific Flexibility

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

36.8 Leave-One-Plate-Out Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

36.9 Hierarchy Composite Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

36.10 Speed-Hierarchy Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

37 Plate Circuits, Junctions, and Global Closure

Plate-circuit closure requires plate-relative Euler vectors and a complete motion network. The eight consecutive route chords close neither a rigid plate circuit nor a global angular-momentum budget.

For consistent relative angular velocities in a closed plate circuit, relative vectors must sum to zero under the declared frame and composition convention. That kinematic closure is not equivalent to the selected second-leg geographic chain; the latter has no velocity vectors to sum.

37.1 Relative Euler-Vector Circuit

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

37.2 Circuit-Closure Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

37.3 Triple-Junction Closure

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

37.4 Junction Migration

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

37.5 Global Surface-Area Accounting

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

37.6 Creation and Removal Balance

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

37.7 Global Angular-Momentum Accounting

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

37.8 Net Plate-Rotation State

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

37.9 Closure Composite Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

37.10 Global-Closure Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

38 Present-Day and Deep-Time Motion Evidence

The project geometry is in a modern-coordinate frame. It cannot be treated as an independently dated deep-time reconstruction, and the source papers do not provide a joint present-day/deep-time motion likelihood for this branch.

38.1 Motion-Evidence Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

38.2 Present-Day Dataset

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

38.3 Deep-Time Dataset

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

38.4 Temporal Averaging

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

38.5 Present-Day Likelihood

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

38.6 Deep-Time Likelihood

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

38.7 Timescale Coherence

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

38.8 Motion-History Reconstruction

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

38.9 Chronological Motion Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

38.10 No Double Counting

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

38.11 Data-Type Holdout

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

38.12 Timescale Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

39 Force, Torque, Power, and Dissipation

Mechanical power, torque and dissipation are outside the permitted public mechanism scope and are not numerically derivable from the distance record. The original budget and falsifier positions are preserved, but no energy values are generated.

39.1 Force-Balance Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

39.2 Torque-Balance Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

39.3 Mechanical Power

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

39.4 Total Power

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

39.5 Kinetic-Energy Evolution

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

39.6 Dissipation Components

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

39.7 Nonnegative Dissipation

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

39.8 Power Sufficiency

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

39.9 Global Power

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

39.10 Energy-Reservoir Depletion

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

39.11 Power-Direction Consistency

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

39.12 Physical-Budget Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

39.13 Physical-Budget Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

40 Motion Counterfactuals and Causal Necessity

A valid motion ablation would rerun a specified forward model after removing one force or inherited-state component. No North American ablation model is included. This is a reserved or unexecuted calculation, not a failed experiment.

40.1 Purpose

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

40.2 Astro-Ballistic No-Event Counterfactual

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.3 Impulse Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.4 Boundary-Memory Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.5 Directional-Anisotropy Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.6 Density and Buoyancy Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.7 Thermal and Phase Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.8 Event-Modified Mantle-Flow Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain

that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.9 Plate-Tectonic Gravity Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.10 Plate-Tectonic Buoyancy Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.11 Mantle-Traction Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.12 Boundary-Traction Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.13 Inherited-Weakness Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.14 Leave-One-Event-Out Motion Test

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

40.15 Leave-One-Force-Class-Out Test

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

40.16 Hybrid Interaction Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.17 Component Interaction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.18 Causal Contribution Fraction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.19 Motion Causal-Necessity Rule

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

40.20 Motion-Necessity Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

41 Motion Complexity and Predictive Tests

The source comparison demands independently scored motion outputs. The current geometric setup fixes no site-velocity predictions, finite rotation or Euler-pole estimates, and therefore supports no numerical motion predictive-superiority claim.

41.1 Motion-Specific Complexity Vector

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

41.2 Force-Field Complexity

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

41.3 Coupling Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

41.4 Memory Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

41.5 Reference-Frame Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

41.6 Plate-Specific Parameter Penalty

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

41.7 Motion Information Criterion

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

41.8 Motion Holdouts

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

41.9 Site-Velocity Predictive Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

41.10 Euler-Pole Predictive Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

41.11 Finite-Rotation Predictive Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

41.12 Direction-Change Predictive Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

41.13 Negative Motion Predictions

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

41.14 Randomized Motion Nulls

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

41.15 Motion Null Probability

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

41.16 Predictive Superiority

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

42 Plate-Motion Replacement Viability and Falsification

Without an eligible motion-generating model, the motion replacement classification cannot be made. This leaves comparative standing unresolved at the relevant level, without deleting the conditional chord relation.

42.1 Motion-Comparison Parameter Set

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

42.2 Motion-Model Viable Set

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

42.3 Astro-Ballistic Motion-Replacement Condition

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

42.4 Hybrid Motion Preference

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

42.5 Motion Equivalence

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

42.6 Motion-Replacement Falsification Matrix

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

42.7 Motion Outcome Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

42.8 Motion-Replacement Decision Rule

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

43 Motion-Comparison Synthesis

The motion synthesis records only the original test architecture and the absence of a publicly disclosed predicted velocity field. No replacement qualification or numerical ranking is inferred.

This is a single integrated synthesis or ledger chapter in the canonical hierarchy; it has no independently numbered subsections in the original table of contents. The files contain no modeled North American velocity vectors, angular velocities, plate reference frames or time-indexed kinematic solution.

44 Competing Mountain-Building Mechanisms

Denali is the named middle mountain of the source record, but the geometric turn is approximately 222.678 km away. The placement and offset are geographic facts of the construction; the project files contain no uplift-work model, orogenic chronology, shortening field or independent mountain-growth comparison.

The project geometry preserves the spatial separation

$$c(T, \text{Denali}) \simeq 222.678 \text{ km}.$$

No mountain height, crustal shortening, deformation age, topographic work or uplift rate is solved from this number in the controlling North American source. The first second-leg chord records geometric displacement only.

44.1 Mountains as Shared Observations

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.2 Plate-Tectonic Mountain-Building Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.3 Astro-Ballistic Mountain-Building Classes

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.4 Hybrid Orogenic Model

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.5 Mountain-Location Comparison

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.6 Mountain-Orientation Comparison

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.7 Shortening Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.8 Crustal-Thickness Comparison

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.9 Elevation and Relief Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.10 Orogenic Chronology

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.11 Orogenic Power and Work

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result.

Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.12 Mountain Counterfactual

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.13 Mountain Comparison Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

44.14 Mountain-Building Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45 Trench, Descent, Bending, and Underthrusting Comparison

The northern end point is a defined Arctic terminal coordinate, not an independently observed event-generated trench. The private mechanics restriction is preserved, and no descent, bending or underthrusting energetics are published.

45.1 Observed Trench State

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.2 Plate-Tectonic Trench Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.3 Astro-Ballistic Trench Classes

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.4 Complete Trench Decomposition

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.5 Trench-Axis Comparison

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.6 Depth and Width Residuals

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.7 Curvature Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.8 Deep-Descent Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.9 Descent Mass Flux

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional

mechanism, regional case or independently executed model-comparison result is introduced here. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.10 Bending Energy

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.11 Underthrust Distance

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.12 Trench Chronology

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.13 Mechanism Attribution

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.14 Trench Comparison Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

45.15 Trench Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III. The surface turn and the actual Denali waypoint are separate locations, reported 222.678 km apart by the first corridor segment [5].

46 Ridge, Rift, and New-Material-Production Comparison

The Aleutian station sequence is a chosen path. It is not a forward prediction of spreading axes, new crustal surface area or melt production. The original ridge and rift comparison slots remain empty of new regional outputs.

46.1 Observed Ridge and Rift State

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

46.2 Plate-Tectonic Ridge Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

46.3 Astro-Ballistic Ridge Classes

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings.

46.4 Ridge-Axis Comparison

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings.

46.5 Opening-Rate Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

46.6 New-Area Production

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

46.7 Material-Age Field

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

46.8 Ridge-Flank Symmetry

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings.

46.9 Melt-Production Comparison

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

46.10 Ridge Heat and Composition

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

46.11 Ridge Comparison Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

46.12 Ridge Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

47 Basin Formation, Subsidence, and Inversion Comparison

The original test distinguishes present basin geometry from a modeled history of subsidence, infill, uplift and inversion. No source-based North American basin time series is available for those distinctions.

47.1 Observed Basin State

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

47.2 Plate-Tectonic Basin Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

47.3 Astro-Ballistic Basin Classes

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings.

47.4 Complete Subsidence Decomposition

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

47.5 Basin Geometry Comparison

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings.

47.6 Subsidence-History Comparison

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

47.7 Sediment-Accommodation Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

47.8 Thermal-History Comparison

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

47.9 Basin Inversion

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings.

47.10 Basin Comparison Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

47.11 Basin Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

48 Plateau Uplift and Crustal-Thickening Comparison

No plateau elevation, inferred crustal root, deformation age or dynamic support map is calculated in the Denali source. The plateau chapter retains the canonical comparison position without a new candidate plateau claim.

48.1 Observed Plateau State

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

48.2 Plate-Tectonic Plateau Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

48.3 Astro-Ballistic Plateau Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

48.4 Plateau Elevation Decomposition

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

48.5 Plateau-Domain Comparison

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

48.6 Elevation and Root Residuals

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

48.7 Dynamic-Support Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

48.8 Persistence Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

48.9 Plateau Comparison Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

48.10 Plateau Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

49 Volcanic Provinces and Melt-Path Comparison

The presence of volcanic islands along the chosen corridor is geographic context rather than an independent volcanic age or production prediction. Composition and melt-path details remain excluded, and no volcanic-model fit is claimed.

49.1 Observed Volcanic State

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

49.2 Plate-Tectonic Volcanic Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

49.3 Astro-Ballistic Volcanic Classes

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

49.4 Melt-Generation Comparison

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

49.5 Melt-Path Comparison

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

49.6 Volcanic-Domain Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

49.7 Volume and Rate Residuals

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

49.8 Composition Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

49.9 Volcanic Chronology

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

49.10 Event-to-Volcanism Lag

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

49.11 Volcanic Comparison Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

49.12 Volcanic Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

50 Terrane Transfer, Sutures, and Continental Assembly

Terrane identities, ancient sutures and material transport require dated and reconstructed material domains. No source file reports North American terrane trajectory calculations, so no continuity reconstruction is inserted.

50.1 Observed Terrane State

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

50.2 Plate-Tectonic Assembly Classes

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

50.3 Astro-Ballistic Assembly Classes

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

50.4 Terrane Trajectory Comparison

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

50.5 Terrane-Rotation Comparison

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

50.6 Material-Identity Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

50.7 Suture Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

50.8 Assembly Graph

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

50.9 Assembly Chronology

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

50.10 Terrane Comparison Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

50.11 Terrane-Assembly Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

51 Gravity and Geoid Comparison

Gravitational potential and geoid comparisons require density and geometry distributions, observational resolution and forward operators. The distance workbook supplies none; no gravity anomaly is inferred from the selected chords.

51.1 Observed Gravity State

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

51.2 Model Density Field

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

51.3 Gravity Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

51.4 Geoid Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

51.5 Resolution-Matched Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

51.6 Gravity Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

51.7 Gravity Misfit

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

51.8 Anomaly-Sign Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

51.9 Depth-Sensitivity Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

51.10 Gravity Counterfactuals

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

51.11 Gravity Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

52 Seismic Velocity, Attenuation, and Anisotropy

The path is called underground in the working records but contains no independently imaged seismic corridor field. Without an elastic model and tomographic observations, no corridor detection or anisotropy match is asserted.

52.1 Observed Seismic State

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

52.2 Elastic Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

52.3 Constitutive Dependence

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

52.4 Attenuation Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

52.5 Anisotropy Tensor

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

52.6 Forward Observation Operator

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

52.7 Resolution Matching

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

52.8 Seismic Misfit

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

52.9 Corridor-Detection Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

52.10 Anisotropy-Direction Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

52.11 Seismic Counterfactuals

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

52.12 Seismic Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

53 Magnetic and Heat-Flow Comparison

The permitted sources do not supply a predicted magnetization or thermal evolution map, nor a matched observation dataset. Energetic and mineralogical details are excluded rather than reconstructed from neighboring material.

53.1 Observed Magnetic and Thermal State

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

53.2 Magnetization Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This

heading retains its source function without creating or claiming a new independently verified North American forecast.

53.3 Magnetic Observation Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

53.4 Magnetic Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

53.5 Magnetic Resetting Test

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

53.6 Thermal Evolution

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

53.7 Heat-Flow Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

53.8 Heat-Flow Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

53.9 Thermal-Memory Test

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

53.10 Magnetic and Thermal Counterfactuals

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

53.11 Magnetic-Heat Comparison Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

53.12 Magnetic and Heat-Flow Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

54 Structural and Geophysical Counterfactuals

The canonical structural counterfactuals distinguish separate causes and interactions. They cannot be evaluated without the same forward state under controlled interventions. This draft does not silently add physical mechanisms to supply those interventions.

54.1 Unified Structural State

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

54.2 No-Event Counterfactual

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.3 Boundary Counterfactual

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.4 Motion Counterfactual

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.5 Convergence Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.6 Extension Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.7 Mantle-Flow Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.8 Damage Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.9 Density Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.10 Thermal Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.11 Phase Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.12 Melt and Permeability Ablation

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.13 Inheritance Isotropization

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional

mechanism, regional case or independently executed model-comparison result is introduced here.

54.14 Leave-One-Structure-Class-Out Test

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

54.15 Leave-One-Event-Out Structural Test

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

54.16 Component Interaction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.17 Counterfactual Consistency

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.18 Structural Causal-Necessity Rule

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

54.19 Structural-Necessity Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

55 Structural Complexity and Predictive Tests

Unpublished predictions do not acquire empirical significance from the existence of known structures. No locked North American structural holdout, null cohort or comparative predictive score is included.

55.1 Structural Complexity Vector

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

55.2 Structure-Specific Parameter Count

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

55.3 Event-to-Structure Assignment Penalty

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

55.4 Lag Complexity

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

55.5 Preservation Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

55.6 Mechanism-Switching Penalty

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

55.7 Structural Information Criterion

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

55.8 Held-Out Structure Classes

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

55.9 Spatial Holdout

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

55.10 Depth Holdout

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

55.11 Chronology Holdout

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

55.12 Observation-Type Holdout

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

55.13 Negative Structural Predictions

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

55.14 Structural Predictive Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

55.15 Randomized Structural Nulls

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

55.16 Structural Null Probability

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

55.17 Predictive Superiority

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

56 Structural-and-Geophysical Replacement Viability

The structural-and-geophysical replacement test receives empty forward output fields and therefore issues no observational or mechanical superiority verdict. This preserves the geometric result separately from the physical claim.

56.1 Structural Comparison Parameter Set

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

56.2 Structural-and-Geophysical Viable Set

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

56.3 Astro-Ballistic Structural Replacement Condition

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

56.4 Hybrid Structural Preference

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

56.5 Structural Equivalence

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

56.6 Structural-and-Geophysical Falsification Matrix

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

56.7 Structural Outcome Classes

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

56.8 Structural Replacement Decision Rule

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that

the North American candidate has been allocated to that class by a completed test.

57 Structural and Geophysical Comparison Synthesis

The structural synthesis keeps the same branch boundaries as the original paper: mountain, trench, ridge, basin, plateau, terrane and deep geophysical comparisons are distinct reporting domains.

This is a single integrated synthesis or ledger chapter in the canonical hierarchy; it has no independently numbered subsections in the original table of contents. The files name Denali and the Arctic terminus but do not contain a new forward structural or geophysical output that can be scored.

58 Chronology-Wide Model Comparison

The chronological role of this paper is preserved without inventing an additional event catalog. The 64 Ma branch name in earlier records is a label, not a source-certified chronological measurement for a North American initiating event.

58.1 Chronology Is a Shared Causal Constraint

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

58.2 Global Chronology Vector

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

58.3 Forward-Time Convention

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

58.4 Causal Dependency Graph

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

58.5 Chronological Violation Indicator

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

58.6 Age Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

58.7 Correlated Chronology Misfit

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

58.8 Response-Lag Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

58.9 Change-Point Comparison

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

58.10 Chronological Causal Coverage

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

58.11 Temporal Holdout

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

58.12 Chronology-Permutation Null

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

58.13 Chronology Comparison Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

58.14 Chronology-Wide Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

59 Paleogeographic and Continental-Reconstruction Comparison

Modern geographic coordinates cannot substitute for paleogeographic reconstruction at an inferred ancient date. The source provides no plate rotations to carry Malpelo, the turn and the terminal corridor into a frozen event-time frame.

The positions in [5] are modern-geographic ϕ, λ. The source does not provide time-dependent reconstruction operators $\mathcal{R}(t)$ that would transport each location into a geological event-time frame. Accordingly no time-indexed geometric identity is asserted.

59.1 Present Geography Is Not the Event-Time State

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

59.2 Shared Paleogeographic Dataset

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

59.3 Model Reconstruction

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

59.4 Centroid Distance

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

59.5 Shape Overlap

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

59.6 Boundary Distance

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-

matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

59.7 Rotation Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

59.8 Adjacency Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

59.9 Material-Identity Residual

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

59.10 Paleomagnetic Comparison

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

59.11 Fragmentation and Merger Accounting

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

59.12 Material Continuity

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

59.13 Event-Time Path Test

No time-indexed Denali path geometry is provided in the controlling calculation or seven-row corridor worksheet. The project's *64 Ma* designation is a research label in the supplied files, not an independently established event age from the leg-length mathematics. A Paper-IV event-time adjudication would require observations and predictions that are not presently in the source record. No comparative chronology result is entered here.

59.14 Reconstruction Ensemble

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

59.15 Paleogeographic Comparison Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

59.16 Paleogeographic Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

60 Causal Coverage and Explanatory Scope

Coverage cannot be calculated merely by counting eight chord segments or familiar regional landmarks. The original score covers independent observation classes and causal chains; no such region-wide predictions are currently available.

60.1 Coverage Is Not Binary

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

60.2 Observation-Class Registry

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

60.3 Coverage Indicator

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

60.4 Weighted Coverage Fraction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

60.5 Causal-Depth Levels

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

60.6 Mean Causal Depth

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

60.7 Causal Chain Completion

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

60.8 Unsupported-Link Penalty

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

60.9 Regional-Tuning Penalty

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

60.10 Explanatory-Scope Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

60.11 Scope Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

61 Model Evidence, Posterior Ranking, and Equivalence

The canonical Bayesian and posterior ranking apparatus remains part of the template, but no model implementation, likelihood, or prior package is present for a numerical comparison in this draft.

Bayesian model evidence requires a likelihood, a declared prior and an executable model family:

$$p(D \mid M) = \int p(D \mid \theta, M)\, p(\theta \mid M)\, d\theta.$$

No such numerical integral or Bayes factor has been evaluated in this North American draft.

61.1 Model Families

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

61.2 Common Comparison Contract

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

61.3 Marginal Model Evidence

The local case includes named geographic features, particularly Denali and the northern terminal. These locations are not presented as independently derived heights, structural histories, crustal density fields or deformation models. The canonical feature-specific comparison is preserved, but its input/output fields are not replaced by source-unsupported regional findings.

61.4 Bayes Factor

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

61.5 Posterior Model Probability

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

61.6 Prior-Sensitivity Analysis

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

61.7 Posterior Predictive Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

61.8 Cross-Validated Model Ranking

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

61.9 Integrated Ranking Vector

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

61.10 No Unregistered Scalar Rank Averaging

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

61.11 Equivalence Interval

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

61.12 Ranking Probability

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

61.13 Posterior-Ranking Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

62 Effective Degrees of Freedom and Description Length

The entrance was chosen by solving against the already chosen aggregate second-leg distance. That fitted degree of freedom belongs in any complexity ledger; it cannot be ignored by treating a reported zero difference as an externally discovered constraint.

62.1 Raw Parameter Count Is Incomplete

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

62.2 Effective-Complexity Ledger

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

62.3 Event-Catalog Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted

here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

62.4 Initial-State Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

62.5 Boundary-State Complexity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

62.6 Search-Space Complexity

The documented geometric fit uses a specified turn, eight prescribed second-leg chords, and an entrance **solved** to match their sum. The source further recognizes an entrance-location family at the same chord distance. This is a selection degree of freedom, not an independently observed two-leg symmetry. The input record does not establish the total candidate search volume, rejected route counts, or any calibrated penalty; accordingly no information criterion or numerical complexity score is assigned to this North American construction.

62.7 Revision Description Length

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

62.8 Data Description Length

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

62.9 Total Description Length

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

62.10 Causal Compression Ratio

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

62.11 Encoding and Logarithm Convention

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

62.12 Effective-Flexibility Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

63 Sequence-Wide Null Models

The canonical null families belong to a comparative sequence-wide test, not a request to generate new North American investigation paths. No randomization or Monte Carlo probability is asserted for the existing fitted equality.

The familiar empirical null calculation would require N complete admissible simulated trials, a frozen statistic and a full-search replay. No null distribution has been generated for the fitted Malpelo equality, and no chance significance is inferred from $\Delta L \approx 0$.

Selection-order record: (1) turn held fixed; (2) ordered second leg chosen and accumulated; (3) entrance coordinate solved to match that accumulated sum; (4) equality printed at calculation precision. The exact equality is therefore not an unfitted null realization, and no p-value is assigned.

63.1 Purpose

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

63.2 Null Family

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

63.3 Uniform Spatial Null

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

63.4 Geological-Opportunity Null

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

63.5 Boundary-Conditioned Null

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

63.6 Plate-Preserving Null

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

63.7 Chronology-Permutation Null

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

63.8 Direction-Randomization Null

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

63.9 Event-to-Structure Assignment Null

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

63.10 Inherited-State Randomization Null

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

63.11 Topology-Preserving Null

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

63.12 Reference-Frame Null

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

63.13 Complete Null Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

63.14 Empirical Null Probability

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

63.15 Full-Pipeline Null Exchangeability

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

63.16 Class-Specific Nulls

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

63.17 Null-Model Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

64 Multiple Testing, Selection Bias, and Revision Accounting

The record establishes a specific search ordering: fixed middle turn and second-leg corridor, followed by solving the entrance. This known selection path is retained transparently; no correction factor or false discovery estimate is invented.

64.1 Complete Search Ledger

Recorded inputs: fixed turn $(62.3843^\circ\text{N}, 146.8997^\circ\text{W})$; ordered route M →Denali→Juneau→Unalaska→Adak→Amchitka→At Siberia→Arctic terminal; fitted Malpelo-region entrance. **Recorded source choice:** a bearing selected in the original calculation toward a reference Ecuador location, with other equal-chord bearings acknowledged. **Not recorded:** a closed candidate catalog, all attempted entrance bearings, rejected waypoints, or a comparative fit search against Plate Tectonics. This ledger states only what can be traced in the project files.

64.2 Selection Record

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

64.3 Confirmatory Family Definition

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

64.4 Family-Wise Error

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

64.5 False-Discovery Control

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

64.6 Selection-Adjusted Probability

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

64.7 Holdout Depletion

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

64.8 Model-Version Registry

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

64.9 Stopping Rule

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

64.10 Selection-Bias Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III. Selection history matters: the source solved Malpelo entrance coordinates after fixing the turn and second-leg sum [5].

65 Global Advance-Prediction Comparison

A genuinely advance prediction must be frozen before inspecting the independent target data. No new predictive claim is written into this initial corpus draft, and the source waypoints remain calibration inputs rather than future tests.

65.1 Prediction Registry

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

65.2 Required Prediction Classes

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

65.3 Predictive Distribution

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

65.4 Continuous Predictive Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

65.5 Binary Predictive Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

65.6 Spatial Prediction Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

65.7 Proper-Score Requirement

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

65.8 Calibration

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

65.9 Calibration

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

65.10 Resolution

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

65.11 Negative Predictions

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

65.12 Prospective Validation

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

65.13 Prediction Comparison

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

65.14 Advance-Prediction Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

66 Hybrid Causal Decomposition

Hybrids cannot be judged simply by describing an event and conventional tectonic processes side by side. Original parent limits and intervention positions are reserved because neither North American parent forward state has been computed.

66.1 Hybrid Models Require Explicit Attribution

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

66.2 Parent Ablations

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

66.3 Parent Necessity

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

66.4 Interaction Difference-in-Differences Diagnostic

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

66.5 Observation-Class Attribution

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

66.6 Dominance Fraction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

66.7 Hybrid Outcome Classes

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

66.8 Hybrid Complexity Requirement

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

66.9 Hybrid Search and Revision Parity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

66.10 Hybrid Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

67 Regional Versus Global Classification

A well-defined North American geometric candidate is narrower than an eligible global causal model. Regional standing and global replacement therefore occupy separate rows in the original decision architecture.

67.1 Regional Domains

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

67.2 Regional Viability

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

67.3 Global Viability

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

67.4 Transferability Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value.

67.5 Parameter Heterogeneity

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

67.6 Regional Contribution Fraction

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

67.7 Global Classification Rules

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

67.8 Regional-to-Global Falsifier

This is a distinct canonical rejection position, not a finding of failure. It requires the associated model prediction, observed comparison, uncertainty and frozen rejection criterion to be available and executed. No completed North American result crossing that criterion is reported in Papers I–III.

68 Complete Paper-IV Viability

The integrated decision requires that upstream physical and reconstruction eligibility and the comparative gates all be fulfilled for the same model version. They are not reported as complete in the current research files.

The source decision architecture requires distinct admissibility and relative-qualification gates. For this draft, the condition that a comparable *global causal* forward output exists remains unsatisfied by available material; the appropriate epistemic status is **not evaluated**, not proof of physical impossibility.

68.1 Eligibility Sets and Qualification Gates

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

68.2 Complete Model Eligibility Set

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional

mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

68.3 Astro-Ballistic Eligibility

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

68.4 Shared Parameter Intersection

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

68.5 Posterior Overlap

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

68.6 Complete Adjudication Score

The canonical statistic compares registered model outputs with the same observation and uncertainty definitions. There is no such model-output/observation pair for the North American case in the uploaded record; the scalar, interval, likelihood or residual therefore remains uncomputed rather than set to a favorable or unfavorable value. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

68.7 Primary Replacement Condition

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

68.8 Qualification-Gate Conjunction

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

68.9 Hybrid Preference Condition

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

68.10 Complete-Viability Decision

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

69 Formal Replacement Decision Tree

The canonical decision tree is retained in order, while its steps are marked according to the documented North American handoff. A blank or withheld result is not transformed into a negative numerical test or a positive decision.

The original twelve-step decision sequence is retained; each step records data and status rather than being replaced with a new set of questions. A step cannot pass on the basis of a missing observation or a private, unreported physical parameter.

69.1 Decision Step 1: Mechanical Eligibility

Papers I–II convey documented geometry but no source-supported energy budget, constitutive simulation, mechanical response field, or independently verified physical trajectory. Therefore this step records **not adjudicable from supplied material**, rather than positive eligibility or mechanical falsification. The fixed turn is not assumed to be a measured physical turn.

69.2 Decision Step 2: Global Reconstruction Eligibility

Paper III has no supplied global time-slice reconstruction, ancient material-coordinate history, or plate-motion reconstruction derived from the Denali working files. The modern-coordinate Malpelo-to-Arctic path does not fulfill this criterion. **Eligibility remains unassessed**, with no automatic consequence for the reproducible geometric calculation.

69.3 Decision Step 3: Boundary Viability

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

69.4 Decision Step 4: Motion Viability

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic

observation. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

69.5 Decision Step 5: Structural and Geophysical Viability

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

69.6 Decision Step 6: Chronology and Paleogeography

The source contains a geographically ordered route and a project designation using 64 Ma, but no independent dated event association or event-time paleogeography for the path. **Chronology/paleogeography status: unverified.** This is not evidence of a negative chronological result; the required chronological inputs are absent from the supplied public calculations.

69.7 Decision Step 7: Null and Selection Control

For the defined geometry, $c(E, M)$ was made equal to the prescribed eight-segment total **by fitting** E. A direct-chord match obtained that way is not an independently withheld equality outcome. The source gives a reproducible calculation and a defined selection sequence, but does not report an empirical null population or completed model-ranking calculation for this decision-tree step. The inherited criterion remains in place, and its numerical status is **not evaluated from the supplied files**.

69.8 Decision Step 8: Causal Necessity

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

69.9 Decision Step 9: Predictive Performance

The fitted entrance coordinate and the original waypoint chain are calibration quantities in the supplied calculation; they are not an independently withheld outcome. The files document neither preregistered prospective targets nor out-of-sample predictions and outcomes. **Predictive performance cannot be scored from this source set**, and no accuracy score is added by the present mirror.

69.10 Decision Step 10: Complexity-Adjusted Preference

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

69.11 Decision Step 11: Hybrid Comparison

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

69.12 Decision Step 12: Replication

At this decision step, the supplied North American material supports replication of **the declared geometric calculation**, including its entrance fitting rule and segment inventory. It does not provide the competing, independently evaluated Earth-history models and matched observations needed to replicate a Paper-IV ranking. Accordingly the replication criterion is met only for **input arithmetic**, not for causal-model adjudication. No model is preferred or rejected on the strength of this limited replication.

69.13 Final Outcome Classification

The canonical comparative outcome classes are retained as classification slots, not assigned outcomes. No model has been ranked because the North American package lacks executed matched simulations, independent observation vectors, uncertainty-calibrated residuals and a source-frozen model-selection result. The fitted two-leg numerical equality belongs to the **geometry-input** record. It does not automatically populate a final causal-replacement, complementarity, failure or equivalence category.

69.14 Formal Decision Rule

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test. The source calculation remains valid only under its stated spherical chord metric and selected path; it is not a global causal ranking.

70 Paper-IV Claim Ledger

The claim ledger prevents the reported equal-chord result from being recast as a direct physical observation, and prevents withheld mechanics or missing global predictions from being treated as tested.

Claim	Narrow exact wording	Evidence / status
NA-IV-C01	Under the selected metric, direct first chord and sum of successive second chords match at reported precision	Calculated/fitted geometry [5,6]
NA-IV-C02	Fixed turn is independent from Denali location	Recorded, 222.678 km first segment [5]
NA-IV-C03	Equal-leg geometry establishes event mechanics	**Not claimed**
NA-IV-C04	North American event produced global boundary network	Not evaluated
NA-IV-C05	North American event produced present long-time plate motion	Not evaluated

Claim	Narrow exact wording	Evidence / status
NA-IV-C06	North American case outperforms Plate Tectonics	No matched numerical comparison
NA-IV-C07	Global replacement qualified	Not established
NA-IV-C08	Mineralogy or energetic details	Reserved / omitted by instruction

This is a single integrated synthesis or ledger chapter in the canonical hierarchy; it has no independently numbered subsections in the original table of contents. The available North American source contains exact geometric constructions but no frozen comparative model implementation.

71 Complete Paper-IV Falsification Matrix

The canonical falsification matrix keeps conclusions modular: one unsupported causal link is not a disproof of the arithmetic identity, and correct arithmetic cannot establish a mechanism. No new completed adverse comparison is reported.

Canonical test class	What can presently be adjudicated?	Bounded result
Geometry	Source's equal-leg construction	Reported equality under declared choices
Physical admissibility	No public model	Unexecuted; not a negative result
Boundary and motion	No North American forward fields	Unexecuted
Structural and geophysical	No matched predictions/datasets	Unexecuted
Chronology and paleogeography	No frozen event-time reconstruction	Unexecuted
Comparative predictive replacement	No matched models/holdouts	Unexecuted

71.1 No Cross-Compensation

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

71.2 Compartmentalized Failure

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

72 Independent Replication Protocol

The replication protocol follows the existing data and algorithm lineage from the Denali file and workbook through Papers I–III. Comparative replication levels remain pending where physical results and observation packages do not exist.

72.1 Replication Level R1: Source and Selection Audit

R1 is satisfied as a **source-traceability task** insofar as the provided records identify the fixed turn, solved entrance, eight-segment order, printed first segment, and the seven downstream workbook rows. A new reader

can recompute the specified spherical chord and surface arc values under $R = 6{,}371\,\mathrm{km}$. This does not elevate R1 to independent geophysical replication, geological observation, mechanical solution, model comparison, or a completed causal replacement adjudication.

72.2 Replication Level R2: Papers I Through III Handoff

The Paper-I handoff is a source-bounded geometric record: reference sphere $R = 6{,}371\,\mathrm{km}$, fitted entrance E, fixed turn M, ordered eight-chord route, and separate surface-arc entries. Paper II supplies no completed physical solver result; Paper III supplies no independently dated reconstructed route. At R2 these distinct upstream statuses can be checked for consistency, but they cannot be promoted into a finished causal reconstruction or adjudicated geological result.

72.3 Replication Level R3: Comparison Models

The supplied Denali files do not include two implemented competing physical models evaluated on common geological observations. The existing Paper-IV comparison architecture specifies what such an adjudication means in the canonical research program, but the North American source bundle supplies only the fitted spherical geometry and its provenance. R3 is therefore **not executed**; an internally repeated chord calculation is not a matched comparison of candidate Earth histories.

72.4 Replication Level R4: Shared Data Freeze

The source bundle fixes a **geometric calculation dataset**: reference sphere, author-fixed turn, selected corridor and post-selection entrance solution. The seven downstream chord/arc pairs are tabulated in the workbook; the first turn-to-Denali link and reported totals are documented in *Denali Exact.pdf*. It does **not** provide a frozen shared *observation vector* for competing geological models. Consequently R4 is recorded as a documented geometric-input freeze only, not a completed comparison-data freeze.

72.5 Replication Level R5: Component Comparisons

R5 requires results for separately registered components under the canonical comparison framework. The Denali source files contain no paired mechanical, geological or historical model outputs whose component contributions can be compared. The direct first-leg chord and the eight segmented second-leg chords are **parts of one stipulated geometry**, not independent causal-model components or ablation outcomes. **R5 status: not executed**; a component score or contribution is not assigned.

72.6 Replication Level R6: Counterfactuals

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

72.7 Replication Level R7: Null and Selection Analysis

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

72.8 Replication Level R8: Advance Prediction

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

72.9 Replication Level R9: Final Adjudication

The current record does not contain an executed matched comparison, component ablation, advance-prediction score or historical reconstruction residual on which to adjudicate the competing causal explanations. Earlier R1 arithmetic traceability remains a narrower positive record and is not inherited as an R9 verdict. **R9 status: not reached; North American comparative preference undetermined.** This preserves the original final-adjudication slot without claiming replacement, complementarity or falsification.

72.10 Repository Structure

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

72.11 Required Metadata

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

72.12 Replication Statuses

R1: the original Denali source and its fitted-entrance selection rule can be audited. **R2:** the separate qualified handoffs from Papers I–III can be checked against their manuscripts. **R3–R9:** no executed North American comparative-model, shared-observation, component-ablation, counterfactual, selection-corrected, advance-prediction or final-ranking record is supplied. No success or failure score is imputed to those absent comparisons. Numerical geometry replication remains narrower than replication of a causal replacement claim.

73 Integrated Discussion

The integrated discussion preserves the source paper's purpose without a second independently invented scientific investigation. The available evidence is the source-defined geodesy; the broader global causal adjudication awaits qualifying outputs.

73.1 Paper IV Adjudicates Rather Than Presumes

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

73.2 Continental Drift Is Shared Evidence

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

73.3 Boundary Origin and Motion Maintenance Are Distinct

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

73.4 Astro-Ballistic Replacement Has a Stronger Burden Than Regional Compatibility

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

73.5 Plate-Tectonic Models Also Require Explicit Specification

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

73.6 Initial Conditions Are Explanatory Inputs

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

73.7 Ancient Events May Initiate Without Maintaining

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

73.8 Hybrid Outcomes Are Scientifically Substantive

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

73.9 Chronology and Paleogeography Are Decisive

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

73.10 Deep Geophysics Restricts Surface Narratives

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

73.11 Prediction Distinguishes Reconstruction From Replacement

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

73.12 Regional Failure and Global Failure Must Remain Compartmentalized

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

73.13 Paper IV Is a Decision Architecture

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

74 Limitations

The limitations are explicit, bounded and source-specific: no published physical mechanism, no independent observational comparison package, no global forward reconstruction, and no held-out numerical adjudication. These are not statements that any missing test failed.

74.1 Conditional Inputs

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

74.2 No Completed Global Simulation

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

74.3 Comparison-Model Breadth

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

74.4 Astro-Ballistic Catalog Uncertainty

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

74.5 Initial-Condition Uncertainty

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

74.6 Paleogeographic Uncertainty

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

74.7 Constitutive Uncertainty

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

74.8 Computational Scale

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

74.9 Observation Dependence

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

74.10 Preservation Bias

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

74.11 Selection Risk

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

74.12 Model Nonuniqueness

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

74.13 Hybrid Nonuniqueness

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

74.14 Prediction Availability

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

74.15 Bibliographic Production

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

74.16 Declared-Scope Limitation

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

75 Conclusions

The first-draft conclusion preserves the narrow result and its correct dependencies. The fixed-turn North American construction demonstrates equality under its selected metric to reported numerical precision. It neither establishes nor rejects causal replacement, and the later corpus passes cannot silently upgrade its status.

75.1 Conclusion 1: The Comparison Concerns Causal Organization

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

75.2 Conclusion 2: Eligibility Is Conditional

This is an original methodological definition or decision slot. It is retained with the same position in the manuscript, while the qualified handoff remains geometrical. A section label specifying an outcome class does not mean that the North American candidate has been allocated to that class by a completed test.

75.3 Conclusion 3: Boundaries and Motion Must Be Compared Separately

The calculated line segments are station-to-station chords in a selected geometric construction. They do not supply a fitted or predicted motion vector, event-created boundary classification, time-resolved plate network or graph-matching output. The original prediction class stays intact without promoting the path into a global tectonic observation.

75.4 Conclusion 4: Initial Conditions Count

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

75.5 Conclusion 5: Ancient Impulse Is Not Permanent Power

This is a physical-state or physical-budget component of the original comparison. The public Denali sources report only the relevant geographical and metric framework, not the specific field, response coefficient, or numerical result. Proprietary energetic and mineralogical content is reserved, and no new parameter value is supplied.

75.6 Conclusion 6: Surface and Deep Predictions Must Agree

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

75.7 Conclusion 7: Chronology and Paleogeography Can Reject Modern Alignments

A dated reconstruction requires an independent chronological input or an explicitly time-indexed model output. The 64 Ma project designation and present-day route coordinates alone do not establish a dated geological event, age residual or lag prediction. This section retains the original temporal test location without fabricating a chronology.

75.8 Conclusion 8: Causal Necessity Is Required

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

75.9 Conclusion 9: Complexity Must Include Hidden Flexibility

The known North American selections are the turn and eight-segment corridor, with the entrance solved afterward to satisfy the printed equality. Their roles as fitted or author-declared quantities must appear in the parameter and selection register. No numerical effective-dimensionality estimate, prior, or search-adjustment penalty is asserted here.

75.10 Conclusion 10: Null Models Must Preserve Geological Opportunity

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

75.11 Conclusion 11: Advance Prediction Is Decisive

The canonical criterion distinguishes a prediction fixed in advance from a geographical relation constructed after choices were made. The corridor stations and solved entrance are calibration inputs, not held-out targets. This heading retains its source function without creating or claiming a new independently verified North American forecast.

75.12 Conclusion 12: Regional Success Is Not Global Replacement

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

75.13 Conclusion 13: Hybrid Preference Requires Joint Necessity

The original comparison requires a controlled reference calculation and the corresponding altered or component-removed model under matched initial conditions. Because the public North American record does not contain that causal forward-model family, no component dependence or interaction fraction can be inferred from the chord geometry.

75.14 Conclusion 14: Equivalence Is an Allowed Result

This canonical subsection remains in its original chapter and causal-comparison role. The only corresponding North American calculation available is the declared equal-leg geometry from the source record. No additional mechanism, regional case or independently executed model-comparison result is introduced here.

75.15 Conclusion 15: Replacement Requires One Shared Model

The Denali note and workbook are internal source records for the geographic inputs and calculations, while the prior three working papers describe their status. They do not stand in for the canonical independent global observation archive. Dataset version, resolution and custody fields are consequently retained but not certified as an executed North American comparison.

75.16 Final Paper-IV Statement

Paper IV completes its inherited *comparison architecture* but records no executed North American result that ranks competing geological causal models. The audited source permits confirmation of what was geometrically fitted, what was selected in advance of that fit, and which outputs remain absent. Paper V therefore receives a differentiated ledger: geometric arithmetic reproduced under stated inputs; mechanical, dated reconstruction and comparative outcomes unexecuted. This is a source-limited manuscript statement, not a causal-verdict claim.

AI-Assisted Research Disclosure

This North American research corpus is attributed to Justin B Fine, Principal Investigator, Ontomics. An AI system assisted with transcription of the original manuscript hierarchy, presentation, checking against supplied project files, document generation, and drafting of text distinguishing mathematical status from interpretation. This role does not constitute independent validation, simulation, or empirical verification. The principal investigator directs subject matter and release boundaries.

Appendix A — Shared Model-Comparison Data Registry

Registry field	North American entry	Status
Case identifier	North American equal-leg Middle Mountain source construction	Identified
Controlling source	Denali Exact.pdf	Available
Input coordinate ledger	Solved Malpelo entrance, fixed turn, eight ordered second-leg waypoints	Available in source files
Mathematical metric	Direct first chord versus sum of successive second-leg chords	Specified
Observation class	Independent geodetic, geophysical, tectonic and chronological series	Not assembled
Reference-model version	Plate-Tectonic implementation	Not supplied
Candidate-model output version	North American causal forward model	Not supplied publicly
Covariance/uncertainty	Independent observation errors and model uncertainties	Not estimated
Held-out cohort	Not disclosed	Not evaluated

Appendix B — Integrated Model Scorecard

Domain	Canonical comparison requirement	Current status
Geometry	Preserve computed route and provenance	Complete as working source, selection declared
Event mechanics	Physically eligible model	Reserved / not evaluated
Boundary predictions	Model-predicted boundary map and ages	Not evaluated
Long-time plate motion	Predicted velocities, poles and dates	Not evaluated
Surface structures	Forward structural fields and chronology	Not evaluated
Deep geophysics	Independent, resolution-matched observations	Not evaluated
Complexity and null	Frozen priors, selection ledger, full null search	Selection described; no computed score
Out-of-sample prediction	Prospective registered holdout	Not evaluated
Primary replacement	Complete comparative gates	Not established

Appendix C — Advance-Prediction Registry Template

The original prediction registry architecture remains in place. It records claim ID, frozen prediction, prediction date, model version, observation domain, source and acquisition status, uncertainty definition, comparative null, scoring rule, failure rule, and adjudication. No new scientific prediction is created in this mirror. Existing waypoints are *known selected inputs* and are not entered as held-out observations.

Appendix D — Model-Version and Selection Audit Template

The recorded source-selection sequence is: original turn fixed at 62.3843° N, 146.8997° W; second leg declared as a sequence of eight chord segments and summed; first-leg entrance solved at about 0.448874° N, 81.429273° W to

match that sum; reported equality 8,061.8708 km versus 8,061.8708 km at displayed precision. Prior alternative exploratory treatments in historical notes do not replace this later controlling construction. No number of prior candidate trials or search extent has been inferred beyond documentary evidence.

Appendix E — Formal Decision Checklist

- ☒ Author and canonical Paper IV structural source fixed.
- ☒ All 75 numbered chapter positions retained in source order.
- ☒ North American geometric input and solved-coordinate provenance carried forward.
- ☒ Denali location distinguished from the turn.
- ☒ Direct-first-chord versus cumulative-eight-chord method retained.
- ☒ Paper II and III conditional handoffs retained.
- ☒ Reserved mineralogy and energetic mechanics excluded.
- ☒ Missing numerical comparative outcomes not invented.
- ☐ Matched global model versions compared — **not claimed**.
- ☐ Independent prediction and replication adjudicated — **not claimed**.
- ☐ Final canonical corpus freeze completed — **not claimed**.

Appendix F — Figure and Table Production Registry

Included: inherited geography source table, segment-distance summary, provenance snapshot, model-family and decision-status registers, selection audit and claim ledger. Not included: invented plate-boundary maps, geological age maps, causally reconstructed tectonic trajectories, simulated geophysical fields, or visual claims that could be mistaken for measured outputs. The user-supplied continental design illustration is not treated as a new quantitative observation dataset.

Appendix G — Paper-V Handoff

Purpose of the Companion Atlas

Paper V receives the four preceding North American manuscripts as a structured corpus, with exact source mapping and the distinction between geometric results, source assumptions, proposed physical interpretations, reserved mechanisms and missing tests. The original Paper V serves as the companion atlas, not a fresh causal argument.

Causal Audit Fields for Paper V

Maintain separate identifiers for coordinate inputs, metric definitions, reconstructed or measured data, derived numerical results, fitted degrees of freedom, candidate causal edges, physical disclosures, model comparison status, unperformed statistical tests and claimed conclusions.

Paper-V Handoff State

The current confirmed narrow geometric claim is that the declared direct first-leg chord equals the summed eight-segment second leg to reported precision under the solved entrance. No numerical comparative result or completed causal replacement test is sent to Paper V. The provenance, table versions and manuscript states remain working versions v1.6 until the planned corpus-wide refinement sequence is complete.

Required Paper-V Relationships

Source file -> declared coordinate/waypoint -> metric and radius convention -> calculated segment distance -> aggregate comparison -> interpretation -> registered evidentiary status. Competing explanatory claims must retain separate nodes and not be merged merely because the corridor uses familiar named places.

Paper-V Status Categories

Source-calculated / selected / proposed / reserved / not evaluated / empirically tested / verified / falsified are not interchangeable. Paper V must preserve the status of each material, rather than copying a stronger claim from a parent corpus into the North American branch.

AI Companion Limitation

An AI research companion should not infer absent geology, energetic mechanics, public-release-restricted intellectual property or unreported comparative results from the presence of a chapter heading. It should not convert the equal-chord identity into a physically established impact chain or a global replacement verdict.

Appendix H — Paper-IV Production Checklist

This supplementary working-production checklist follows the existing North American working-draft practice; the canonical Paper IV itself contains the A–H appendix sequence, including its production checklist as Appendix H. No new scientific claim is created by this editorial section.

Paper-IV Working-Draft Freeze Status and Handoff

Initial Draft IV of V is assembled. The original comparison sequence and 75-chapter hierarchy are preserved, as are the original A–H appendix positions. This is the pre-refinement version, not a canonical scientific freeze and not a completed comparative adjudication. No mineralogy or energetics are disclosed. Draft V is the next sequential manuscript; the planned approximately fifteen cross-corpus refinement passes follow completion of all five drafts.

References

[1] Fine, Justin B. (2026). *Astro-Ballistic Chronostratigraphic Sequencing IV: Astro-Ballistic Chronostratigraphic Sequencing Versus Plate Tectonics.* Canonical Corpus Freeze 1.0, `ABC-CF1-2026-08-07`. https://ontomics.com/pdfs/abc-paper-iv.pdf. Structural and methodological authority.

[2] Fine, Justin B. (2026). *ABC North America Paper I — Refinement Pass 15 v1.6.* Project manuscript; local inherited geometry.

[3] Fine, Justin B. (2026). *ABC North America Paper II — Refinement Pass 15 v1.6.* Project manuscript; physical/source-disclosure status.

[4] Fine, Justin B. (2026). *ABC North America Paper III — Refinement Pass 15 v1.6.* Project manuscript; reconstruction status and Paper-IV handoff.

[5] *Denali Exact.pdf.* Ontomics supplied project working source; fixed turn, solved entrance, eight second-leg chord segments, equality and Denali displacement.

[6] *Denali_Trench_underground_path___per_segment_arc____chord_lengths-1.xlsx*. Ontomics supplied numerical workbook; second-leg chord and arc provenance.

[7] *Denali Short Math.pdf* and *8-8-2025 64 ma ABC Math Full (1).pdf*. Historical working calculations; developmental, not controlling for the later equal-leg construction.

External Scholarly and Data Context

ABC Sequencing IV - North American Middle Mountain | Public Research Edition v1.7 | 17 November 2026

Citation function and limits. This supplement adds verified external publications and data resources relevant to the named sections of the accompanying v1.6-derived manuscript. These references are **contextual or comparative**, not newly analyzed empirical input, independent support for the proposed passage, or evidence that reserved mechanics or unexecuted model comparisons have been completed. All author-declared coordinates and originally computed chord lengths retain their prior internal provenance.

Section-indexed citation mapping

Manuscript section or subject	External reference IDs
Model-family definitions and reference baselines (section 3)	E06, E07, E12
Likelihood and observational adequacy (section 8)	E13
Predictive performance (section 11)	E14
Pre-registration and model freeze (section 14)	E15
Geological causal comparison (section tectonic background)	E06, E12

Source bibliography and declared relevance

[E06] Bird, P. (2003). An updated digital model of plate boundaries. Geochemistry, Geophysics, Geosystems, 4, 1027.
https://doi.org/10.1029/2001GC000252
Role: Reference digital plate-boundary map and plate-boundary classification for geographic comparison.

[E07] Muller, R. D., et al. (2018). GPlates: Building a virtual Earth through deep time. Geochemistry, Geophysics, Geosystems, 19, 2243-2261.
https://doi.org/10.1029/2018GC007584
Role: Methods and limitations of deep-time plate/geographic reconstructions; no GPlates output has been newly computed here.

[E12] DeMets, C., Gordon, R. G., and Argus, D. F. (2010). Geologically current plate motions. Geophysical Journal International, 181, 1-80.
https://doi.org/10.1111/j.1365-246X.2009.04491.x
Role: Published MORVEL plate-motion kinematic reference for model comparisons.

[E13] Kass, R. E., and Raftery, A. E. (1995). Bayes factors. Journal of the American Statistical Association, 90, 773-795.
https://doi.org/10.1080/01621459.1995.10476572
Role: Bayesian evidence/model comparison methodology; no Bayes factor has been computed for the North American event.

[E14] Vehtari, A., Gelman, A., and Gabry, J. (2017). Practical Bayesian model evaluation using leave-one-out cross-validation and WAIC. Statistics and Computing, 27, 1413-1432.
https://doi.org/10.1007/s11222-016-9696-4
Role: Out-of-sample predictive-model assessment methods; not an executed scoring result.

[E15] Nosek, B. A., et al. (2018). The preregistration revolution. Proceedings of the National Academy of Sciences, 115, 2600-2606.
https://doi.org/10.1073/pnas.1708274114
Role: Study preregistration and advance-declared assessment; not proof that a frozen test has already occurred.

Release integrity and source-status convention

The document cover and running title have been updated for the present public research release. Original internal reference numbers [1], [2], etc. remain unchanged. External citations are identified separately as E01-E18 and by footer notices on their mapped pages; they do not replace or renumber internal provenance sources. Historical draft language and references to v1.6 or earlier pass stages in the underlying manuscript record the development history and are subordinate to this release notice.

Scope remains unchanged: no new causal event has been established by this editorial revision; neither missing observations nor proprietary material have been synthesized to fill an empty source field.