

Meso-Cenozoic Evolution of the Chukchi Borderland - Constraints on the Tectonic Development of the Amerasia Basin, Arctic Ocean*

Ibrahim Ilhan¹ and Bernard J. Coakley¹

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Abstract

Any model for the tectonic development of the Amerasia Basin requires structures to accommodate the continental Chukchi Borderland in a plate-tectonic framework. We have interpreted 2D multi-channel seismic reflection profiles and tied these data to the late 1980's Crackerjack and Popcorn exploration wells in order to: (1) develop a tectono-stratigraphic framework for the Chukchi Shelf and Borderland, and (2) test existing models for the development of the Amerasia Basin.

Based on sequence stratigraphic principles, we have mapped four regional unconformities. These subdivide the basement and basin fill into tectono-stratigraphic sequences. These sequences are: (1) pre-Brookian deformed strata (Mesozoic–Paleozoic), (2) pre-Brookian Syn-rift #1 and Dipping Reflections, (3) Post-rift #1, inferred condensed section and lower Brookian orogenic sediments (Barremian–Pre-Cenozoic), (4) Syn-rift #2 (inferred Upper Cretaceous–Paleocene), (5) Post-rift #2, upper Brookian progradational wedge (Cenozoic), and (6) Glacio-marine (Quaternary). The angular relationship between the inferred Lower Cretaceous unconformity and the underlying Syn-rift #1 sequence along the north-striking normal faults of the Chukchi Plateau is inconsistent with clockwise rotation of the Borderland away from the East Siberia. This falsifies one popular model for the Borderland and its role in the development of the Amerasia Basin. The Dipping Reflections underlying the Lower Cretaceous unconformity are associated with volcanism that may be concurrent with east-west rifting of the Borderland. The recognition of condensed section and continuity of the overlying Cretaceous–Cenozoic orogenic sediments across the southern Borderland substantially constrains other models that require significant discontinuity between the Chukchi Shelf and Borderland since the earliest Cretaceous proposed for tectonic development of the Amerasia Basin, Arctic Ocean.

References Cited

- Bonvalot, S., G. Balmino, A. Briais, M. Kuhn, A. Peyrefitte, and N. Vales et al., 2012, World Gravity Map, Paris, Bureau Gravimetrique International (BGI), map, CGMW-BGICNES-IRD Ed.
- Bujak, J., personal comm., Stratigraphy of Crackerjack No. 1 (OCS-Y-1320), *in* D.W. Houseknecht and D.L. LePain, eds., Paleozoic to Cenozoic biostratigraphy of Arctic Alaska: Detailed palynologic study of 50 exploration wells: Alaska Division of Geological & Geophysical Surveys Special Report.
- Bujak, J., personal comm., Stratigraphy of Popcorn No. 1 (OCS-Y-1275), *in* D.W. Houseknecht and D.L. LePain, eds., Paleozoic to Cenozoic biostratigraphy of Arctic Alaska: Detailed palynologic study of 50 exploration wells: Alaska Division of Geological & Geophysical Surveys Special Report.
- Craddock, W.H., and D.W. Houseknecht, 2016, Cretaceous-Cenozoic burial and exhumation history of the Chukchi shelf, offshore Arctic Alaska: AAPG Bulletin, v. 100, p. 63-100, doi:10.1306/09291515010.
- Drachev, S.S., N.A. Malyshev, and A.M. Nikishin, 2010, Tectonic history and petroleum geology of the Russian Arctic Shelves: An overview: Geological society, London, petroleum geology conference series, p. 591-619.
- Grantz, A., P.E. Hart, and V.A. Childers, 2011, Geology and tectonic development of the Amerasia and Canada Basins, Arctic Ocean, Chapter 50: Geological Society, London, Memoirs, v. 35, p. 771-799, doi:10.1144/M35.50.
- Halgedahl, S., and R. Jarrard, 1987, Paleomagnetism of the Kuparuk River Formation from oriented drill core: evidence for the rotation of the Arctic Alaska plate, *in* I. Tailleur and P. Weimer, eds., Alaskan North Slope Geology, Pacific Section: Society for Sedimentary Geology, Santa Barbara, CA, p. 581- 617.
- Houseknecht, D.W., and K.J. Bird, 2011, Geology and petroleum potential of the rifted margins of the Canada Basin, Chapter 34: Geological Society, London, Memoirs, v. 35, p. 509- 526. doi:10.1111/j.1365-2117.2008.00392.x.
- Jakobsson, M., L. Mayer, B. Coakley, J.A. Dowdeswell, S. Forbes, B. Fridman, H. Hodnesdal, R. Noormets, R. Pedersen, M. Rebesco, H.W. Schenke, Y. Zarayskaya, D. Accettella, A. Armstrong, R.M. Anderson, P. Bienhoff, A. Camerlenghi, I. Church, M. Edwards, J.V. Gardner, J.K. Hall, B. Hell, O. Hestvik, Y. Kristoffersen, C. Marcussen, R. Mohammad, D. Mosher, S.V. Nghiem, M.T. Pedrosa, P.G. Travaglini, and P. Weatherall, 2012, The International Bathymetric Chart of the Arctic Ocean (IBCAO) Version 3.0: Geophysical Research Letters, v. 39, L12609. doi:10.1029/2012GL052219.
- Maus, S., U. Barckhausen, H. Berkenbosch, N. Bournas, J. Brozena, V. Childers, F. Dostaler, J.D. Fairhead, C. Finn, R.R.B. von Frese, C. Gaina, S. Golynsky, R. Kucks, H. Lühr, P. Milligan, S. Mogren, R.D. Müller, O. Olesen, M. Pilkington, R. Saltus, B. Schreckenberger, E.

Thébault, and F. Caratori Tontini, 2009, EMAG2: A 2-arc min resolution Earth Magnetic Anomaly Grid compiled from satellite, airborne, and marine magnetic measurements: *Geochemistry, Geophysics, Geosystems*, v. 10, Q08005. doi:10.1029/2009GC002471.

Mickey, M.B., and H. Haga, 2003a, Biostratigraphy report, Crackerjack No. 1 (OCS-Y-1320): Shell Western E&P, Job No: 22-113.

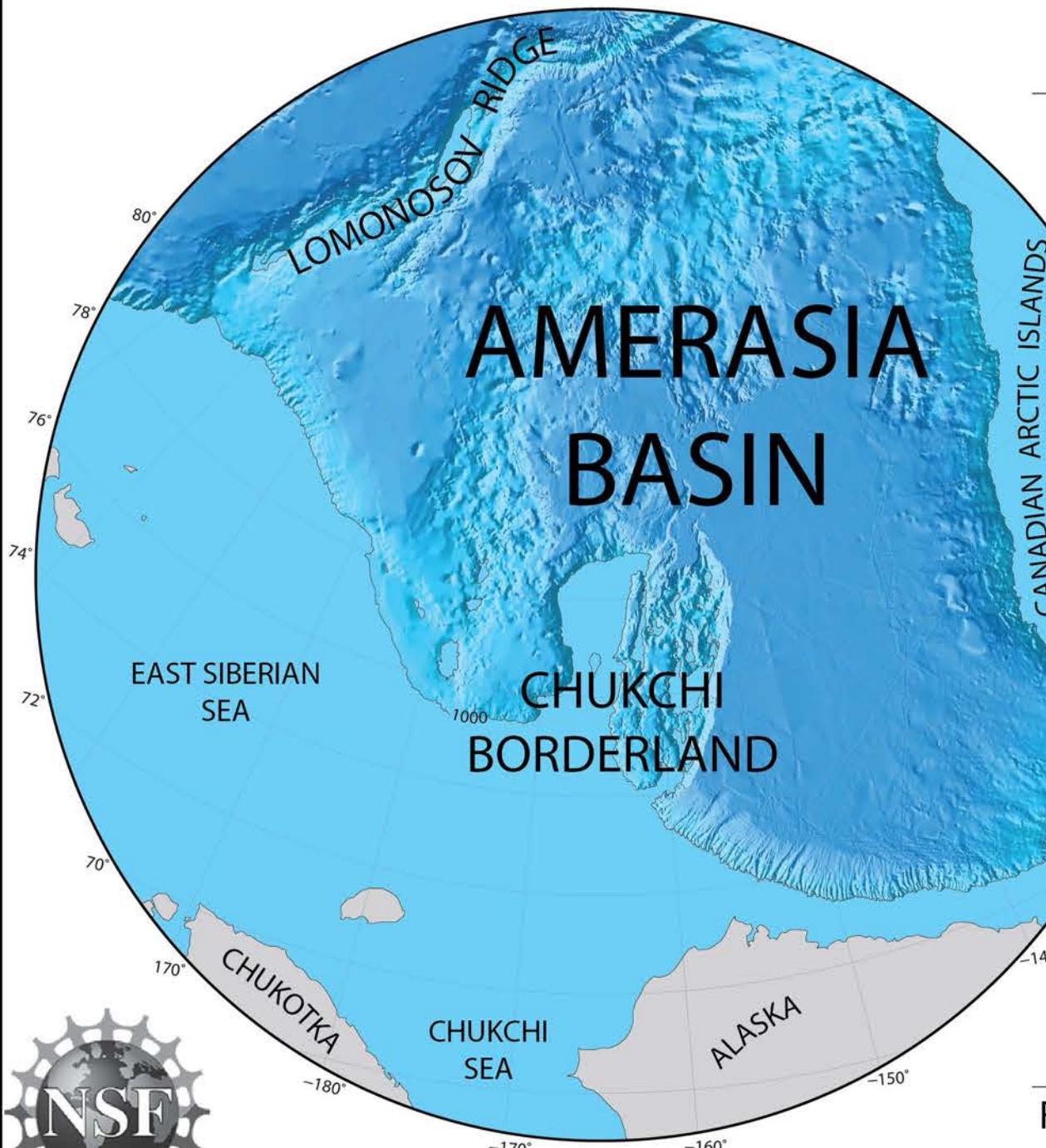
Mickey, M.B., and H. Haga, 2003b, Biostratigraphy report, Popcorn No. 1 (OCS-Y-1275): Shell Western E&P, Job No: 22-113.

Sherwood, K.W., P.P. Johnson, J.D. Craig, S.A. Zerwick, R.T. Lothamer, D.K. Thurston, and S.B. Hurlbert, 2002, Structure and stratigraphy of the Hanna Trough, U.S. Chukchi Shelf, Alaska, *in* E.L. Miller, A. Grantz, and S.L. Klemper, eds., *Tectonic Evolution of the Bering Shelf-Chukchi Sea-Arctic Margin and Adjacent Landmasses*: Geological Society of America, Boulder, CO, Special Papers, v. 360, p. 39-66.



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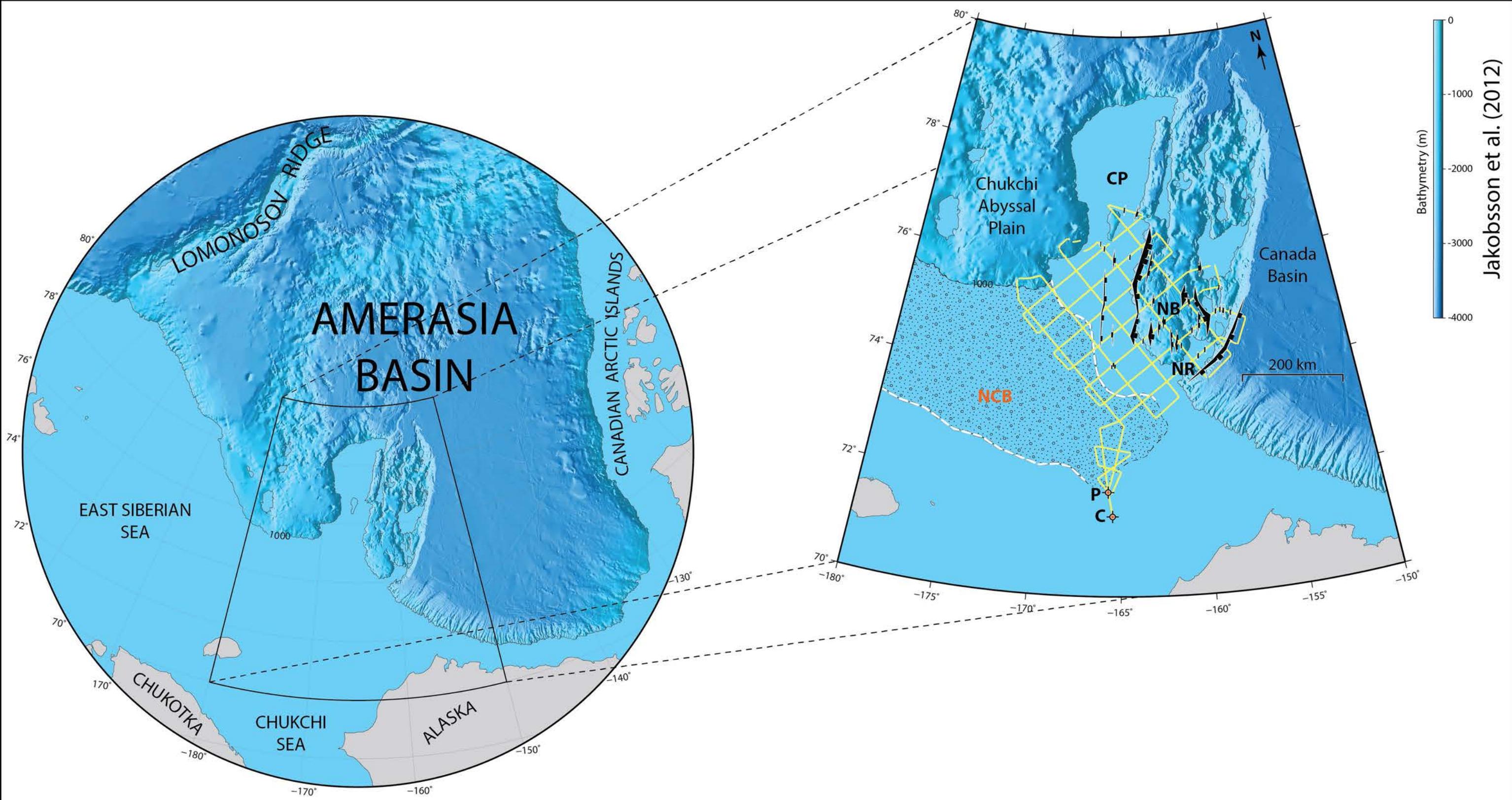
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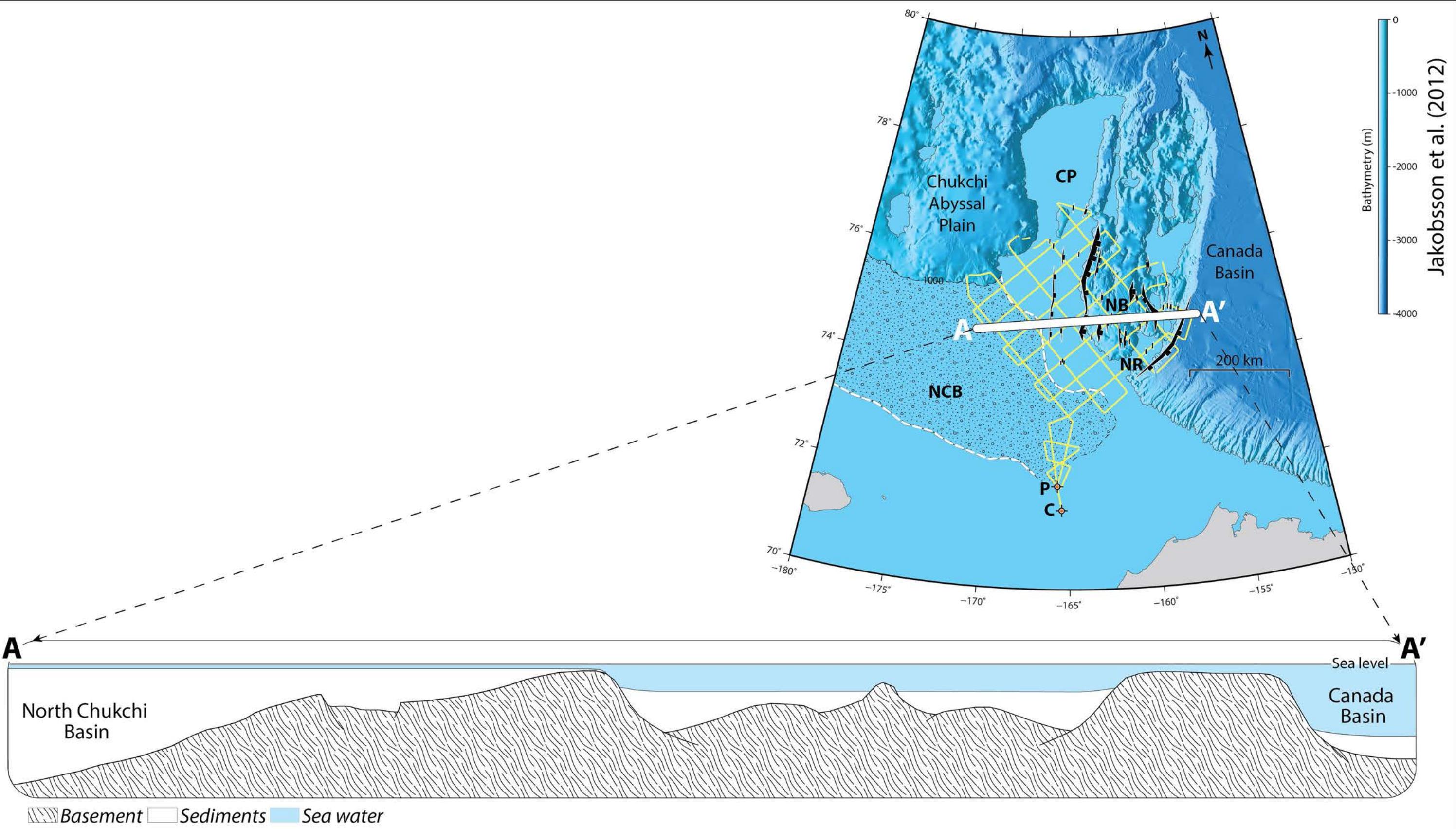
Acquisition of multi-channel seismic reflection profiles in 2011 by the *R/V Marcus G. Langseth* across the transition from the Chukchi Shelf to Borderland

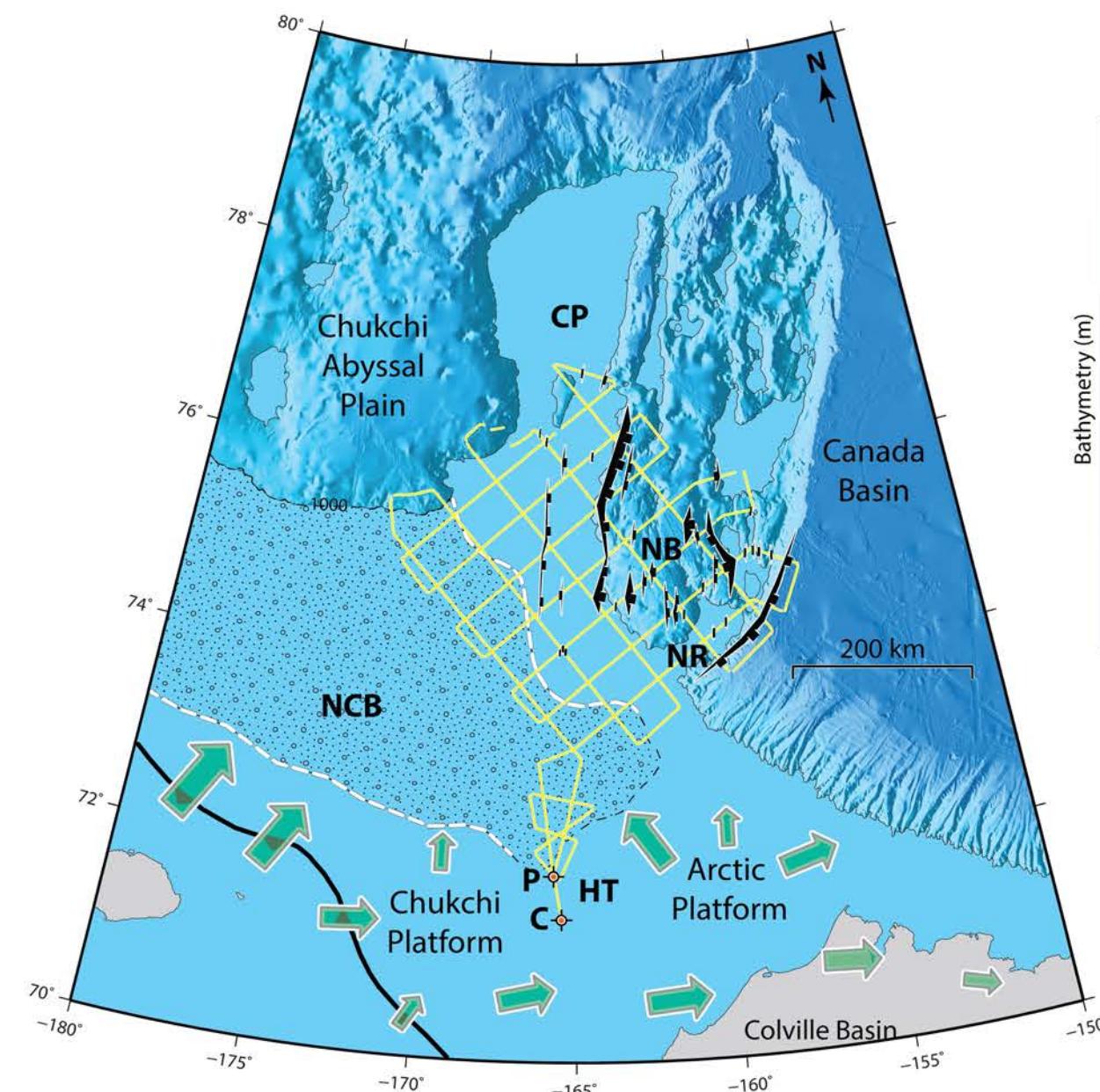
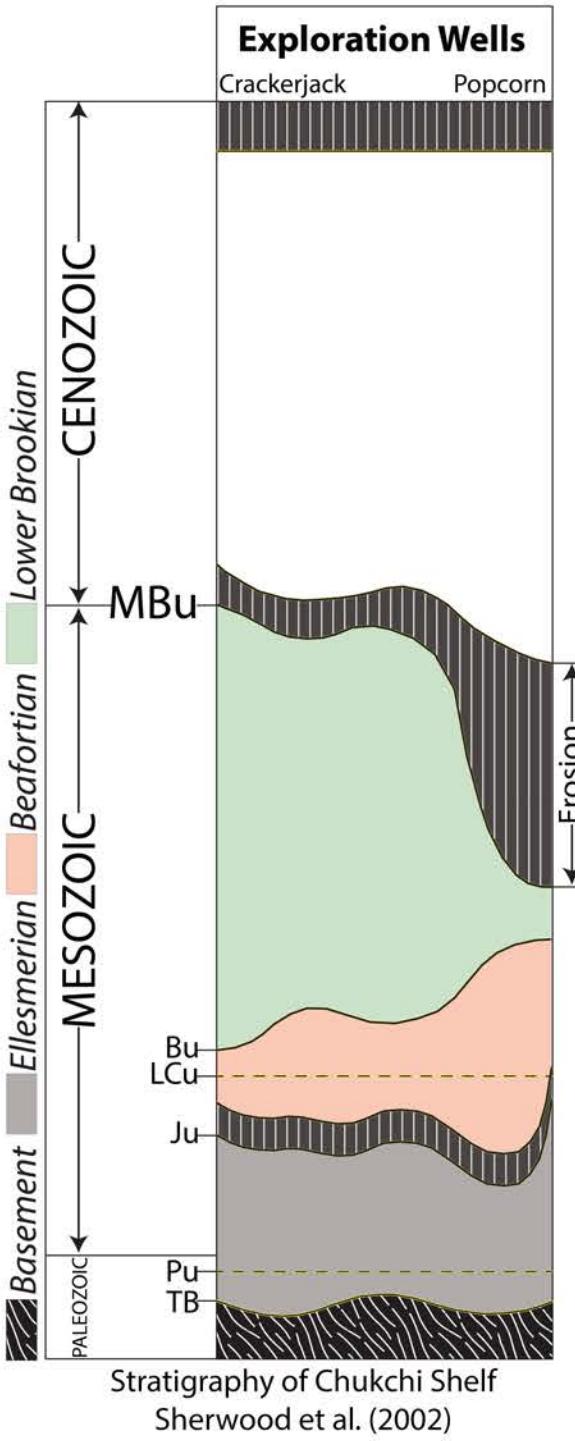
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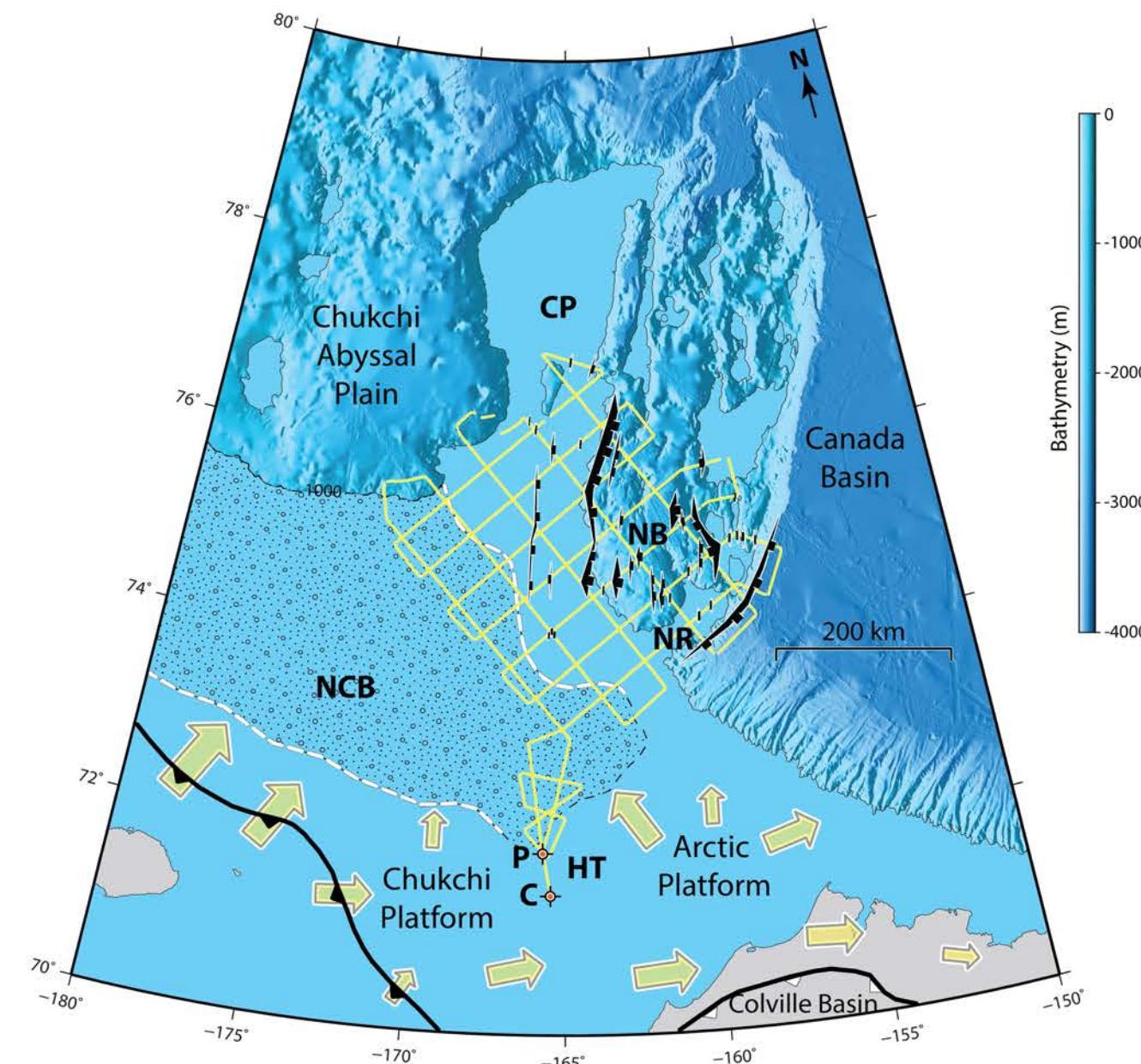
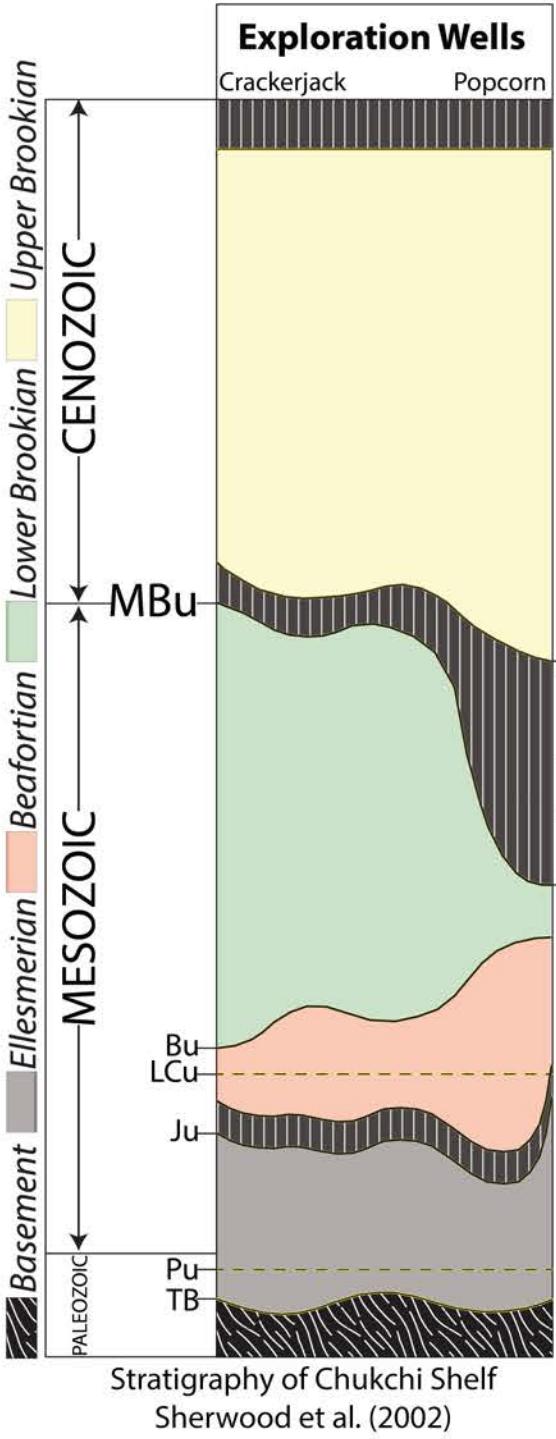




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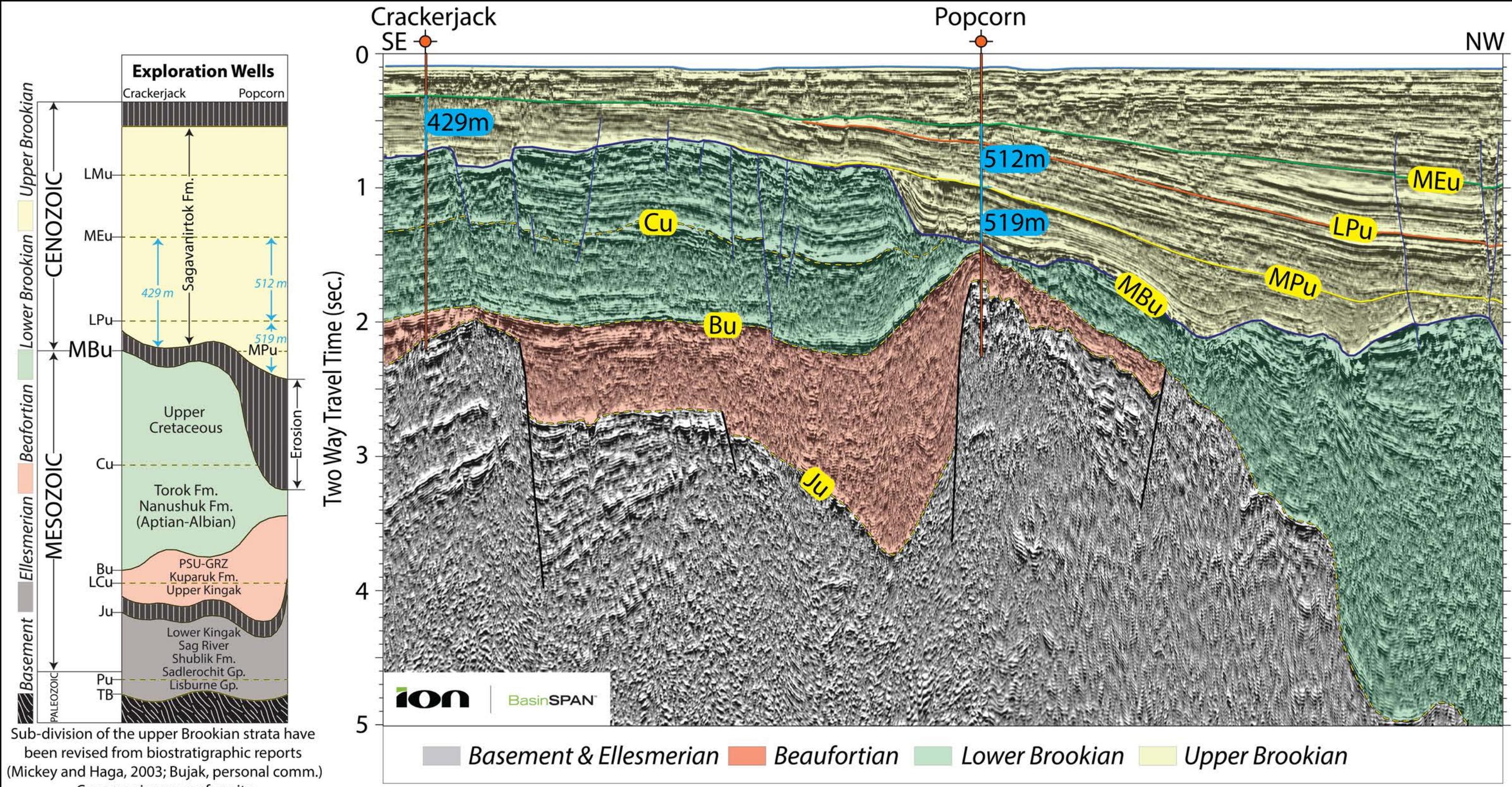




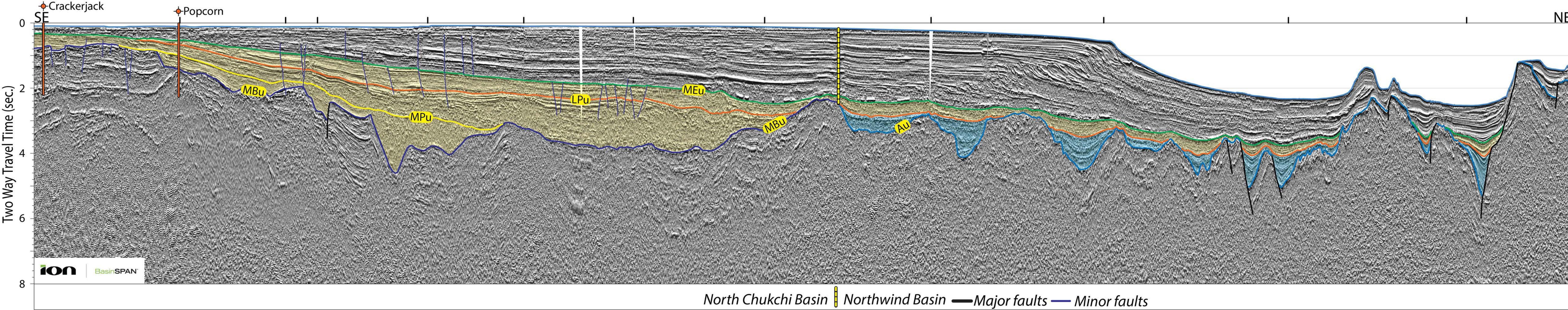


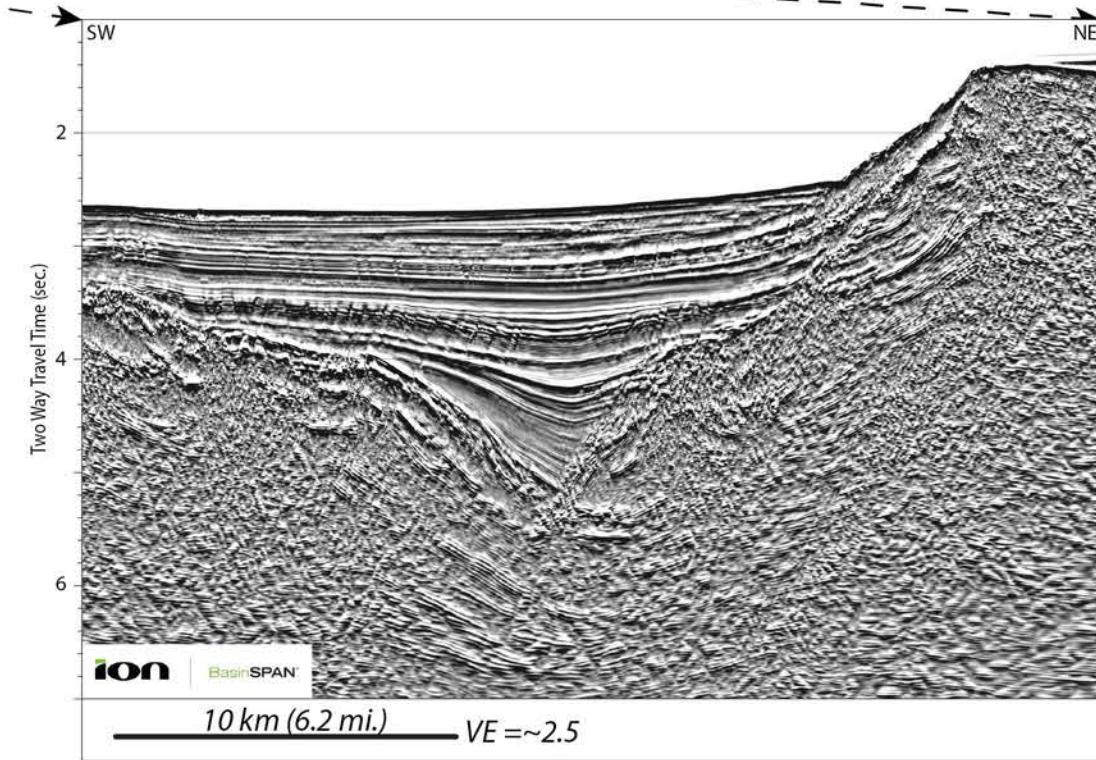
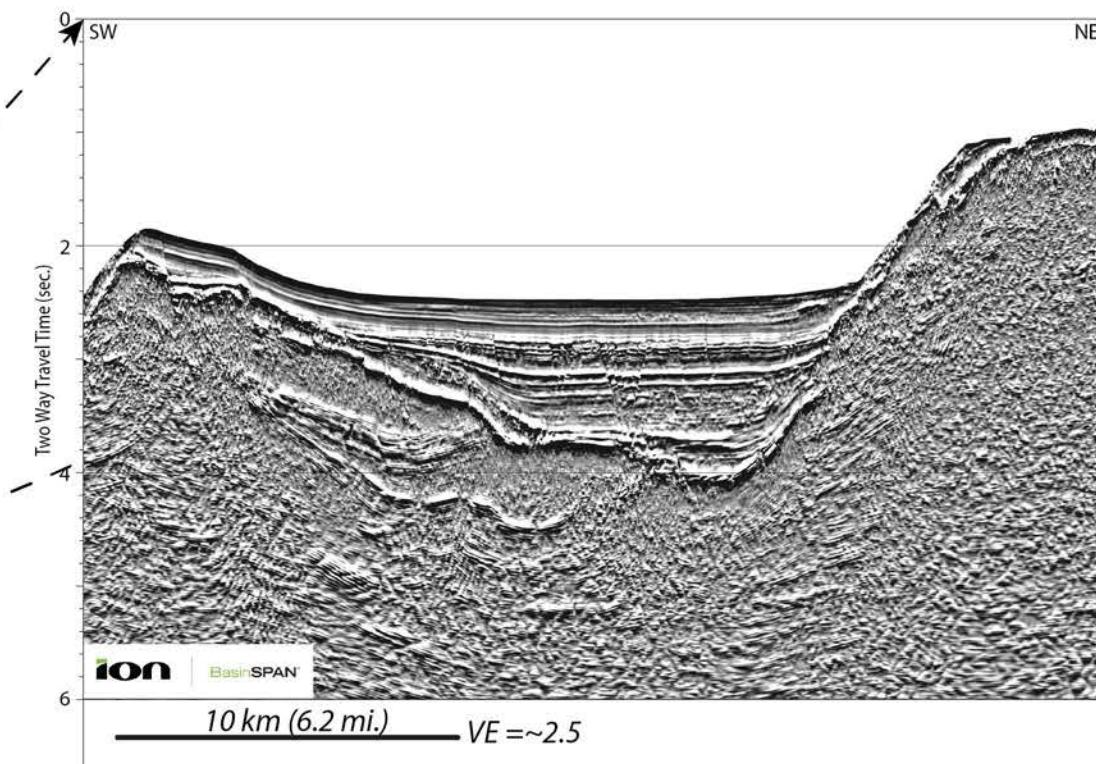
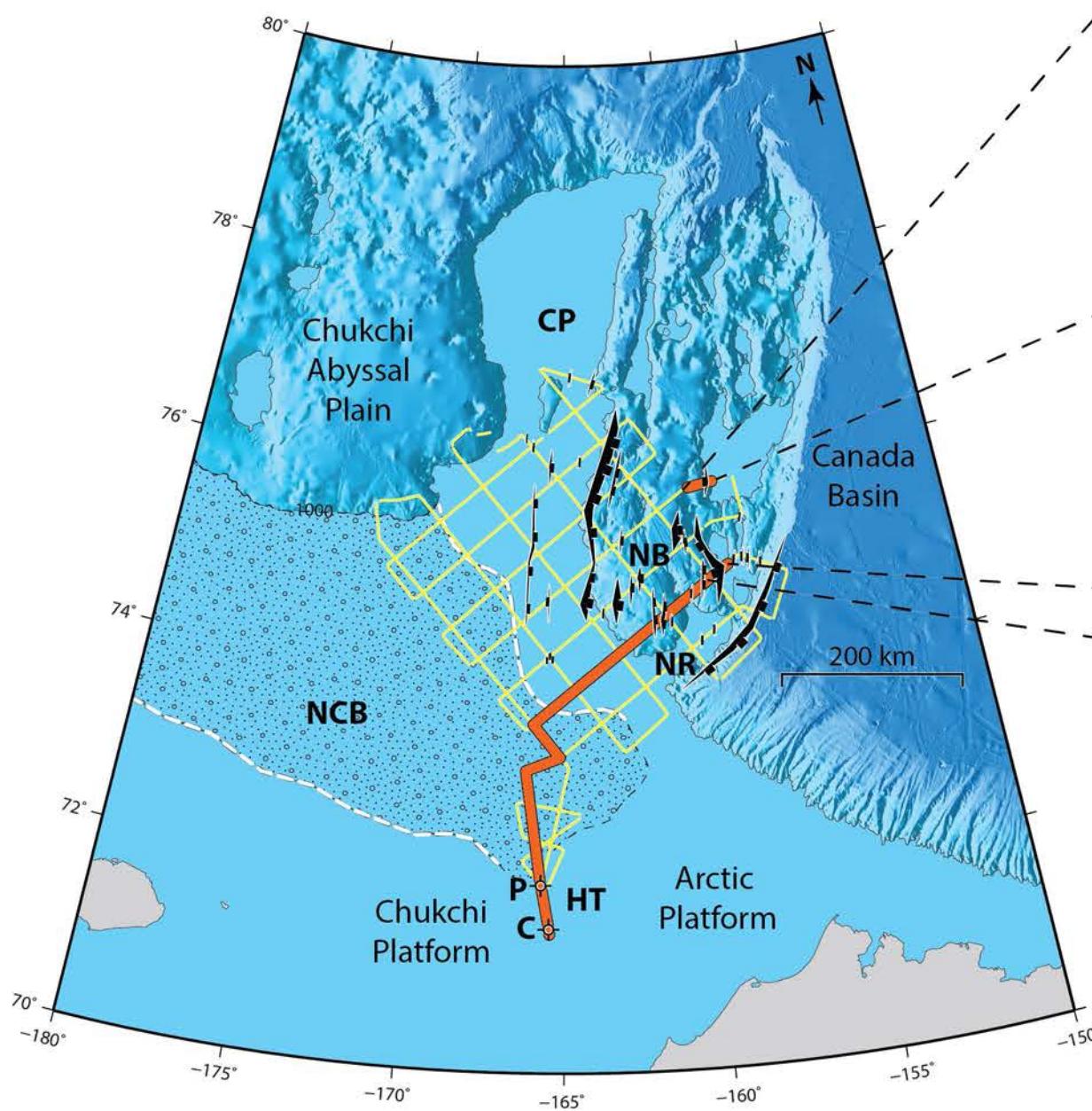
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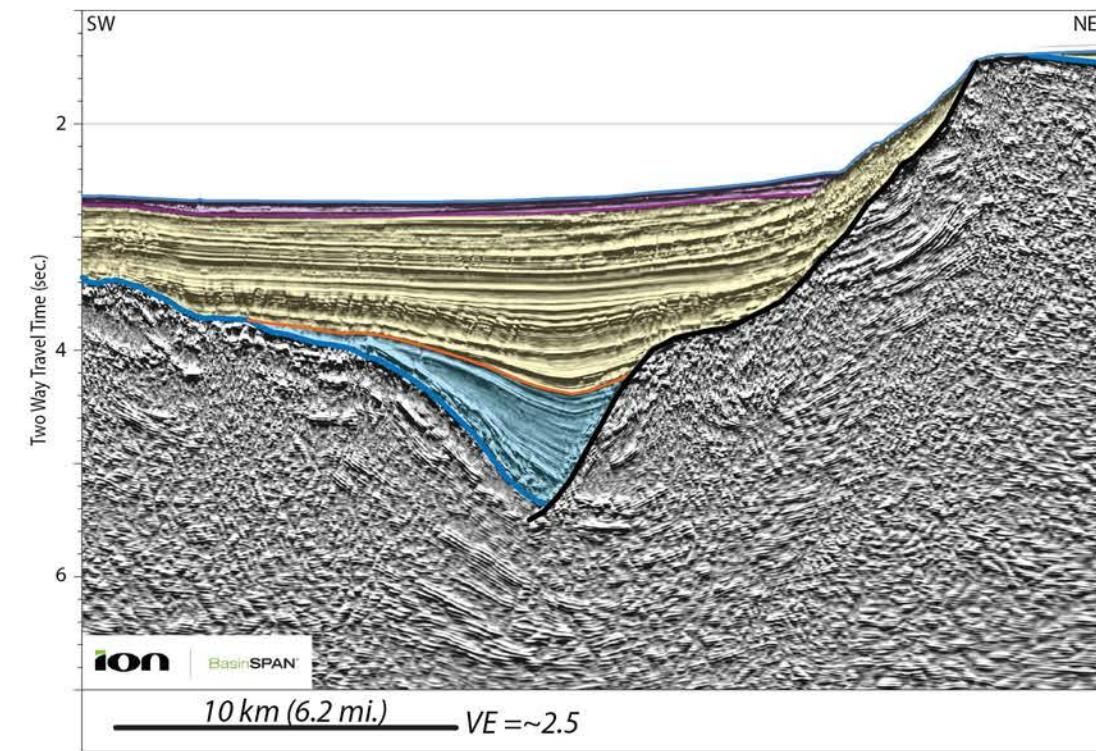
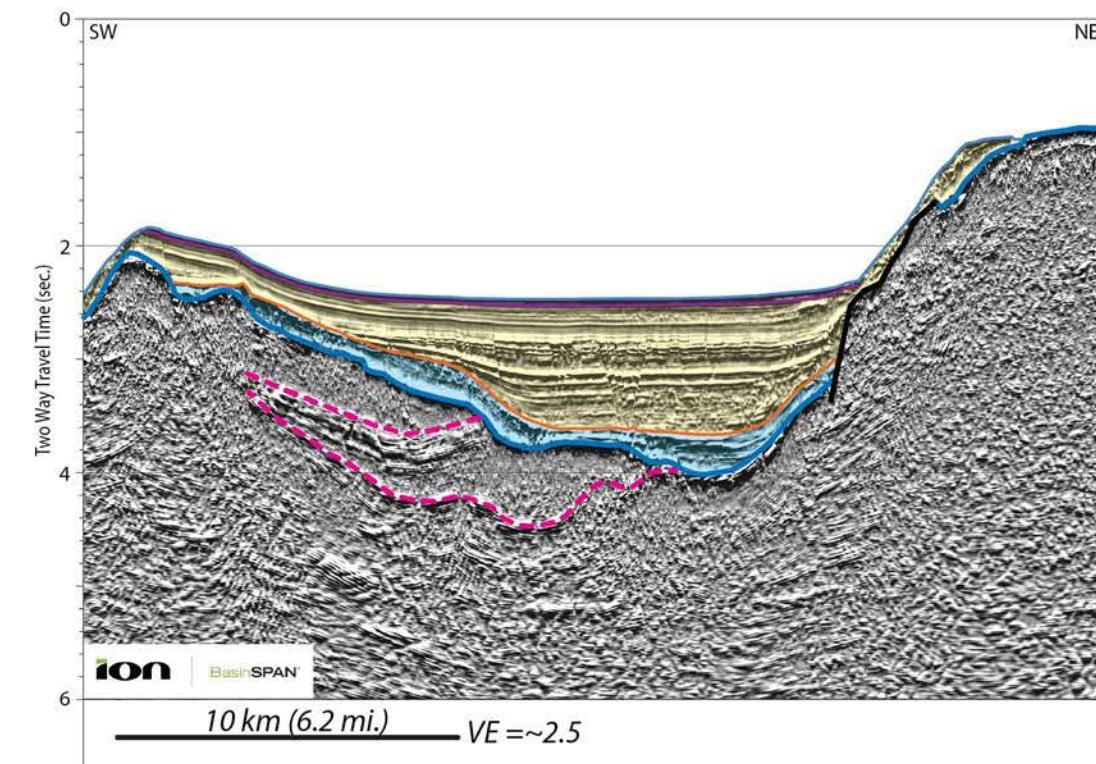
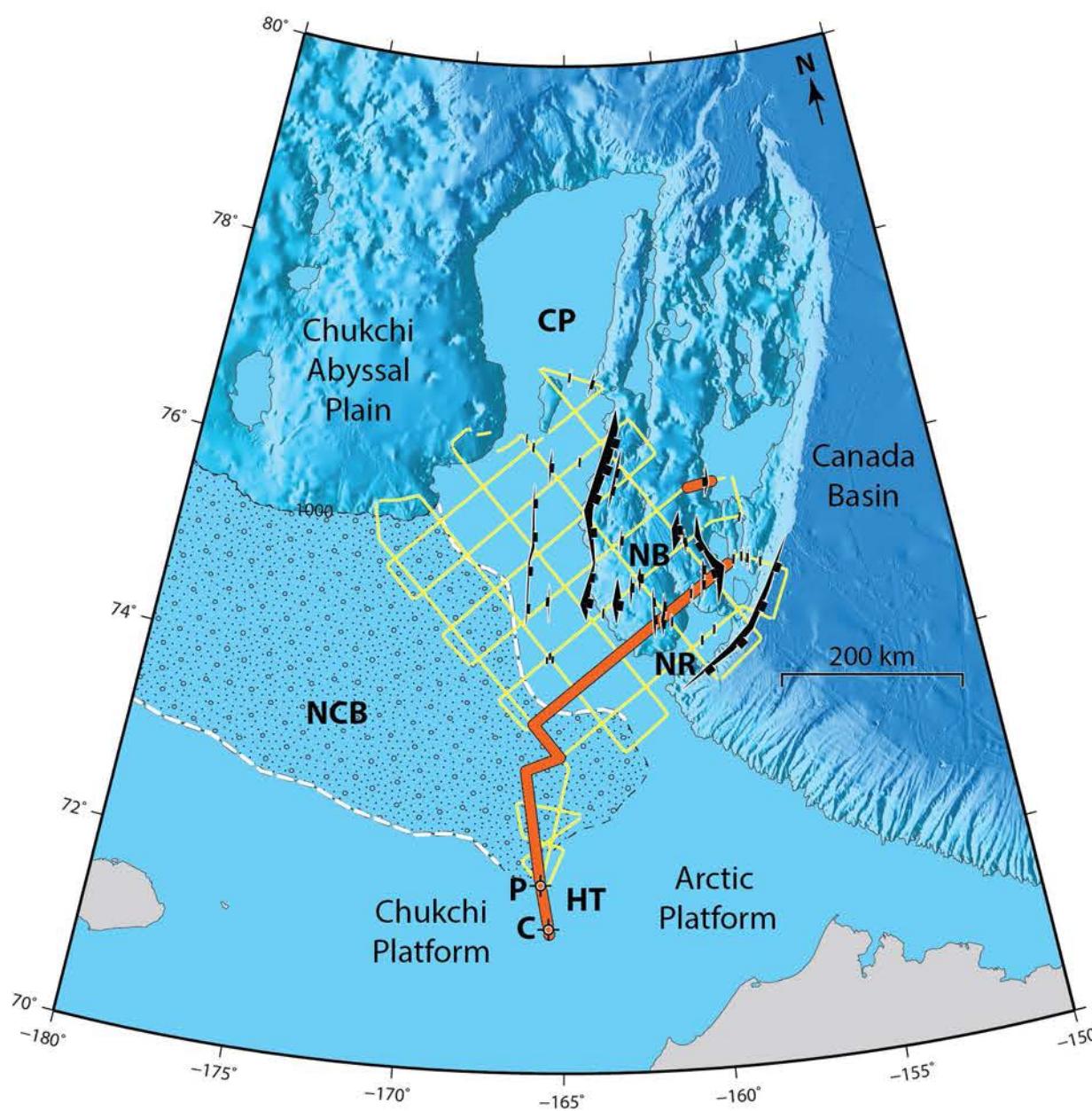
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- Northern limit of Brooks Range frontal thrust belt (Paleogene)
- Sediment transport directions (Houseknecht and Bird, 2011)

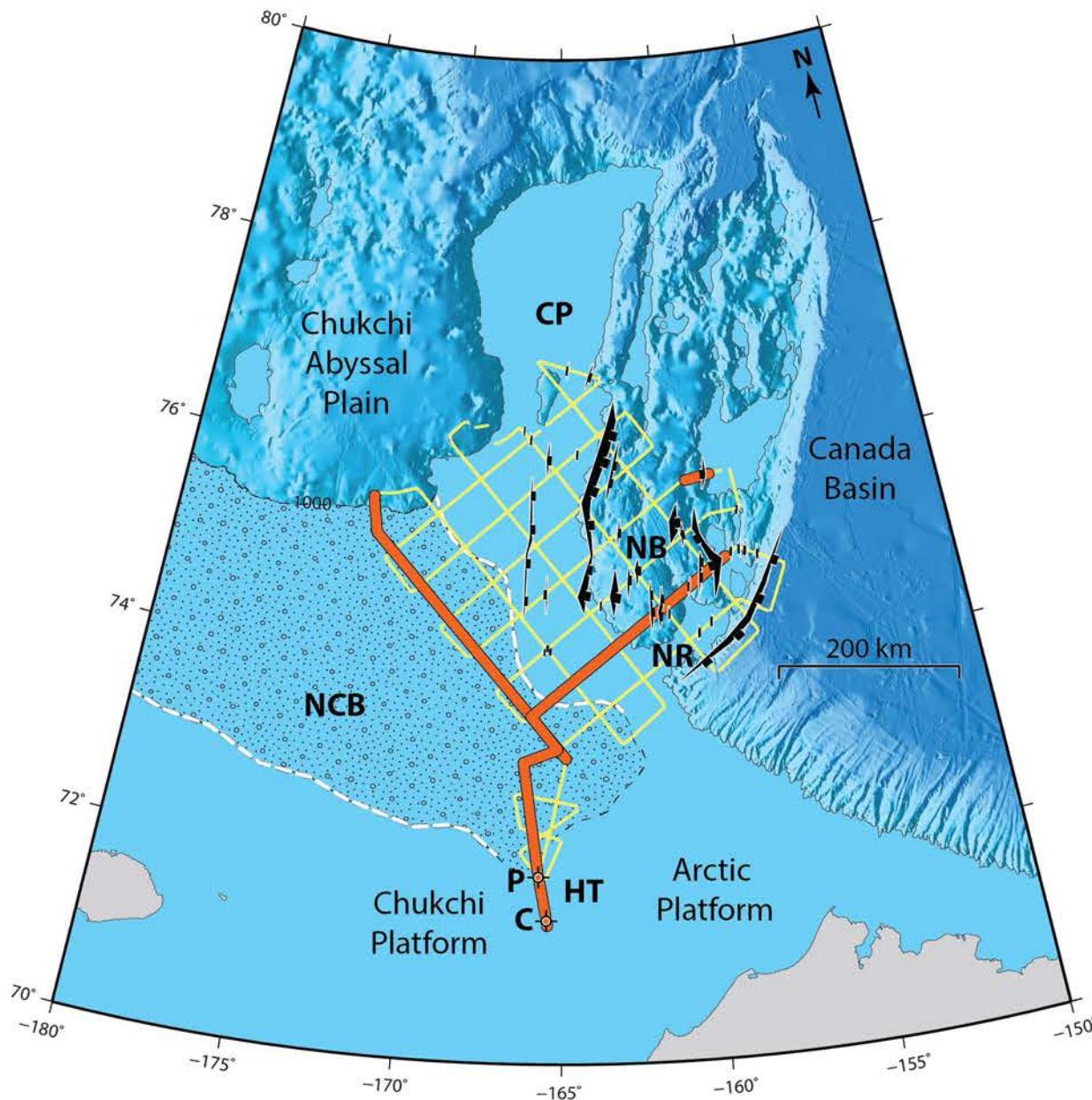


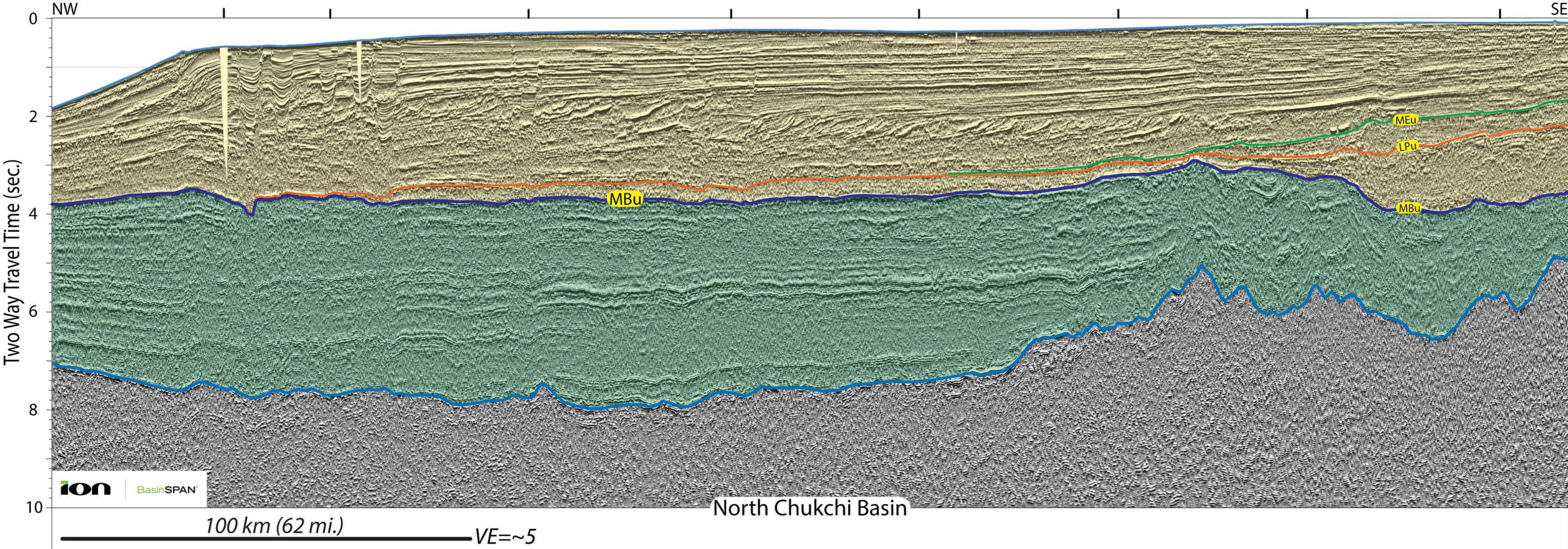
Sub-division of the upper Brookian strata have been revised from biostratigraphic reports (Mickey and Haga, 2003; Bujak, personal comm.) Cenomanian unconformity (Cu; Craddock and Houseknecht, 2016)

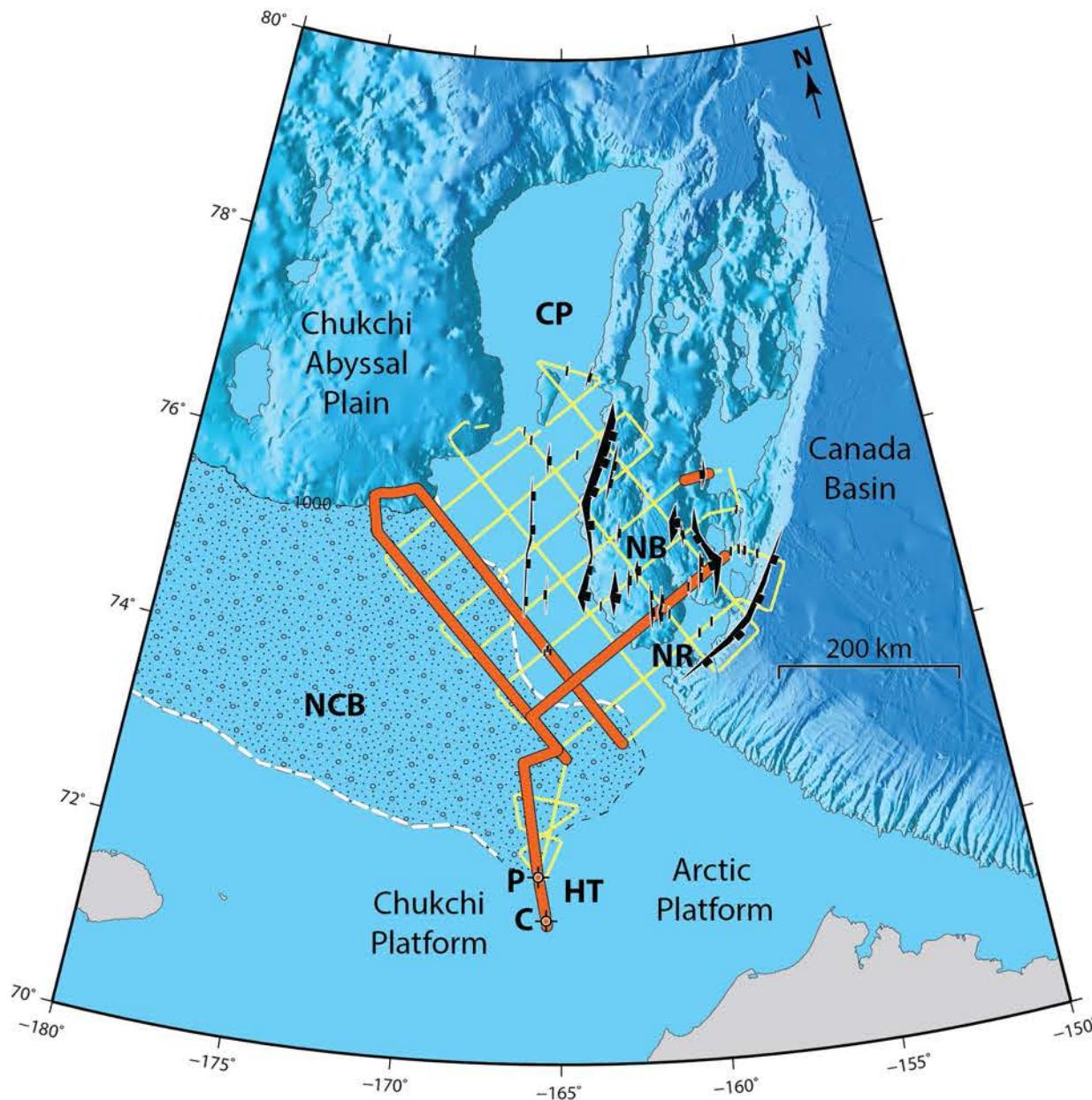


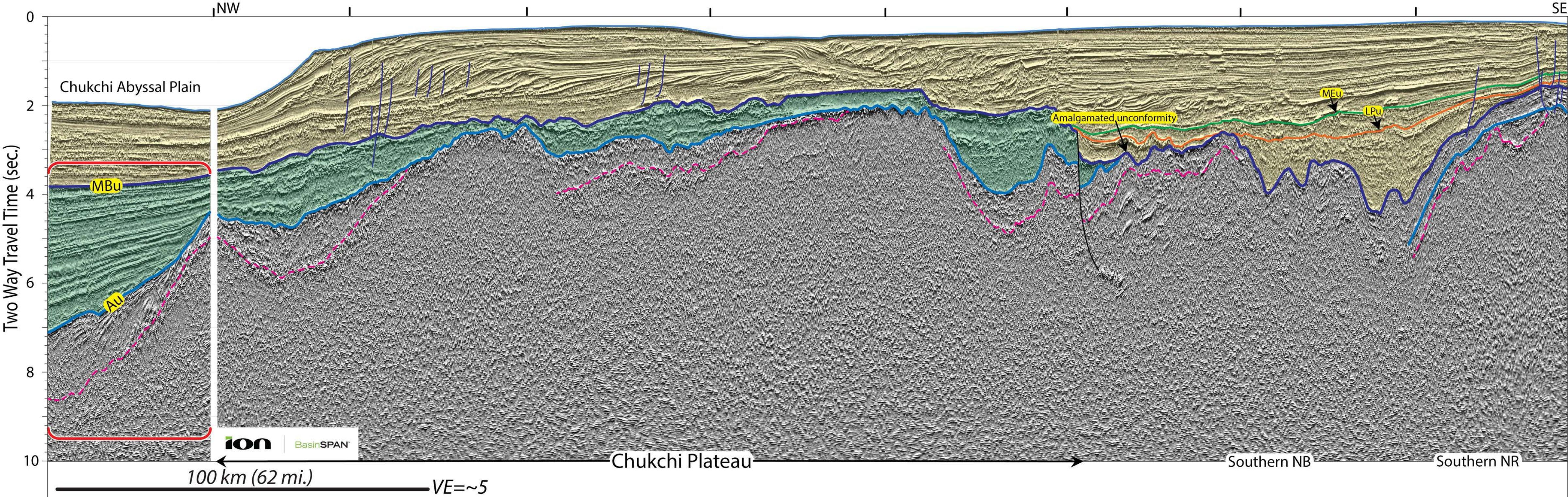


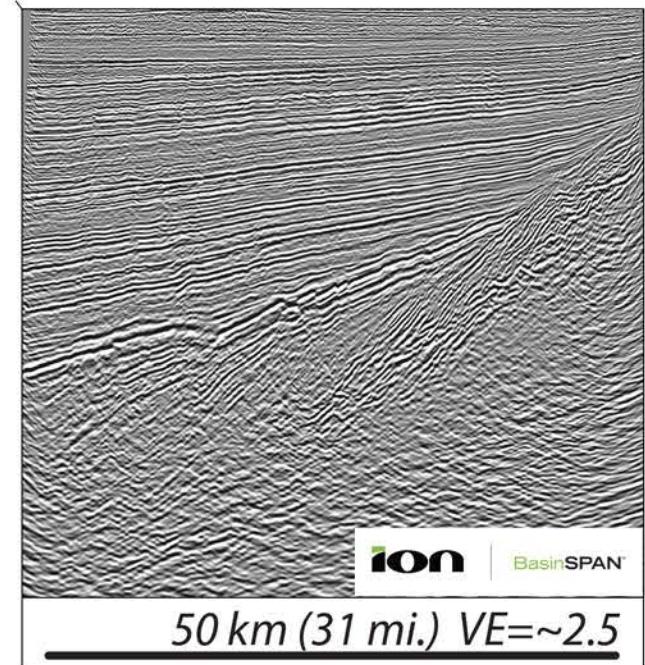
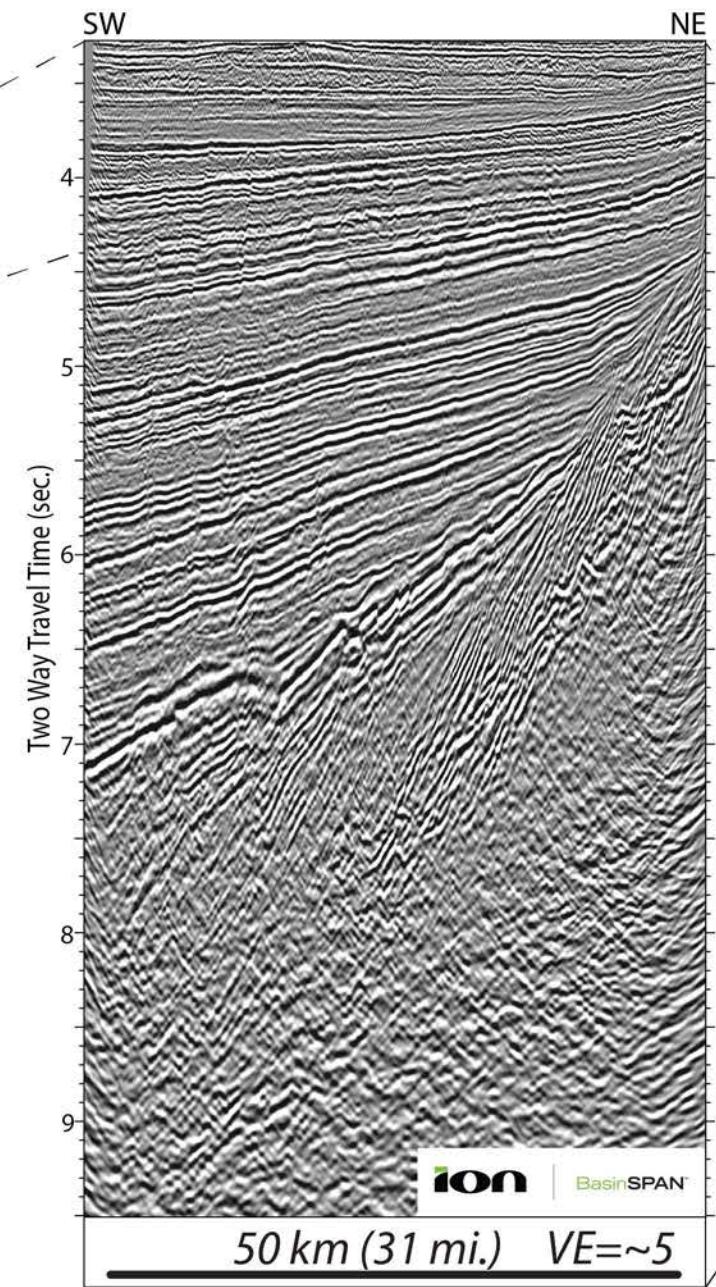
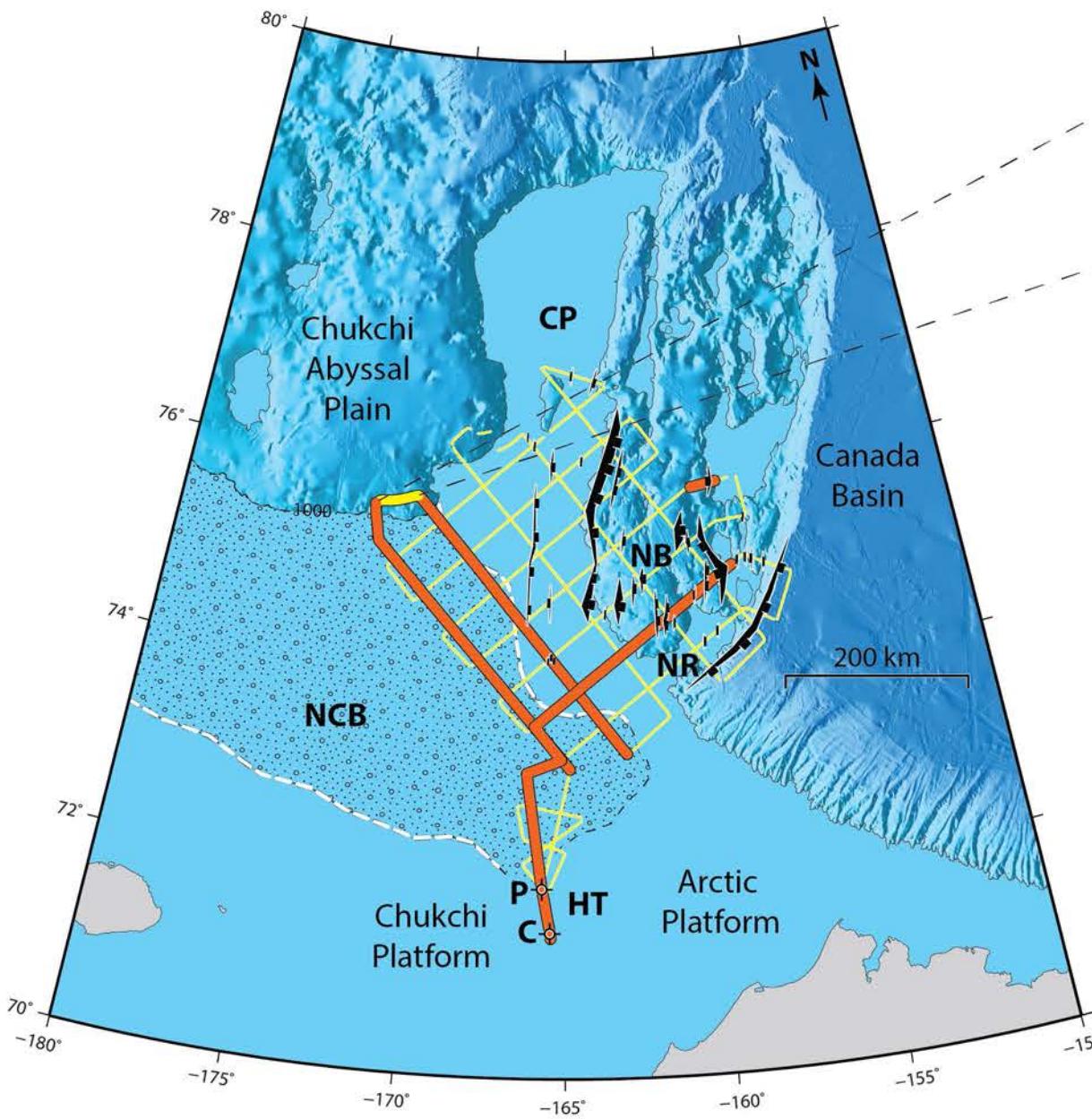










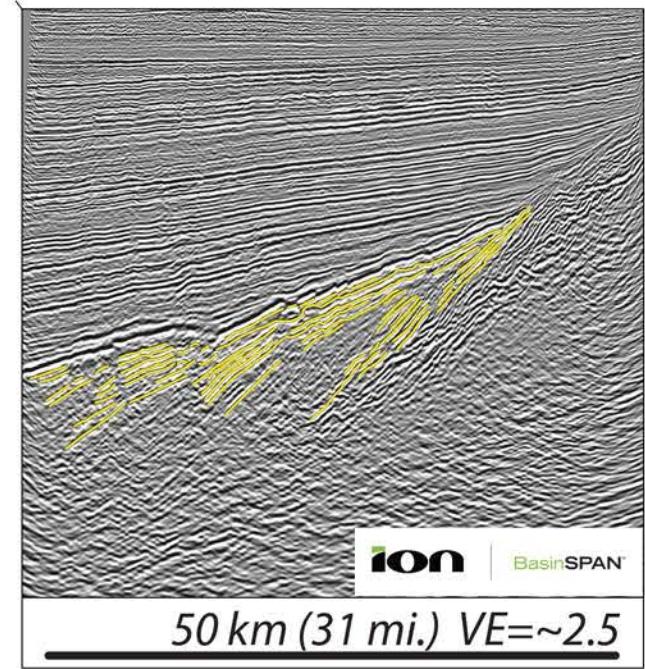
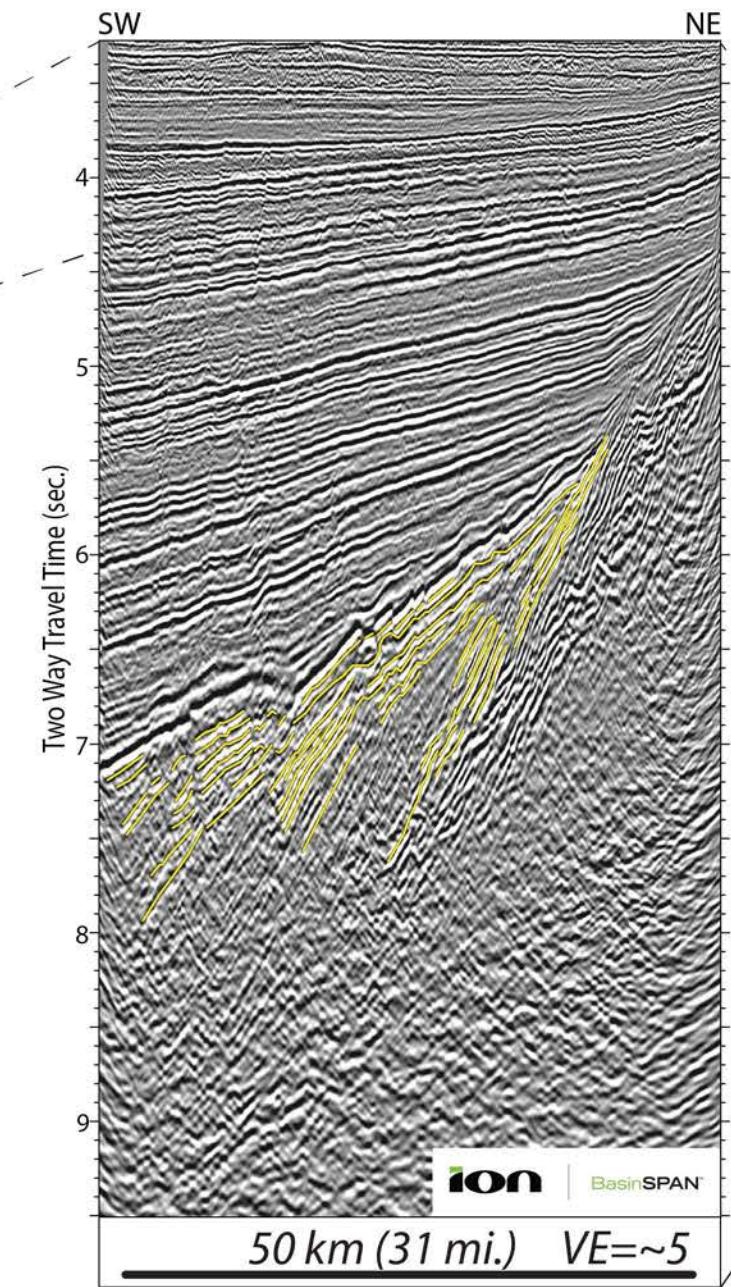
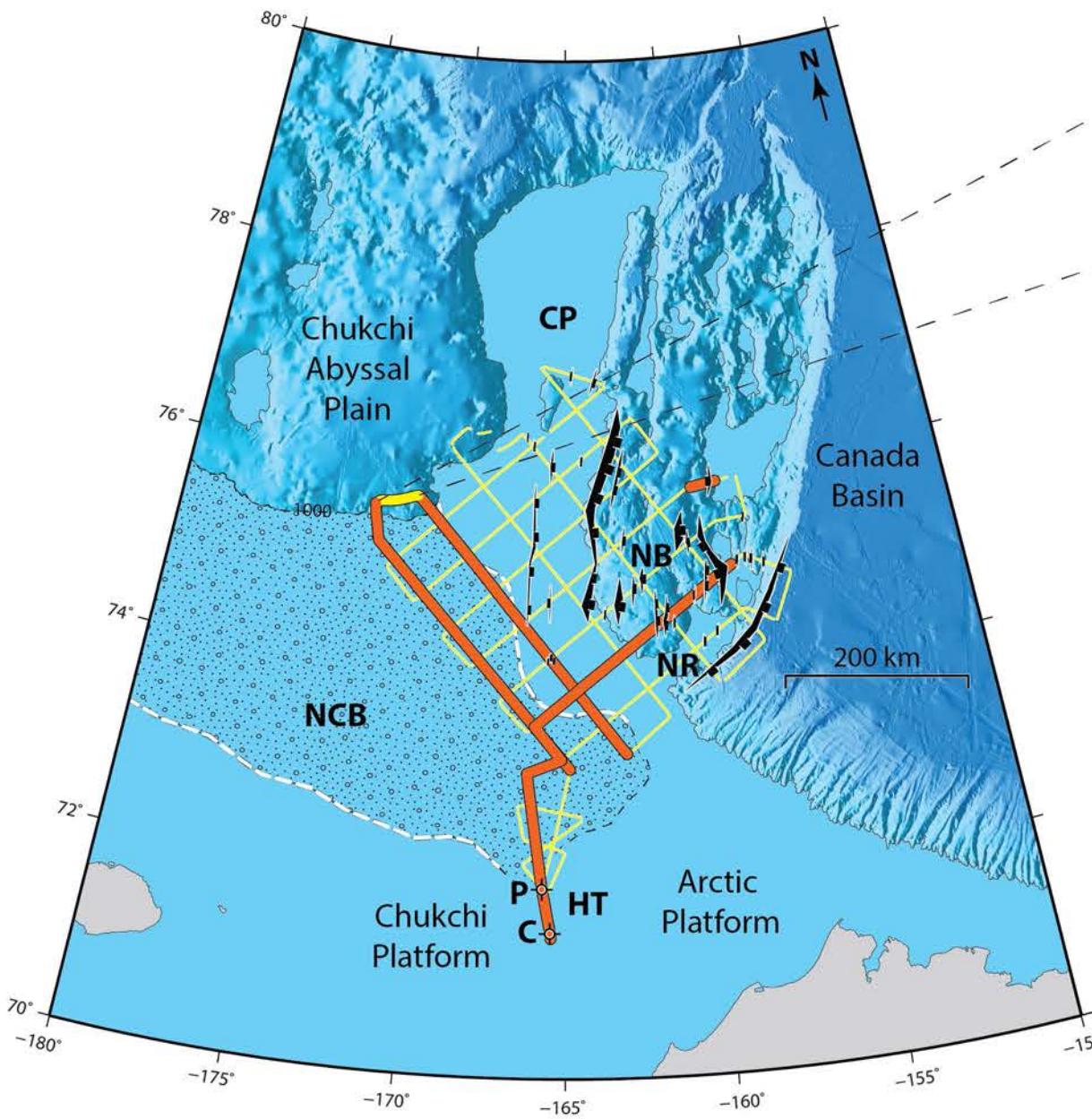


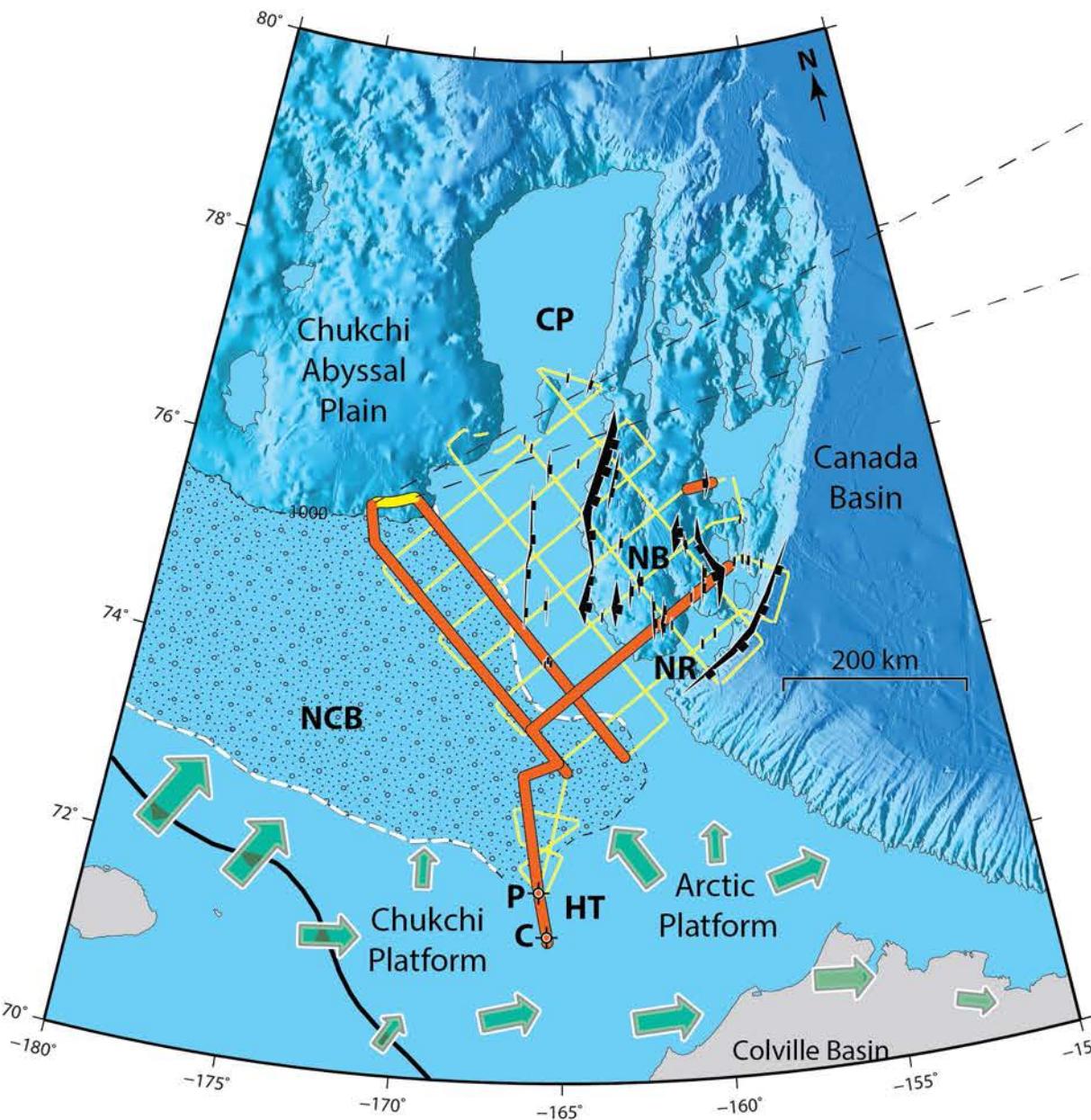
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50 km (31 mi.) $VE = \sim 5$

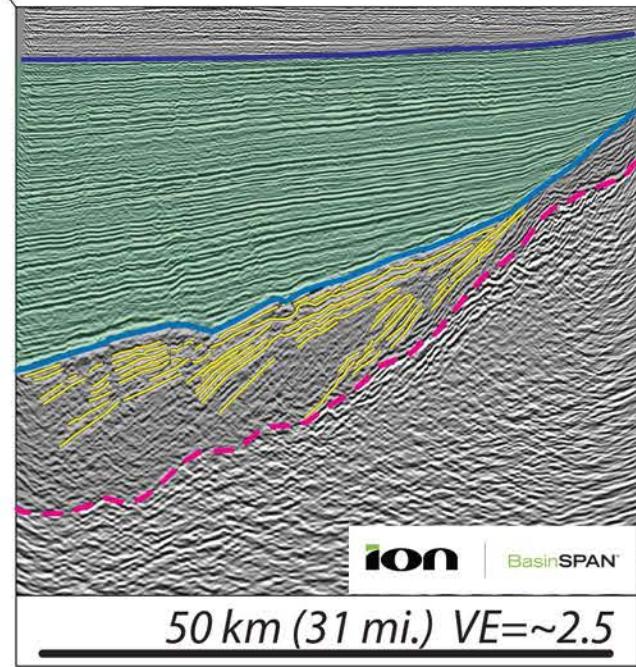
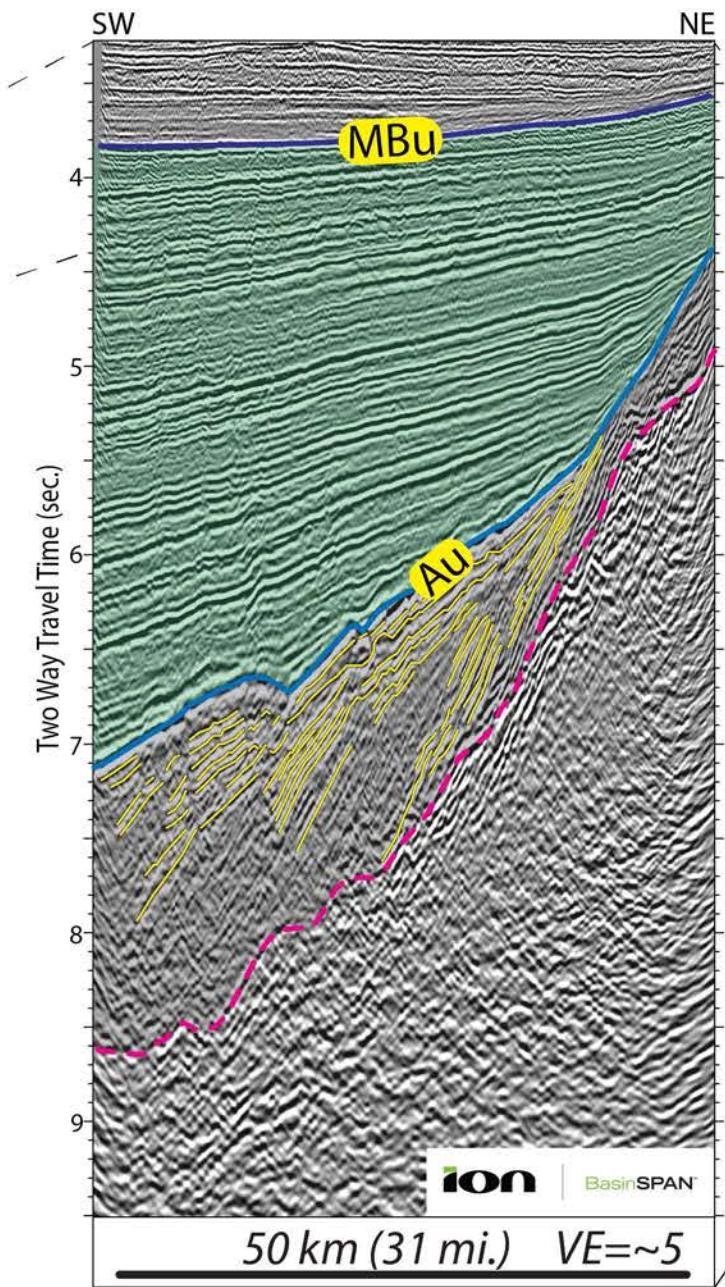
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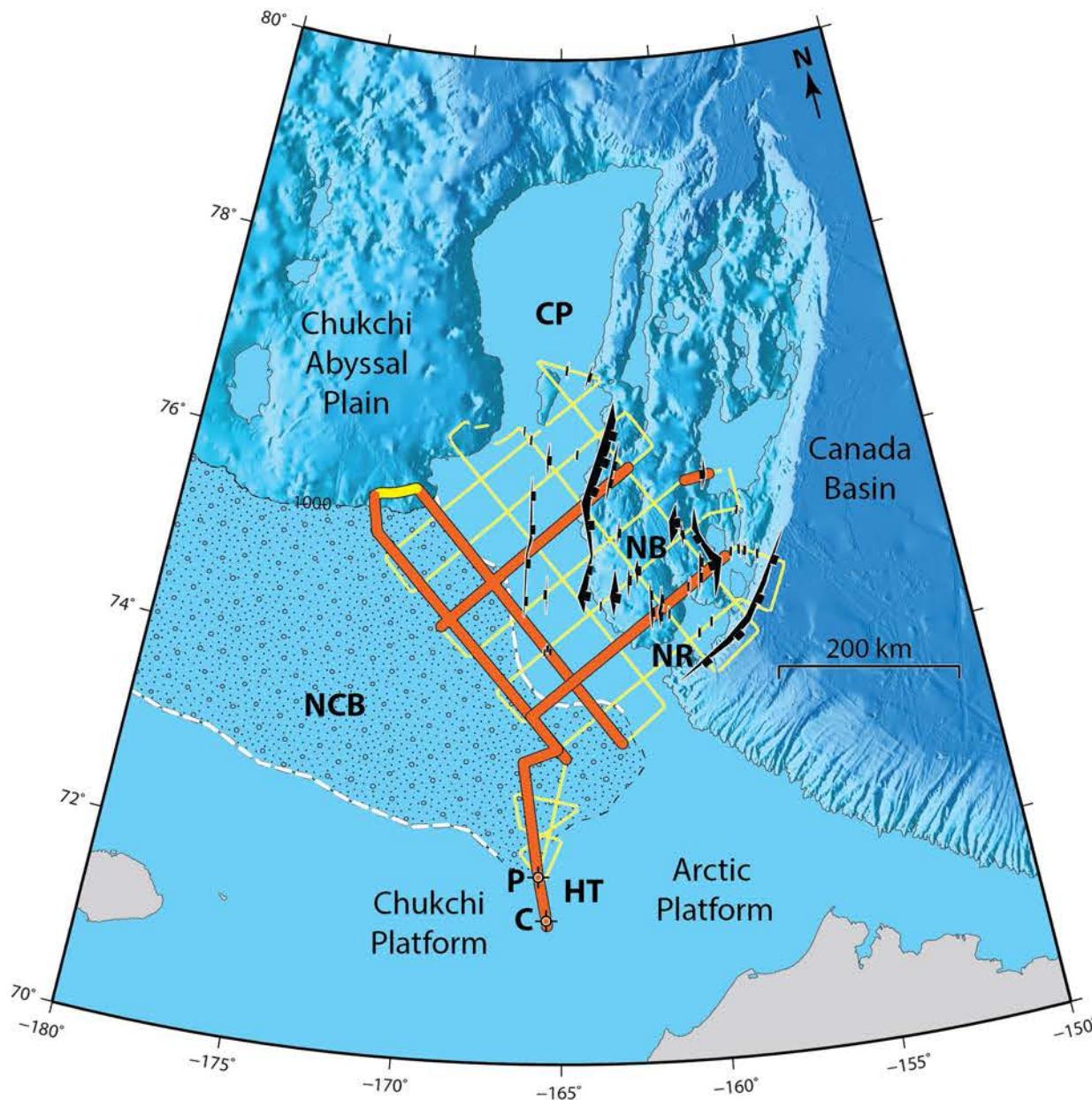
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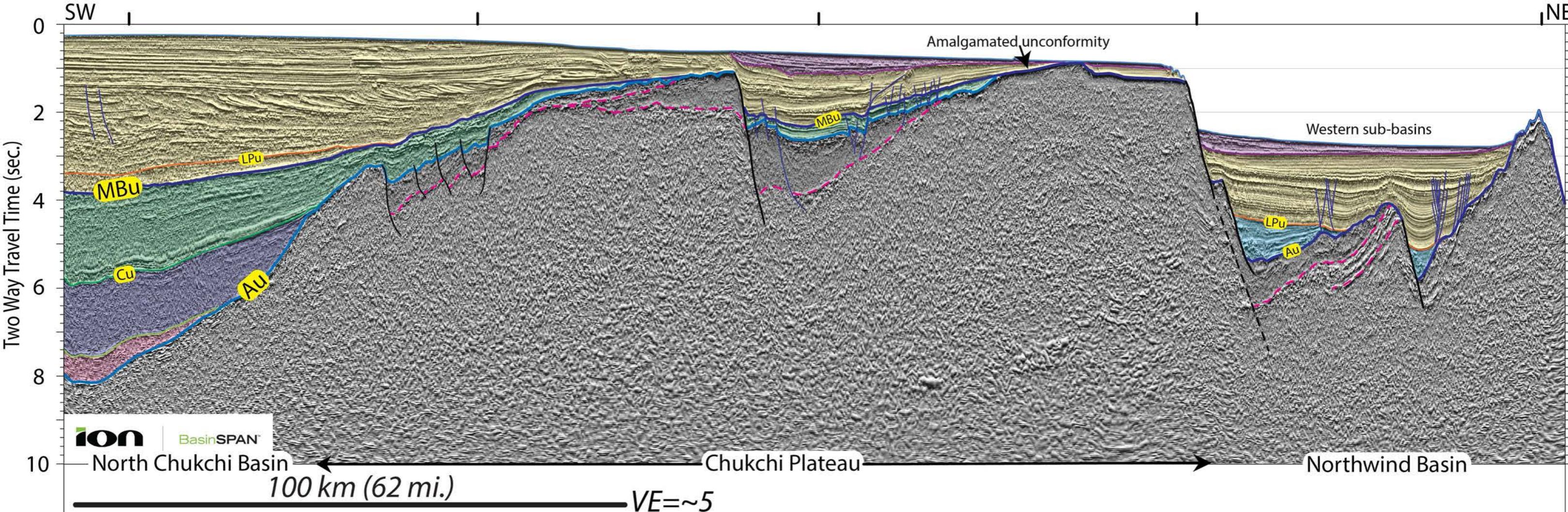


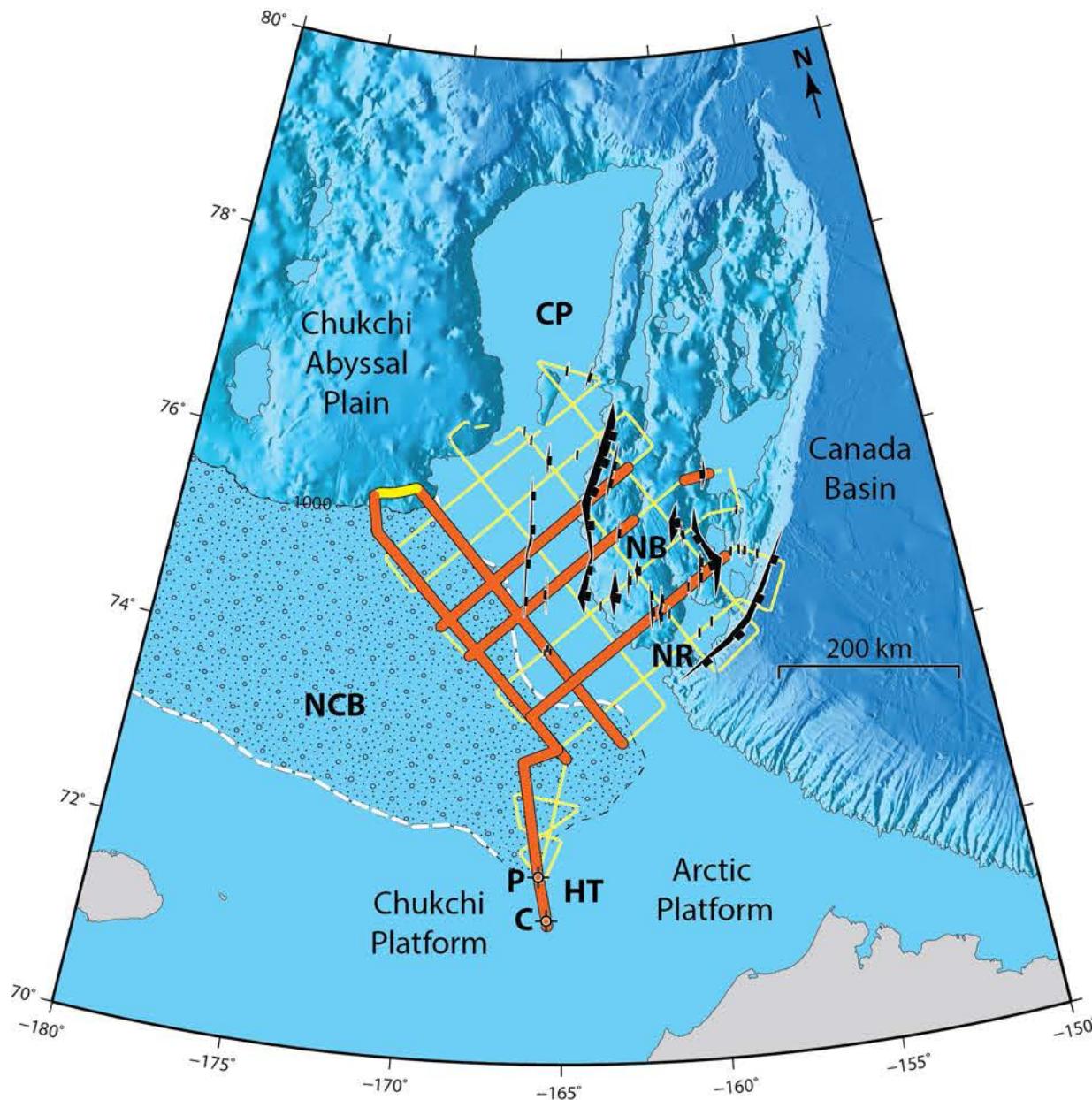


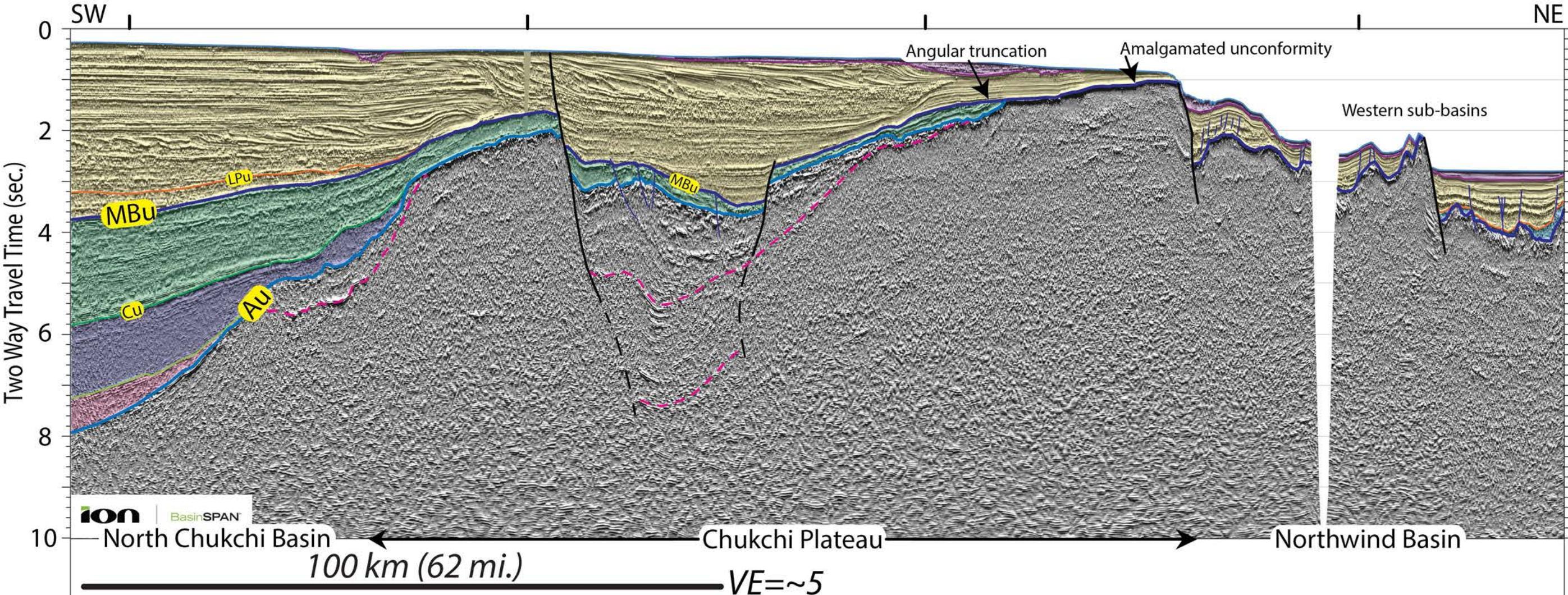
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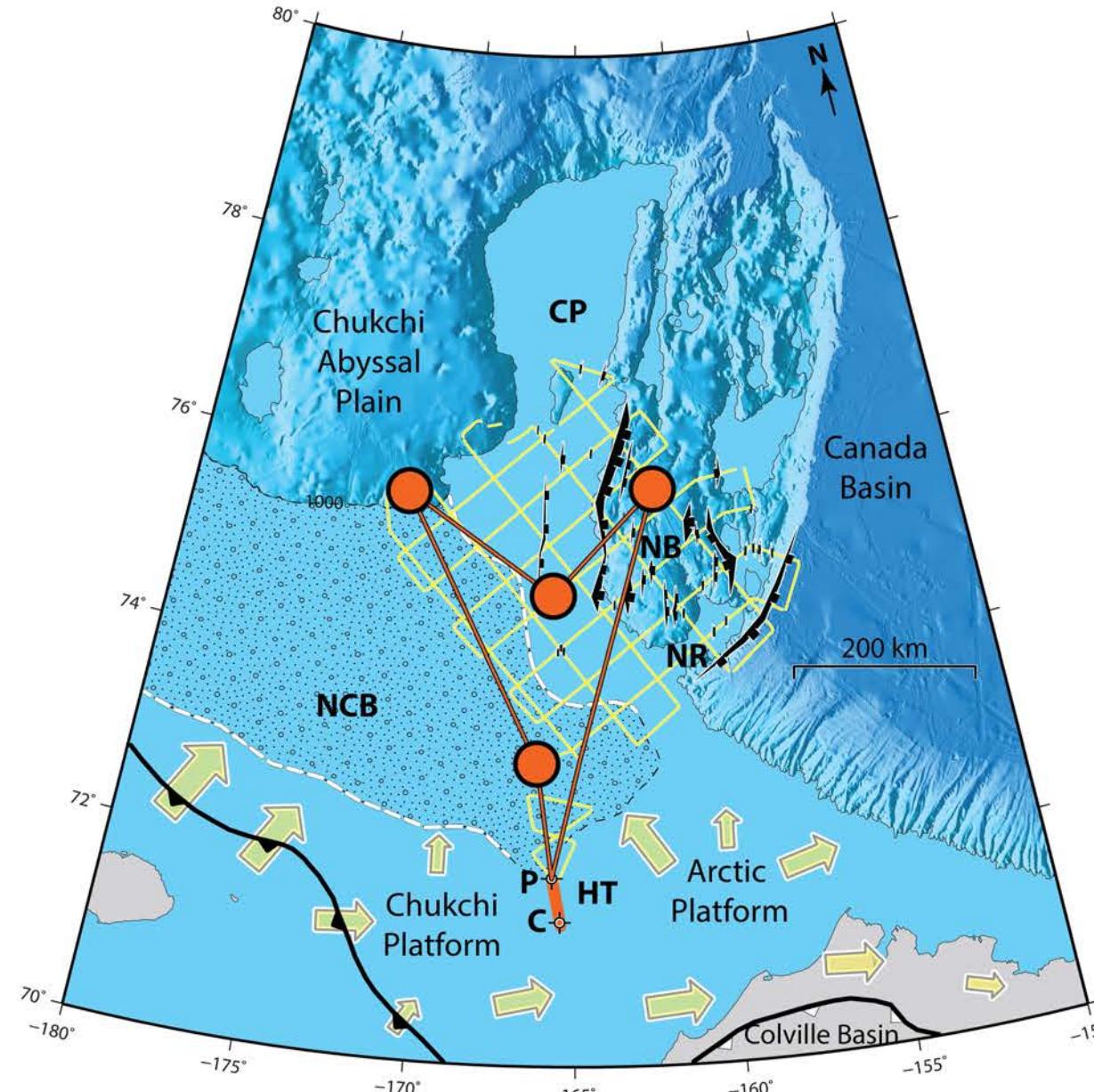
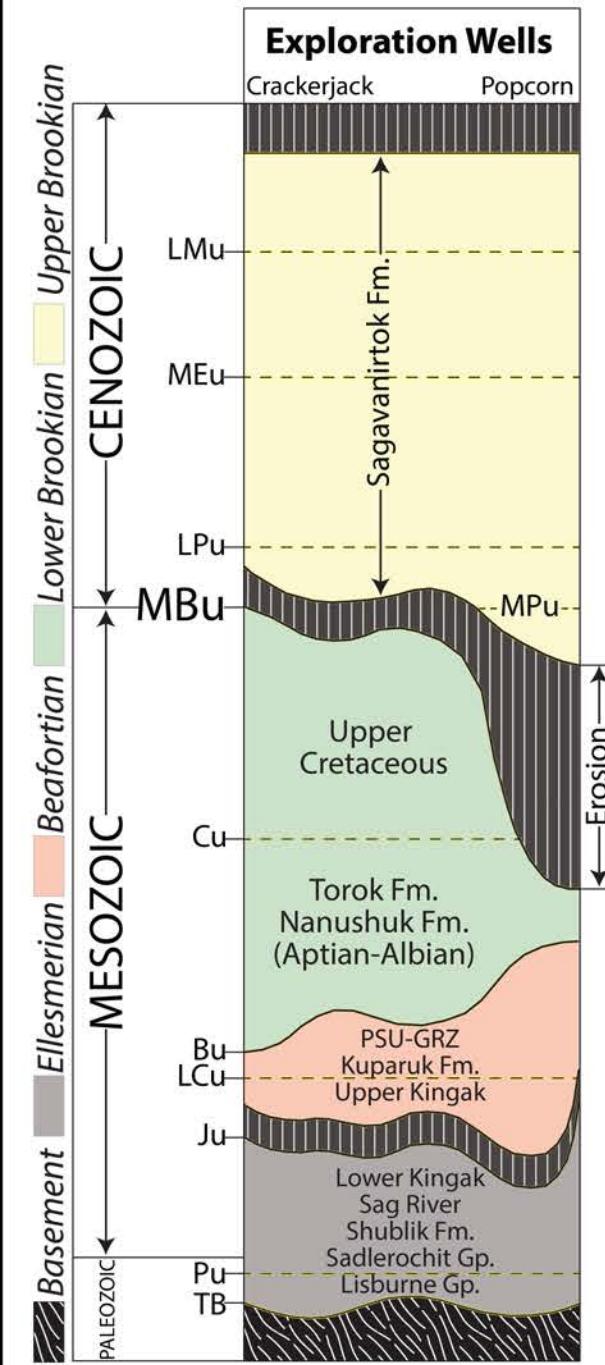




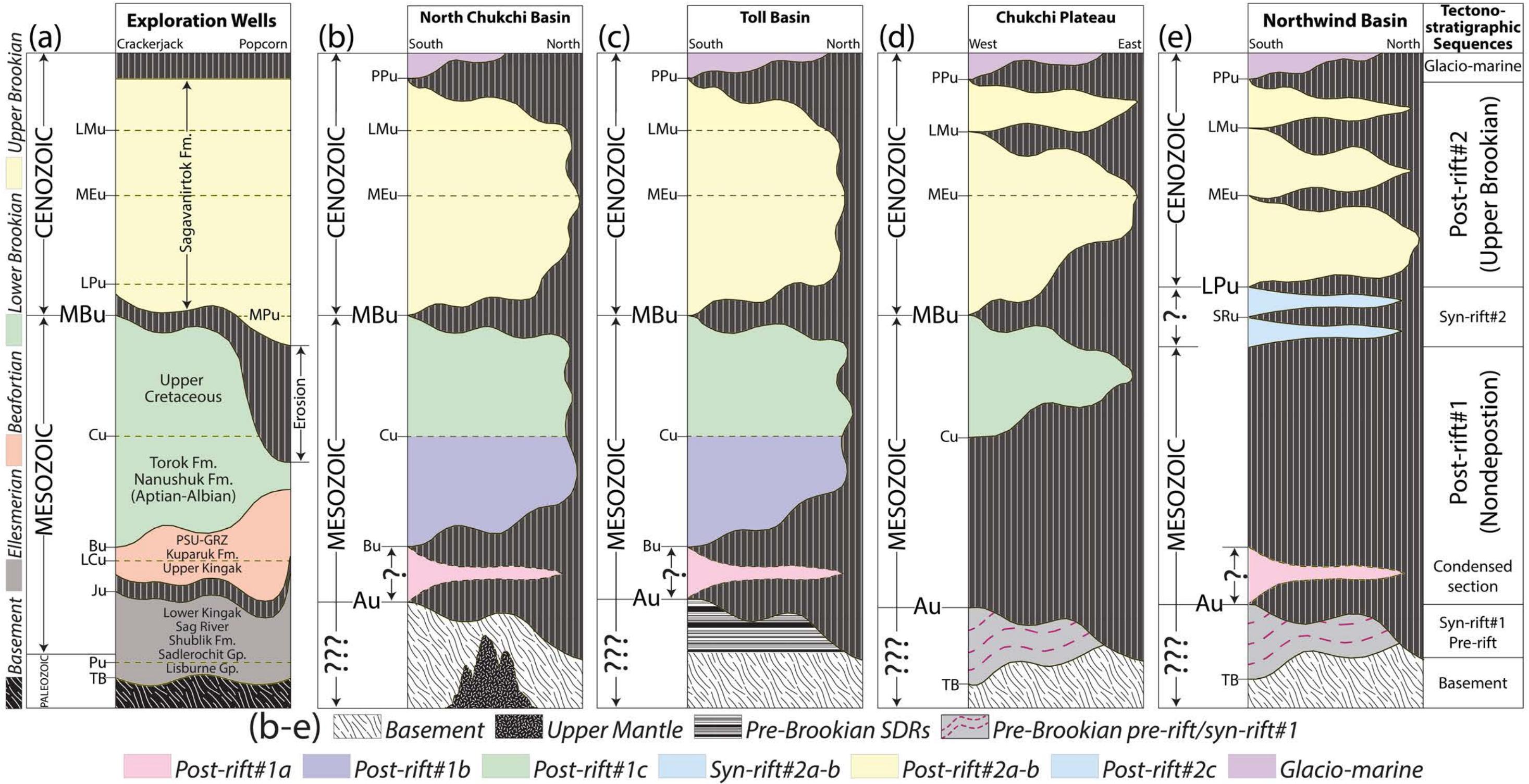




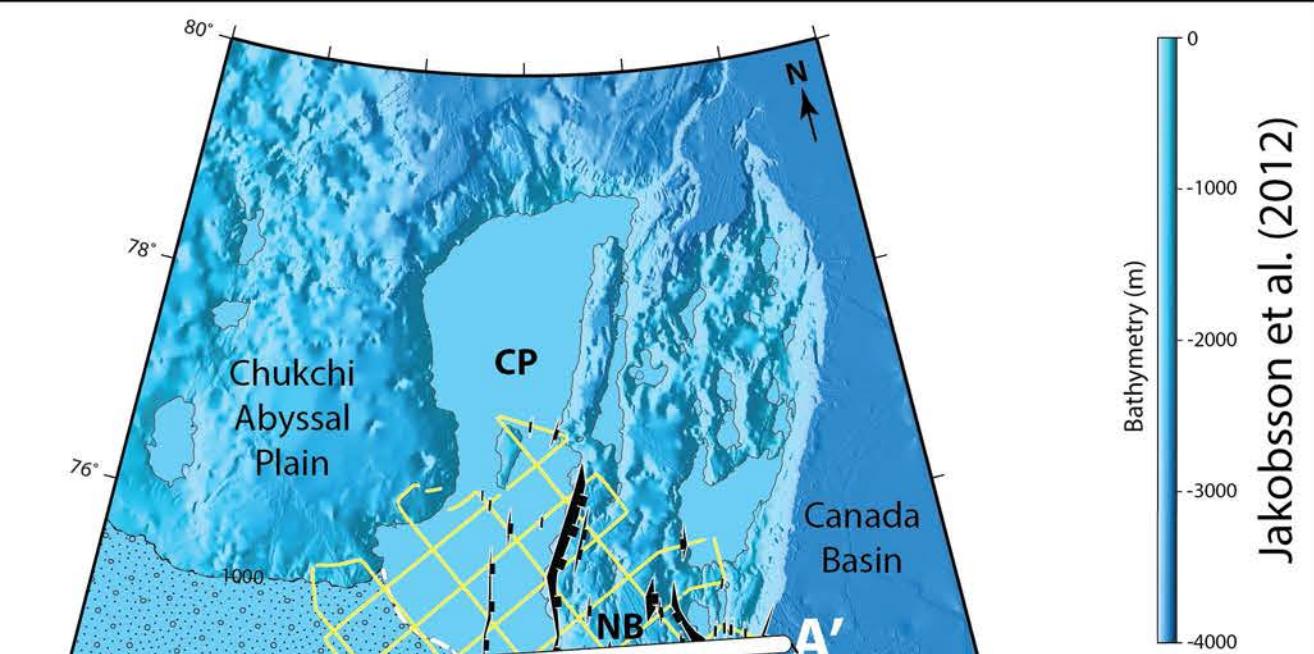




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- Sediment transport directions (Houseknecht and Bird, 2011)



Jurassic-Early Cretaceous



Pre-Brookian pre-rift/syn-rift#1

Pre-Brookian SDRs

Basement

Moho

100 km (62 mi.)

VE=~5

Wrangel-Herald Arch thrust front

A

A'

Chukchi Abyssal Plain

Northwind Basin

Canada Basin

Au

Au

Jurassic-Early Cretaceous

Pre-Brookian pre-rift/syn-rift#1

Pre-Brookian SDRs

Basement

Moho

100 km (62 mi.)

VE = ~5

A

A'

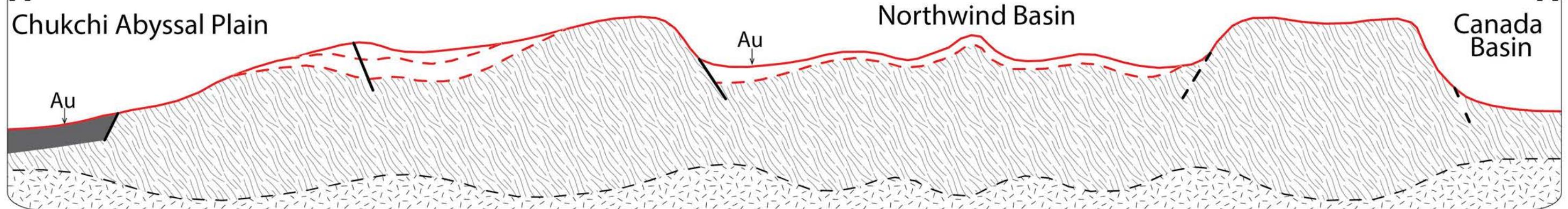
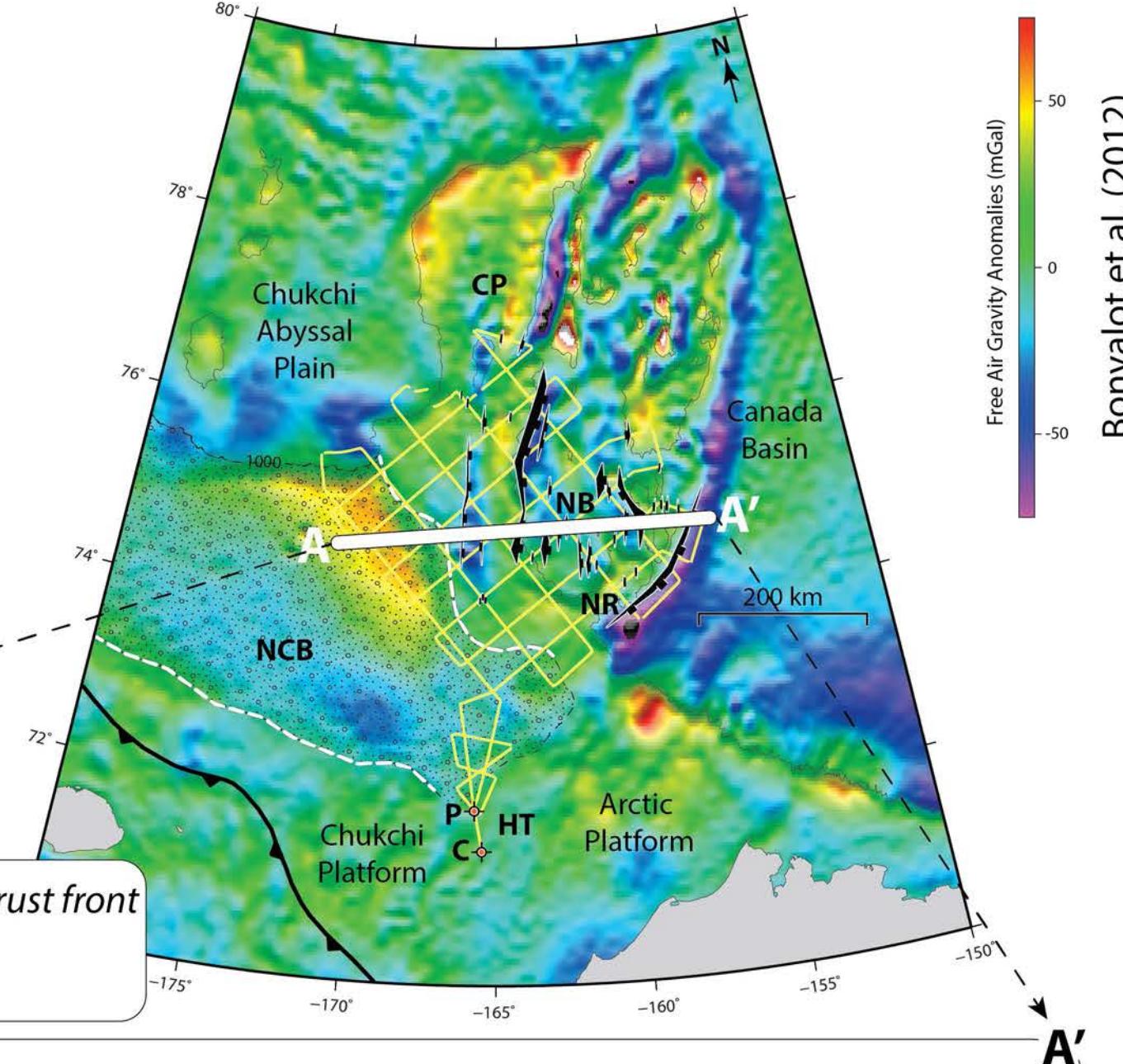
Chukchi Abyssal Plain

Au

Au

Northwind Basin

Canada Basin



Jurassic-Early Cretaceous

Pre-Brookian pre-rift/syn-rift#1

Pre-Brookian SDRs

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A'

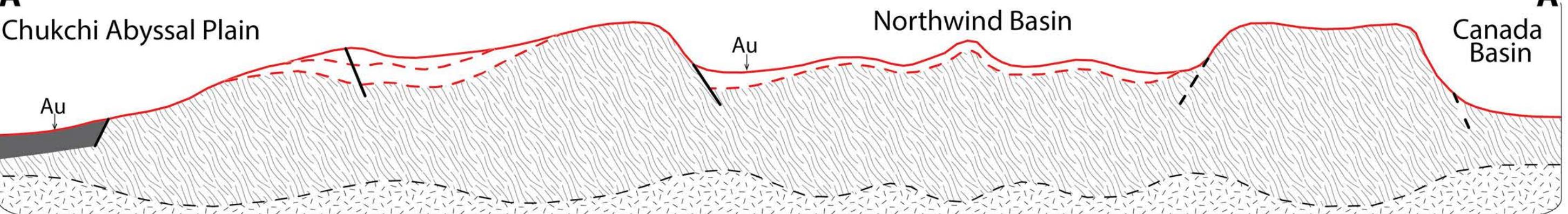
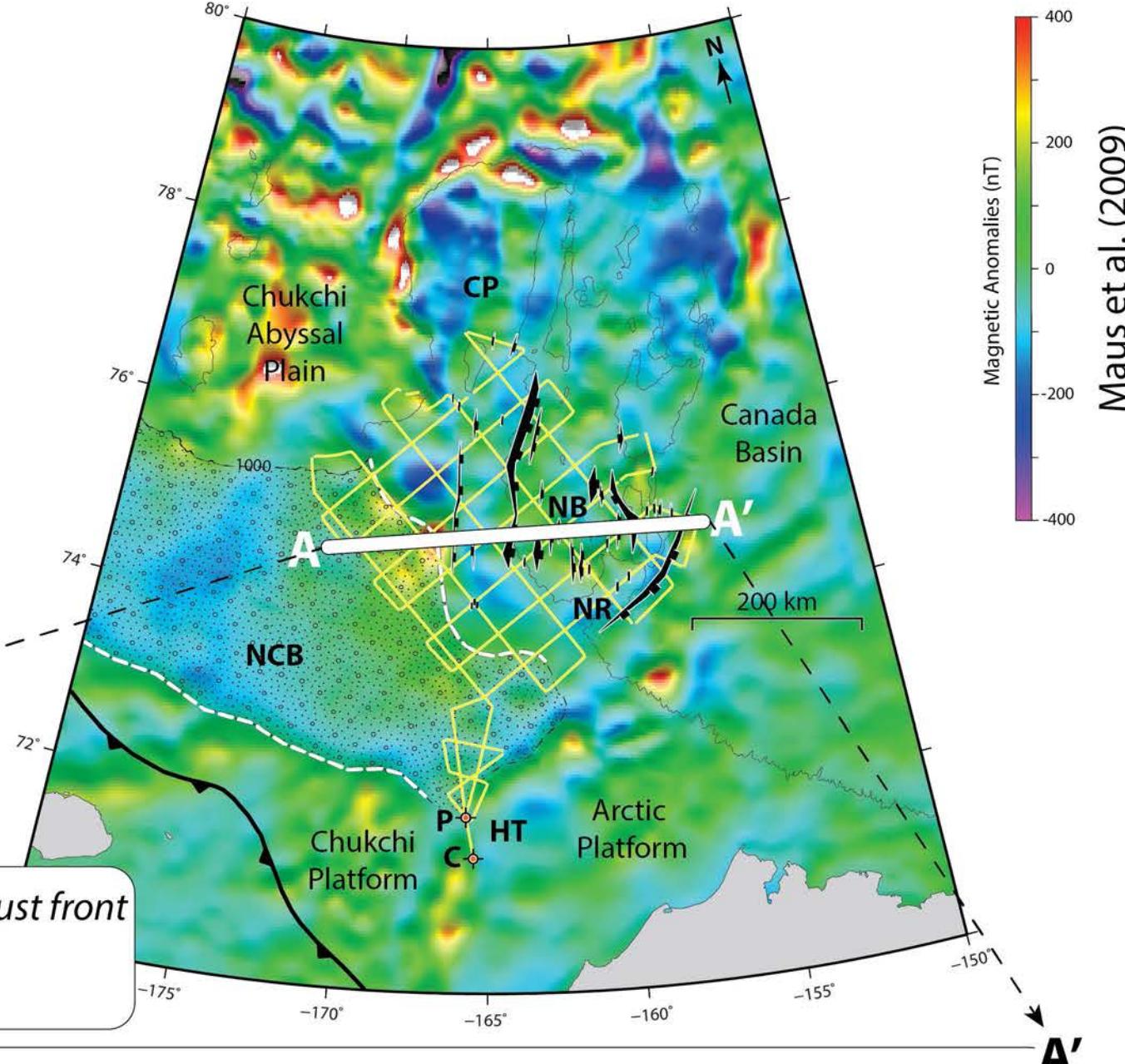
Chukchi Abyssal Plain

Au

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Northwind Basin

Canada Basin



Early-Late Cretaceous

Post-rift#1

Sediment transport

Pre-Brookian pre-rift/syn-rift#1

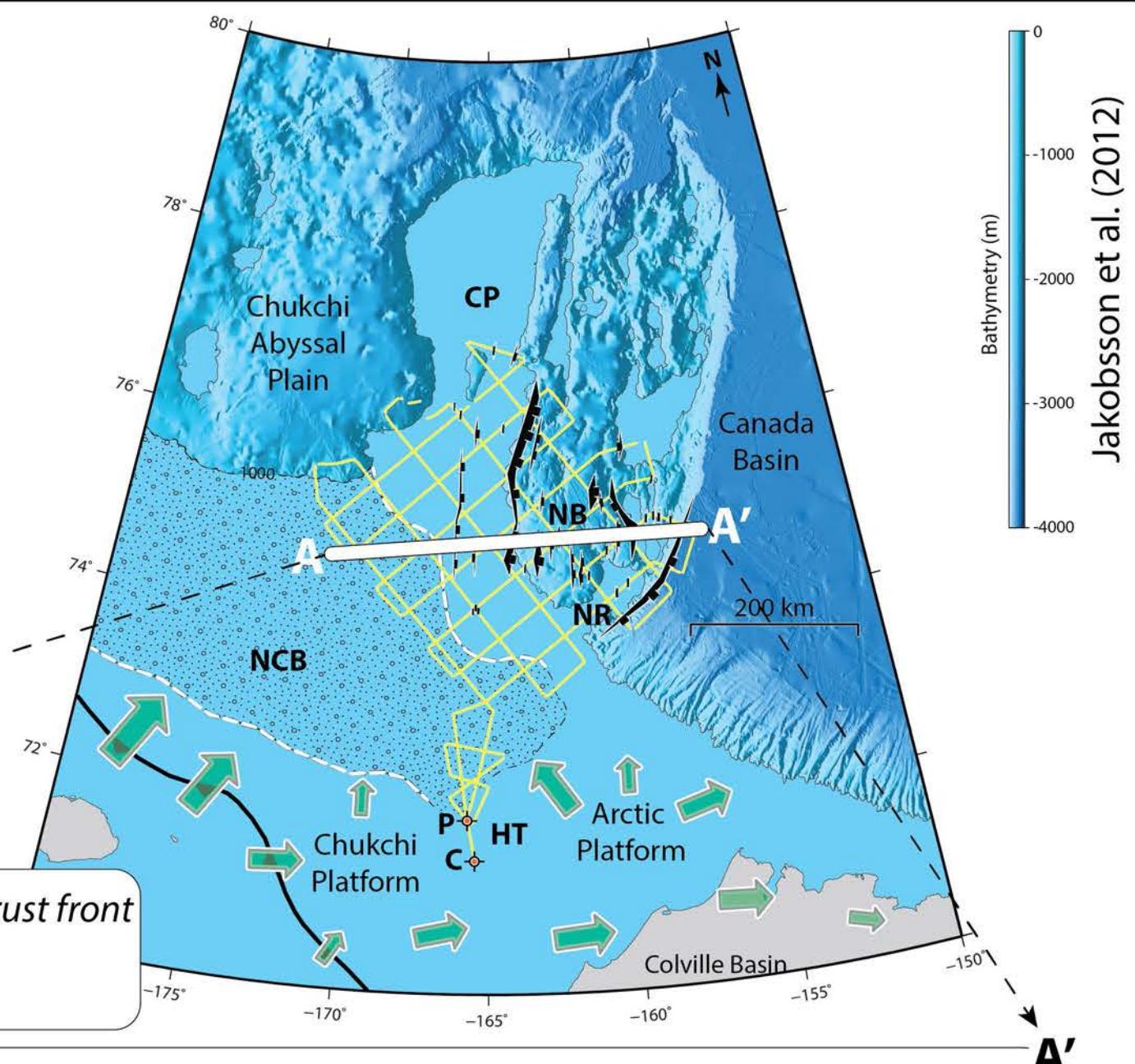
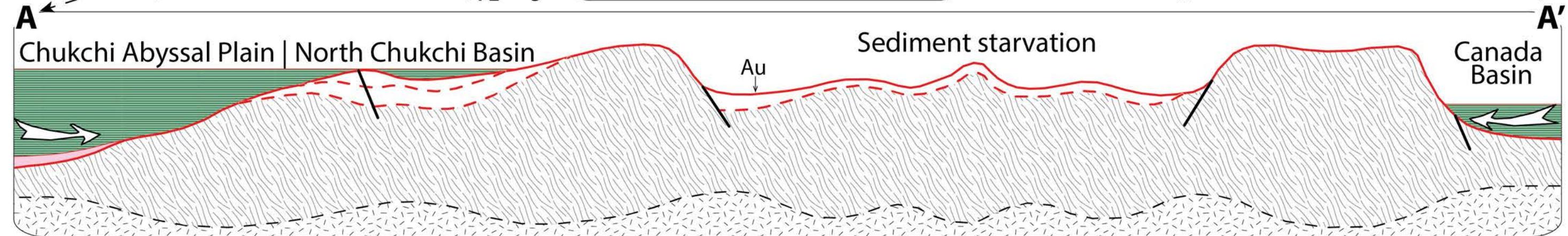
Pre-Brookian SDRs

Basement

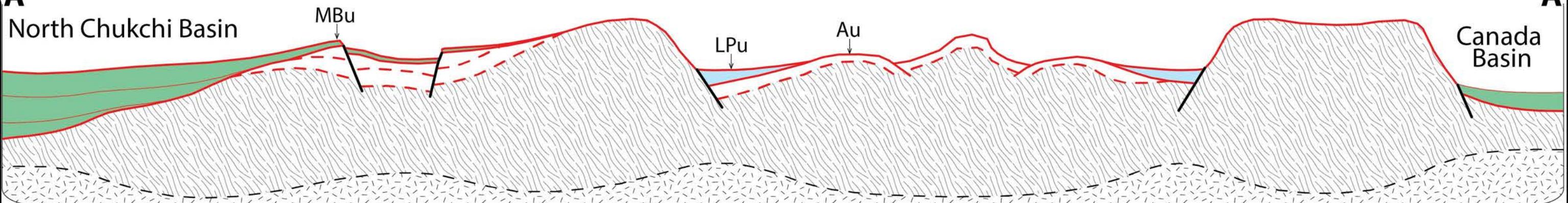
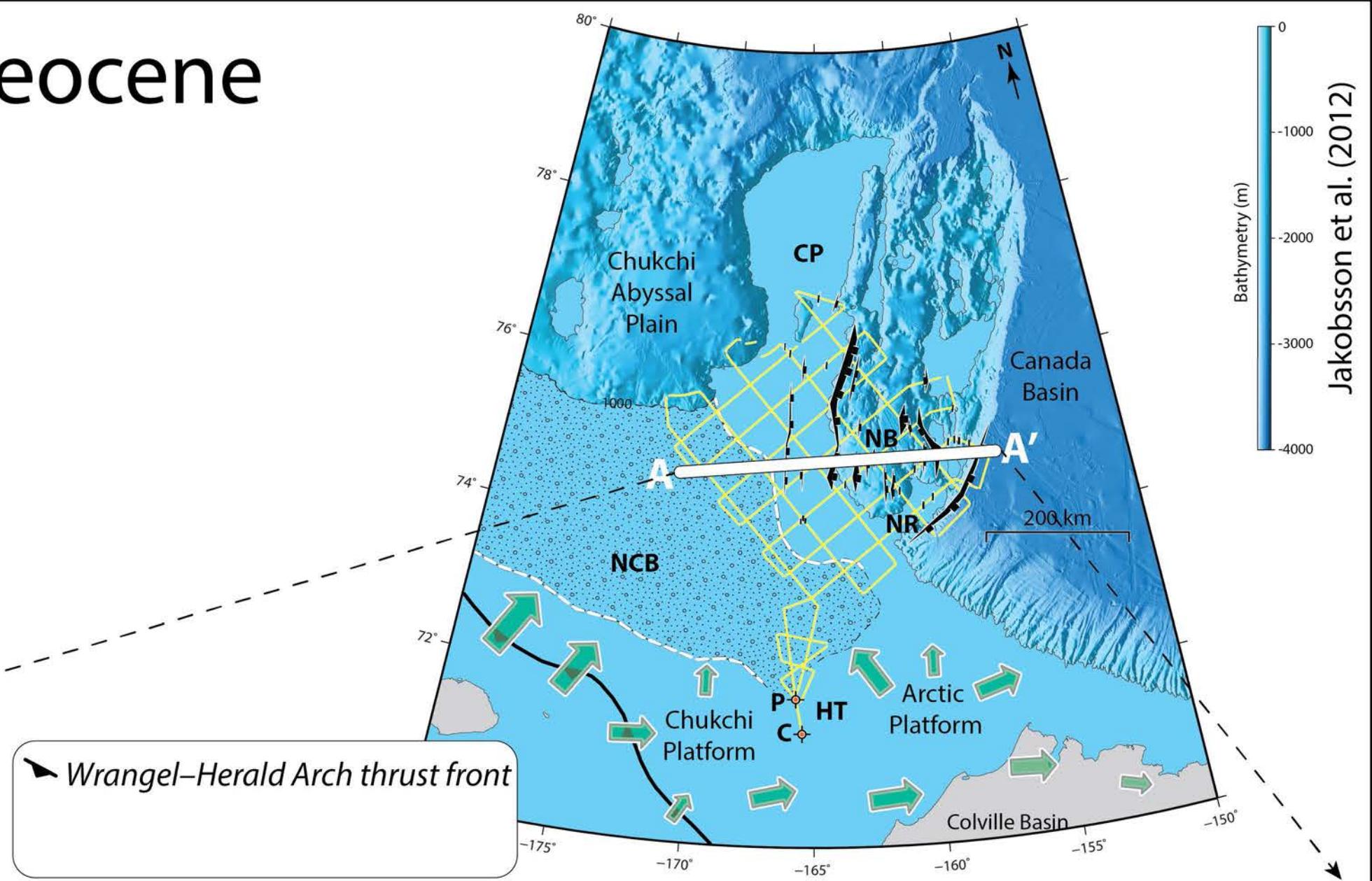
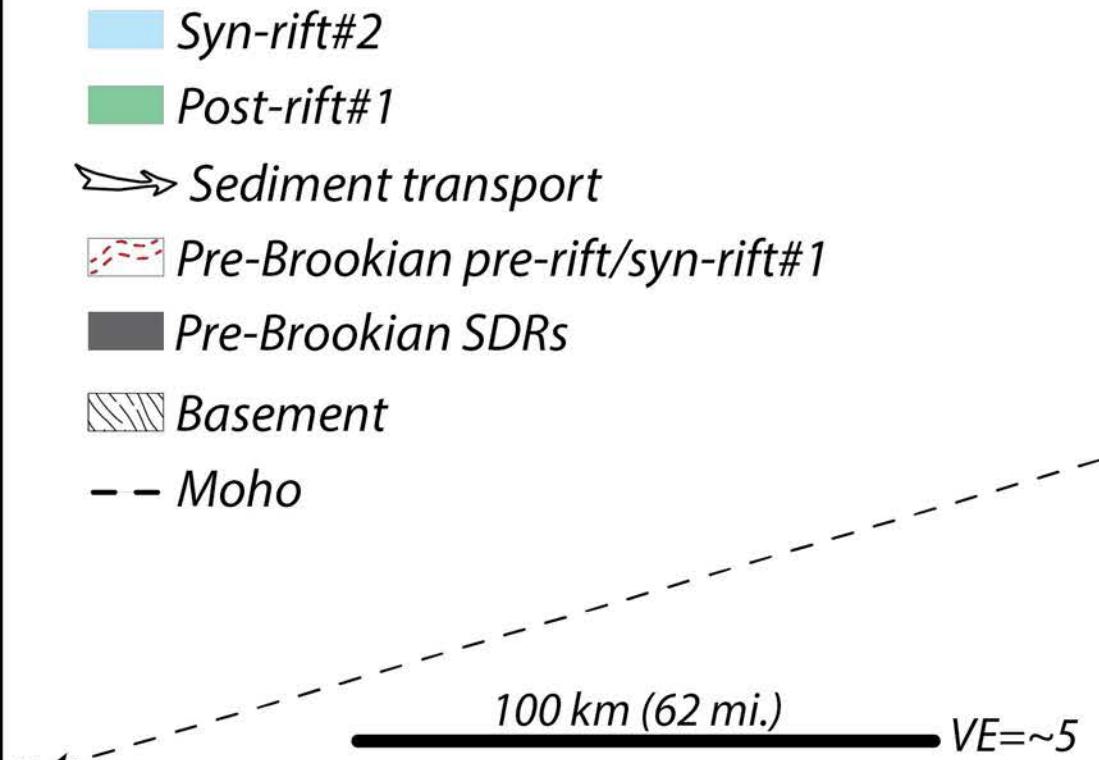
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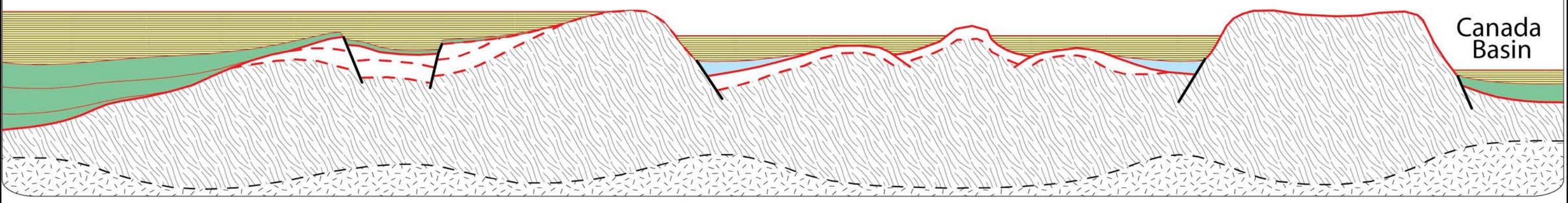
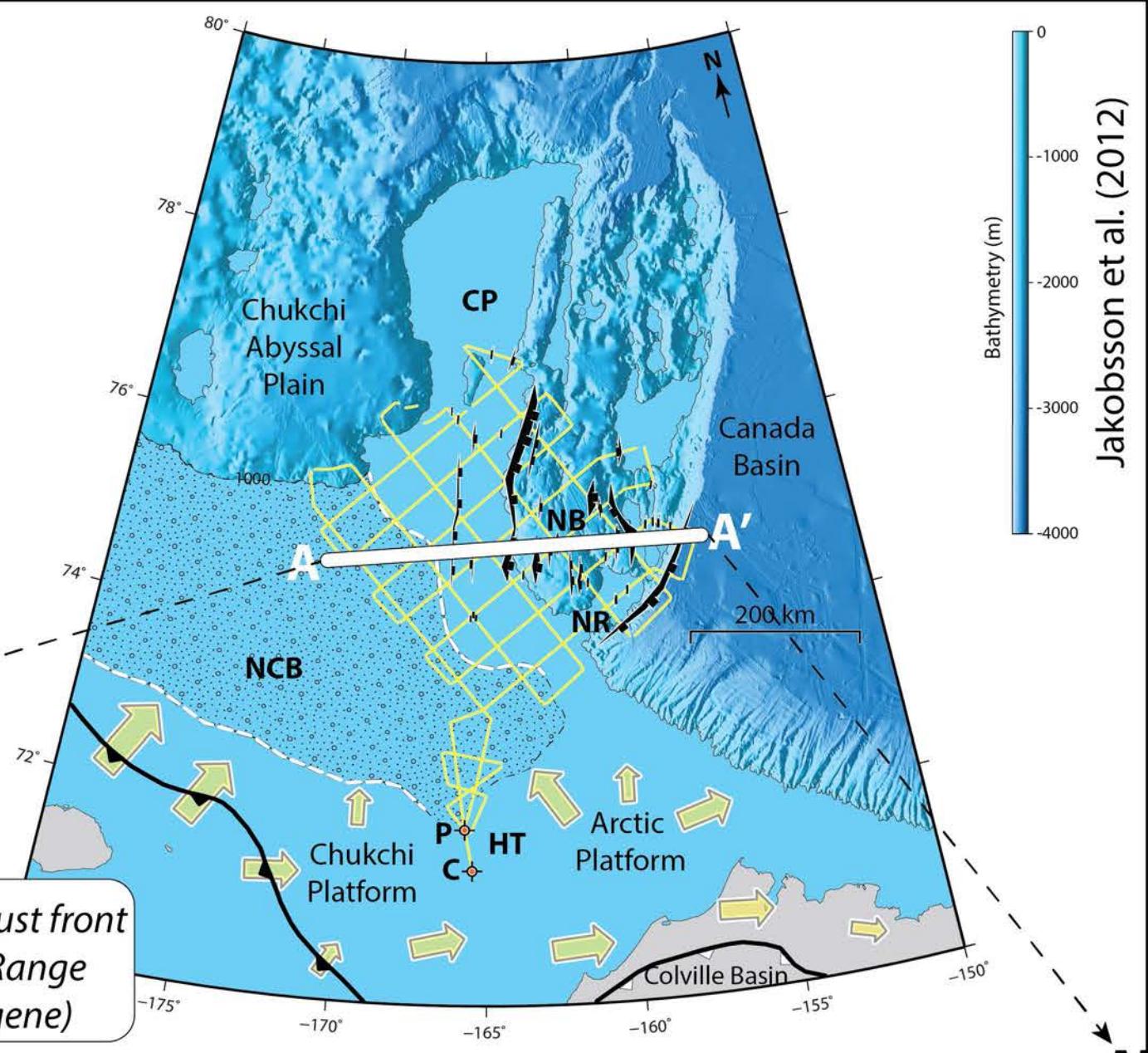
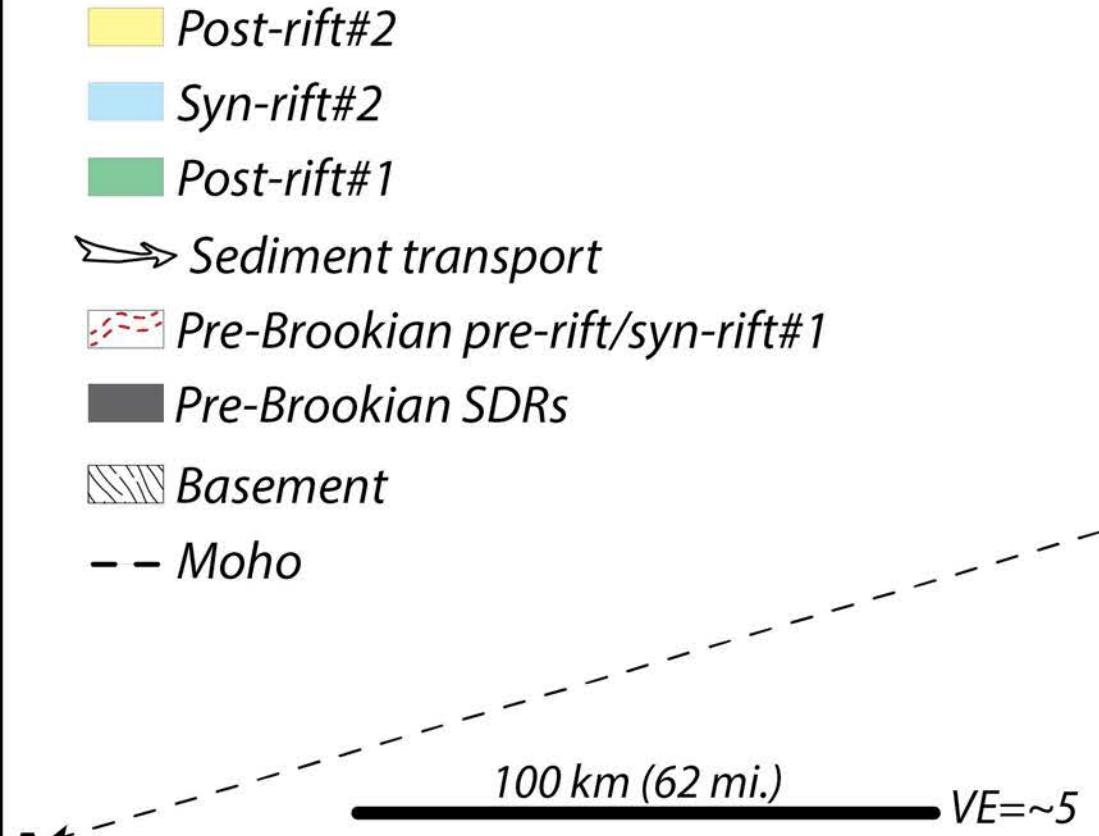
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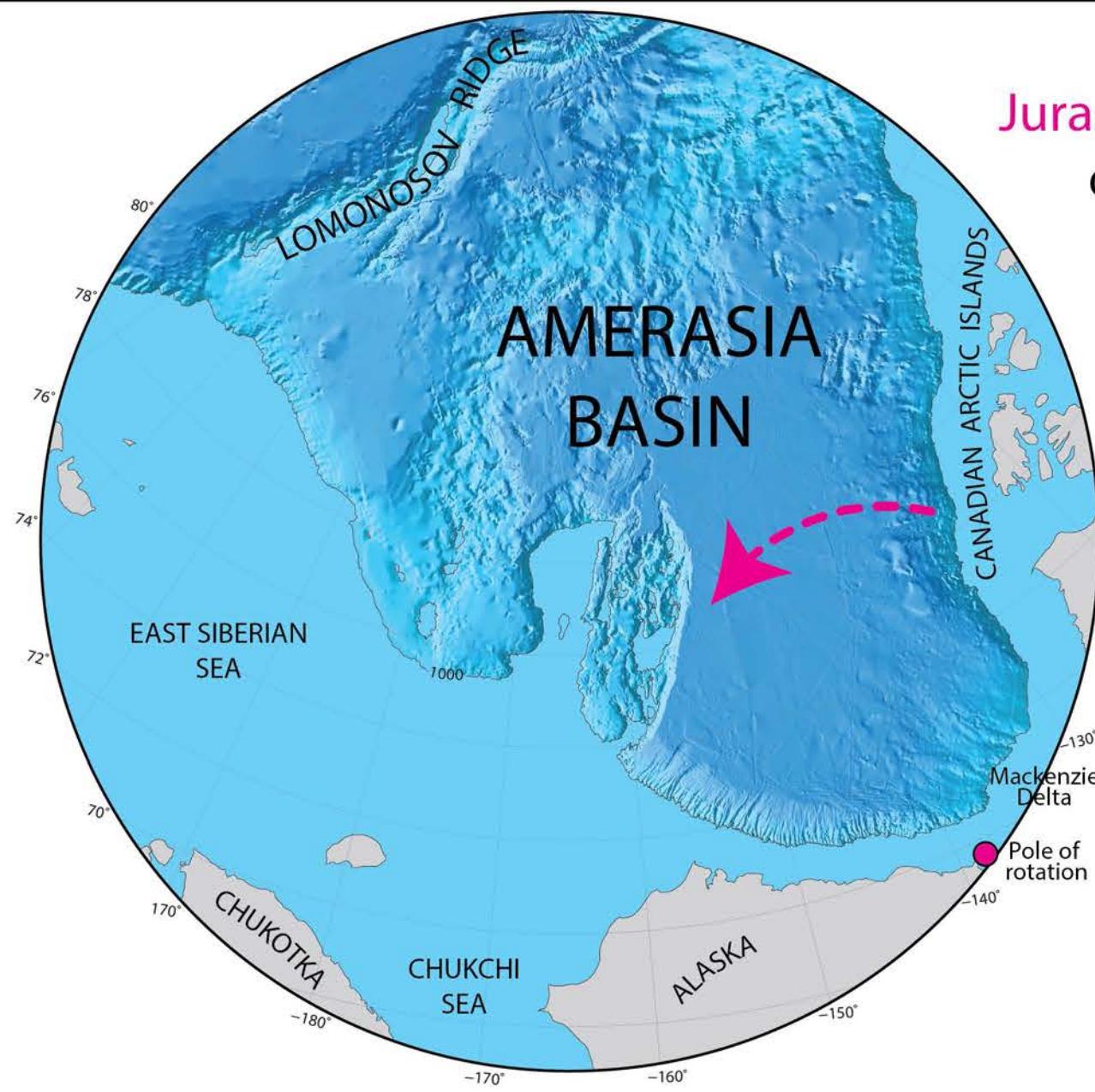


Late Cretaceous-Paleocene



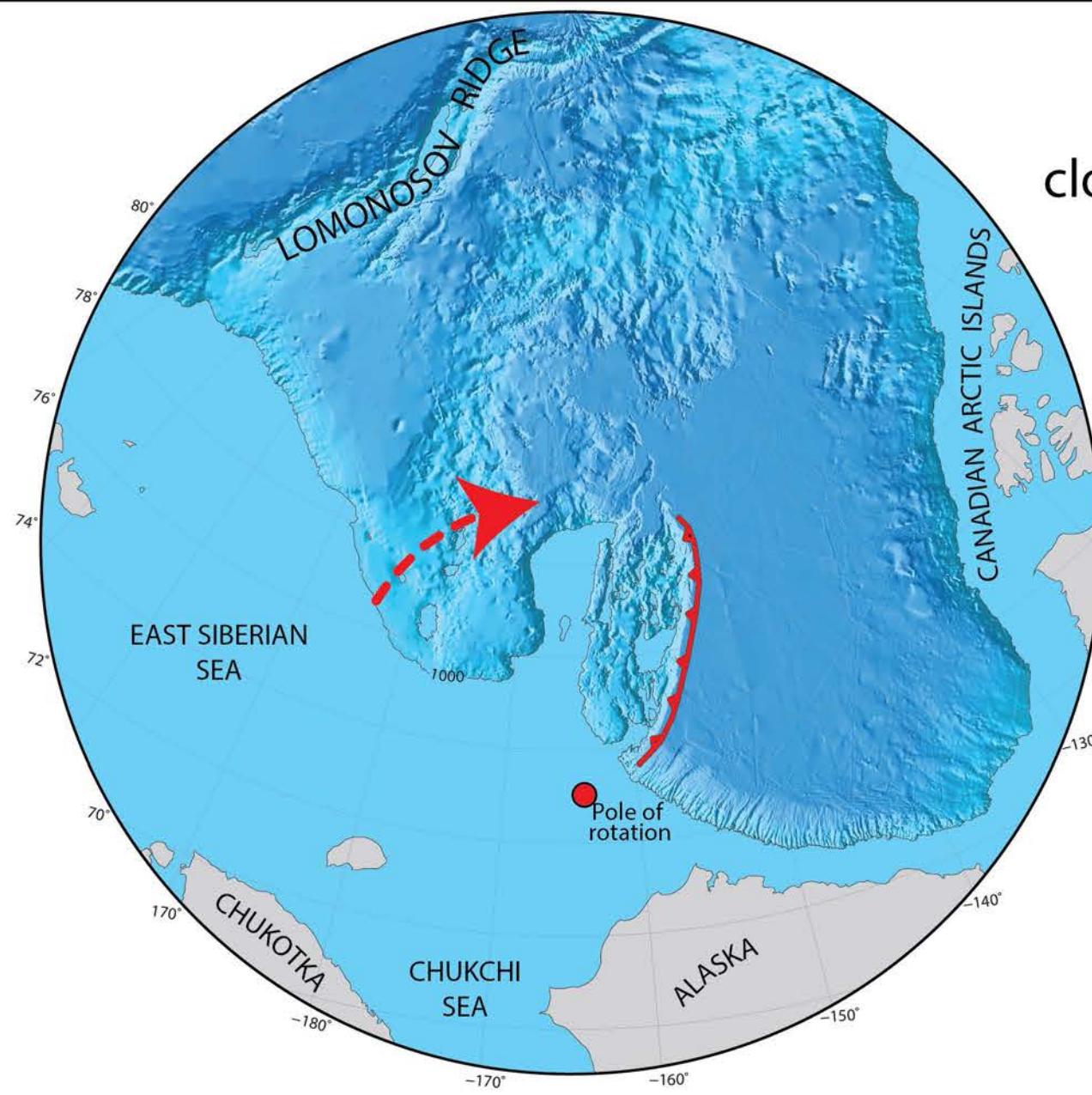
Paleocene-Miocene





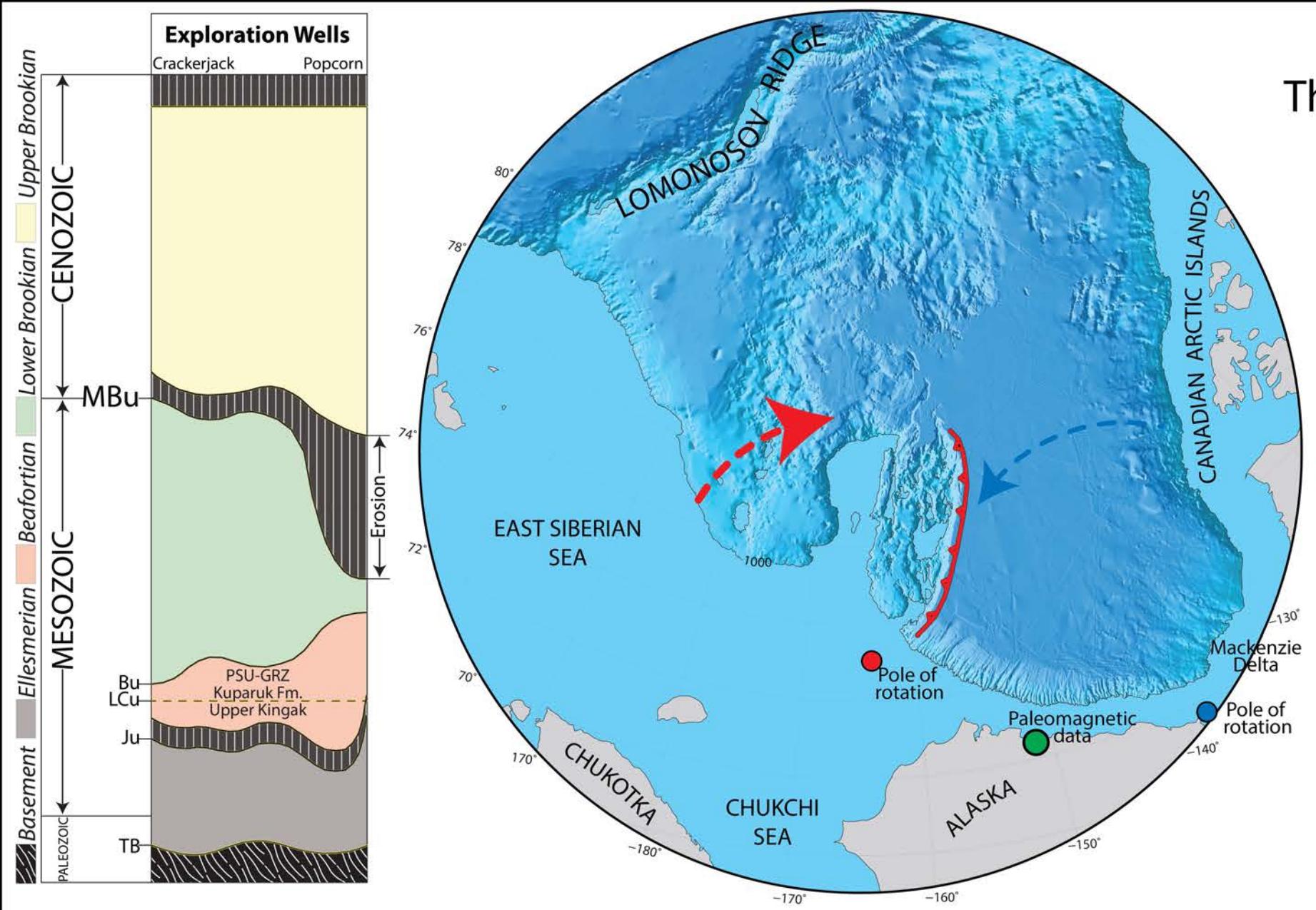
Jurassic (195-140 Ma) counter-clockwise rotation
of the Arctic Alaska-Chukotka microplate
away from the Canadian Arctic Islands

Grantz et al. (2011)



Grantz et al. (2011)

Pre-Valanginian (145.5-140 Ma)
clockwise rotation of the Chukchi Borderland
away from the East Siberian Shelf



The total amount of rotation: 65-70 degrees
(Halgadahl and Jarrard, 1987)

The age of the Kuparuk formation:
Valanginian-Hauterivian (139-131 Ma)
(Masterson and Eggert, 1992)

Grantz et al. (2011)

Conclusions

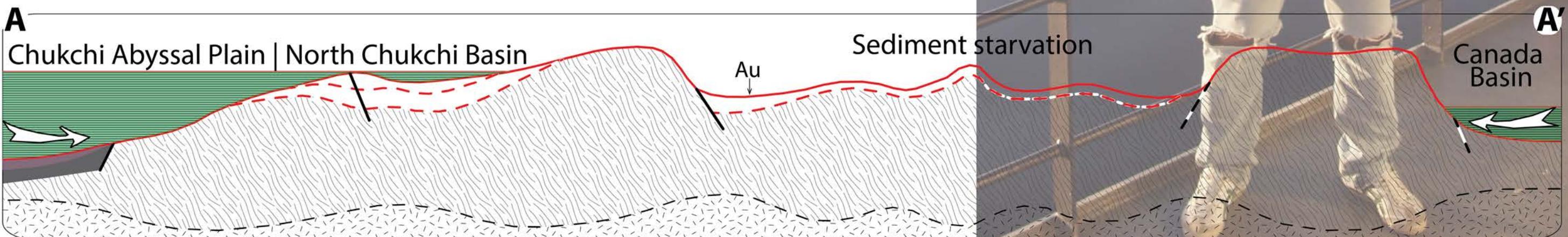
We argue the **fixity** of Chukchi Borderland relative to Chukchi Shelf for the following reasons:

inconsistency of timing and **structural constraints** for the postulated **pre-Valanginian** clockwise rotation of the Borderland away from the East Siberian Shelf;

absence of substantial structural discontinuity between the Chukchi Shelf and Borderland;

recognition of condensed section and **continuity** of the Cretaceous - Cenozoic orogenic sediments.

These observations are consistent with fixity of the Borderland relative to Chukchi Shelf **since the earliest Cretaceous**. This new constrain on the relative position of the Borderland **requires a new model** for the development of the Amerasia Basin.



Expert Geophysicist in Acoustic/Seismic Imaging of the Subsurface

BS

Dokuz Eylul Univ.
Izmir, Turkey

MS

Pukyong National Univ.
Busan, Korea

2007

2010

Viking Geophysical Services
Ankara, Turkey

Geophysical Intern
University of Texas Austin

University of Alaska
Fairbanks

PhD

2018

?

Geophysical Intern
University of Texas Austin

Fairbanks

2018

Geophysical Intern
University of Texas Austin

Fairbanks