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Links between sediment consolidation and Cascadia megathrust slip behaviour

Shuoshuo Han ^{1*}, Nathan L. Bangs¹, Suzanne M. Carbotte², Demian M. Saffer³ and James C. Gibson ²

¹Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin, Austin, TX, USA. ²Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA. ³Department of Geosciences and Center for Geomechanics, Geofluids, and Geohazards, The Pennsylvania State University, University Park, PA, USA. *e-mail: han@ig.utexas.edu

Supplementary Information

Links Between Sediment Consolidation and Cascadia Megathrust Slip Behavior

Shuoshuo Han^{(1)*}, Nathan L. Bangs⁽¹⁾, Suzanne M. Carbotte⁽²⁾, Demian M. Saffer⁽³⁾, James C. Gibson⁽²⁾

(1) Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin, Austin, TX 78758, USA;

(2) Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, USA;

(3) Department of Geosciences and Center for Geomechanics, Geofluids, and Geohazards, The Pennsylvania State University, University Park, PA 16801, USA;

*Corresponding Author: han@ig.utexas.edu

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Table S1 Décollement depth compilation

Table S2 Drilling data compilation

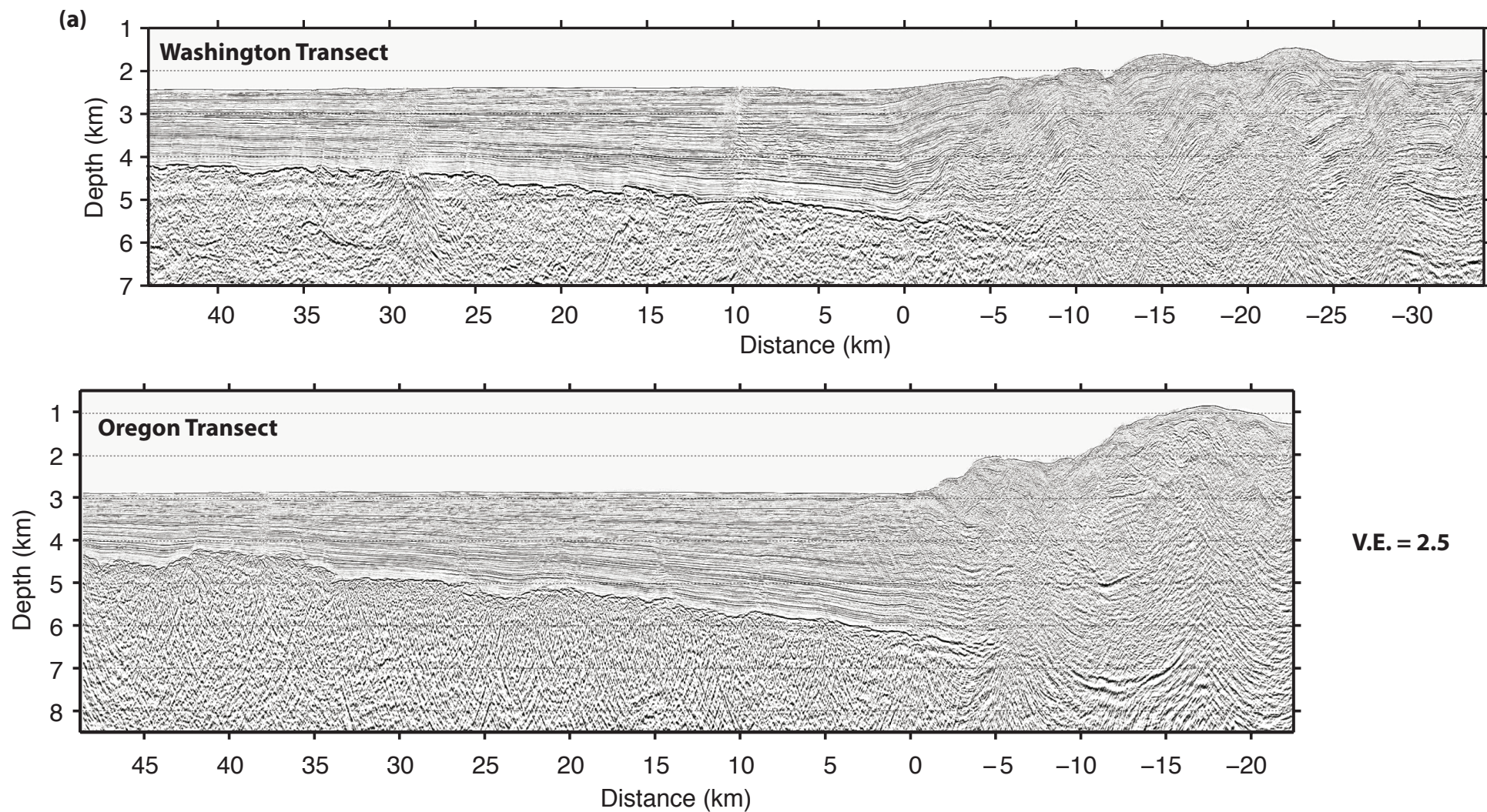
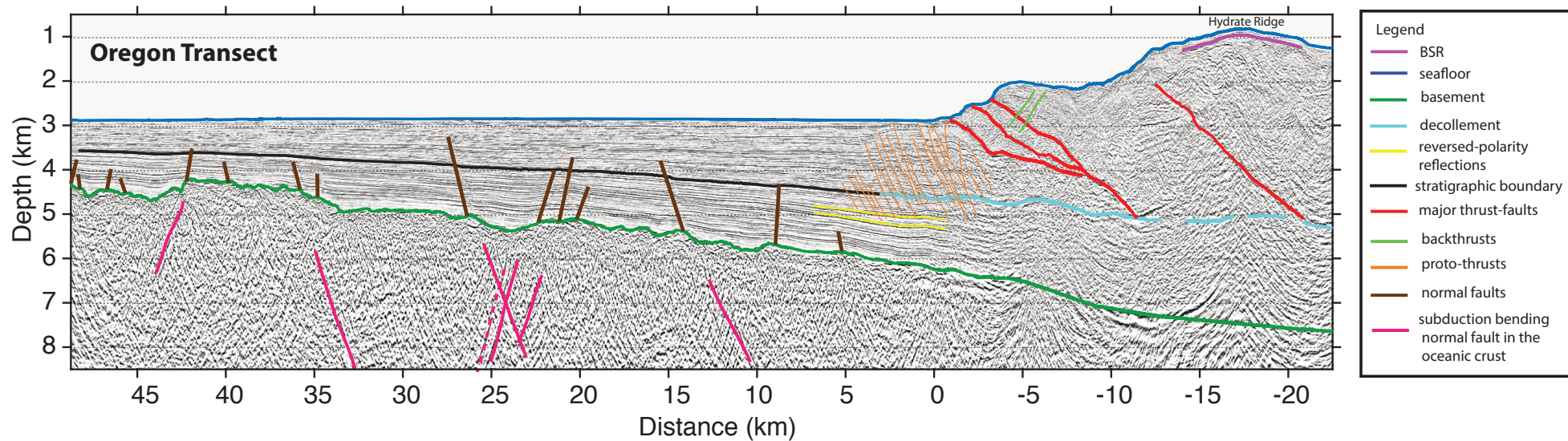
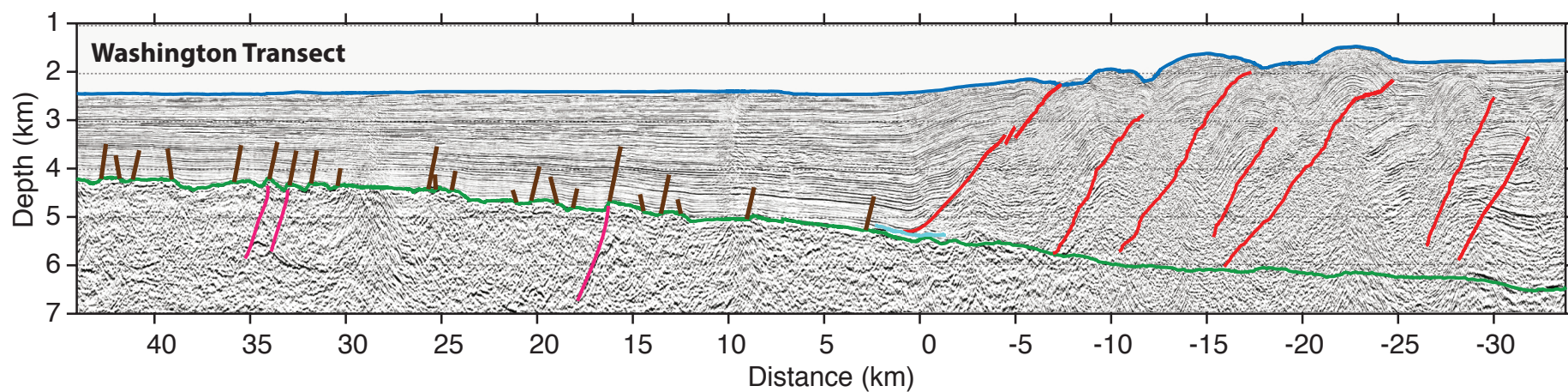


Figure S1. Pre-stack depth migrated (PSDM) images of the WA and OR transects from ~45 km seaward of the deformation front to ~25 km landward of the deformation front. (a) Un-interpreted PSDM image. **(b)** Interpreted PSDM image. The stratigraphic boundary in the legend refers to the boundary between Astoria Fan turbidites and abyssal plain turbidites.

(b)



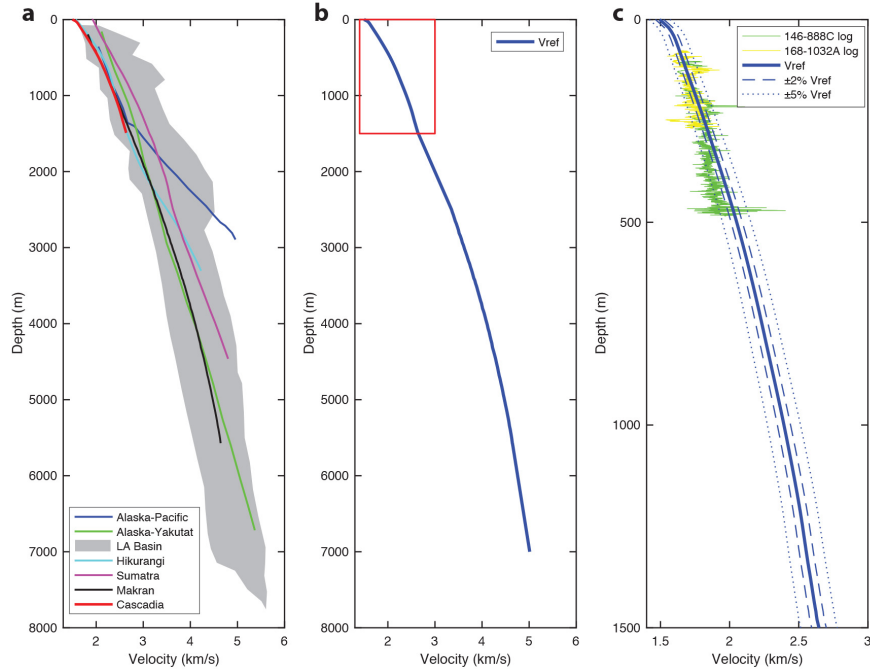


Figure S2 Reference P-wave velocity profile that represents normal consolidation of sediments on the incoming Juan de Fuca plate. (a) Compilation of sediment velocity profiles from Alaska¹, Hikurangi², Makran³, Sumatra⁴, and Los Angeles Basin⁵. (b) Reference P-wave velocity (V_p) profile derived from 40-45 km seaward of deformation front on WA and OR transects and extended to depth >1.5 km using Makran velocity profile. (c) Reference V_p in the 1500 m range (within the red rectangle in Fig. S2b) compared with log measurements from ocean drilling sites 146-888⁶ and 168-1032⁷.

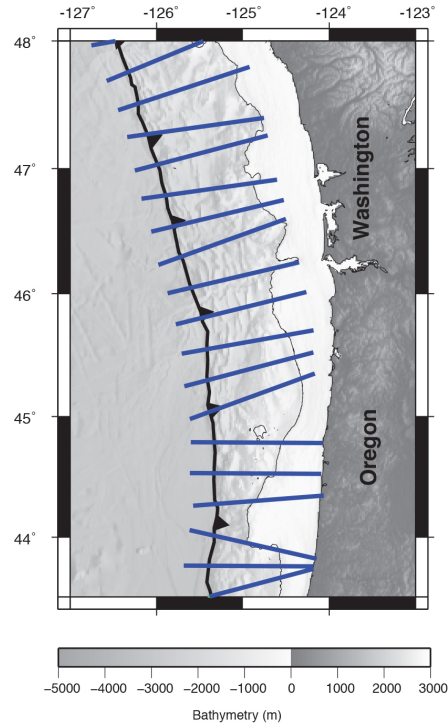


Figure S3 Bathymetry profile locations for accretionary wedge surface taper calculation. Black barbed line: deformation front. Blue lines: bathymetry profiles extracted.

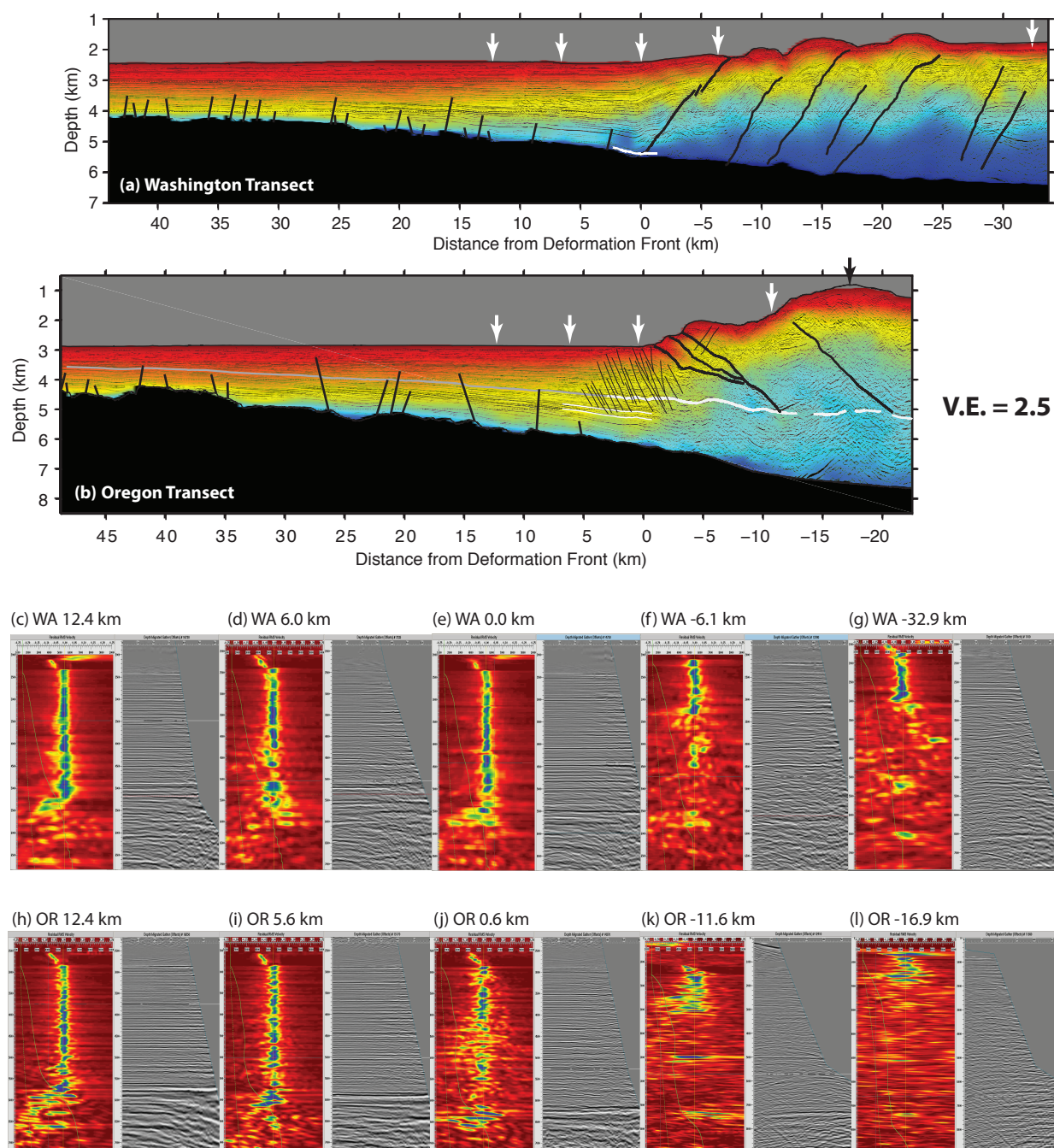


Figure S4. Examples of semblance plots of pre-stack depth migration (PSDM) velocities along WA and OR transects. (a, b) PSDM images of WA and OR transects overlaid by PSDM velocity models. Interpretation is the same as in Fig. S1. Faults are shown in black lines. Decollements are shown in white lines. Horizons with reversed-polarity reflections are in white dashed lines. The boundary between Astoria Fan turbidites and abyssal plain turbidites is shown in grey line. White and black arrows mark the locations of PSDM gathers and semblance plots shown in c-l.

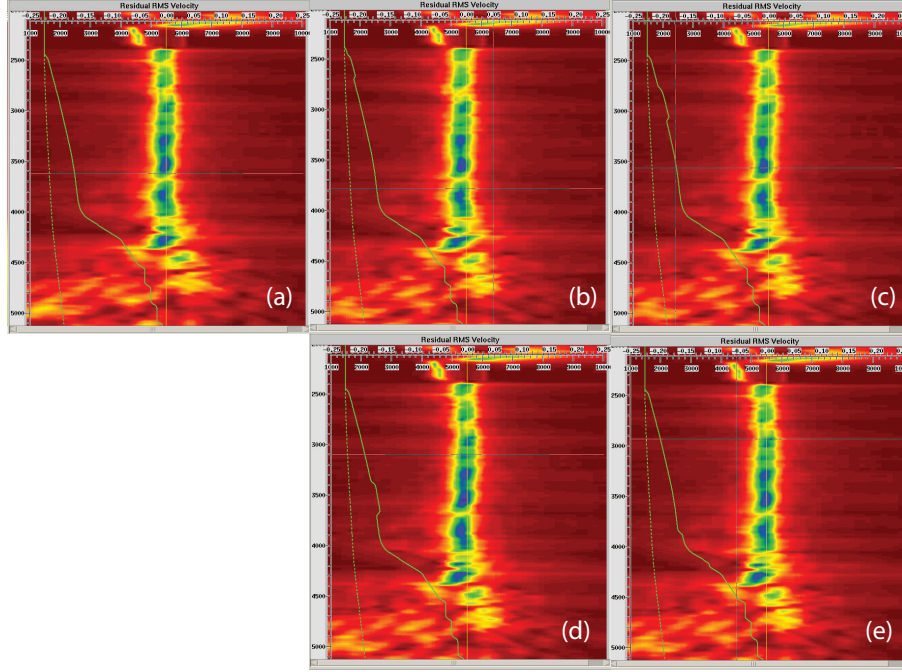


Figure S5 Example of uncertainty test of the velocity model. (a) Original velocity model with semblance for CRP gather 21400 at distance 41.6 km on WA transect. (b-e) 5% velocity anomaly is added to a 300 m layer at different depths of the velocity profile with the semblance plot of the resulting migrated gathers. The relative residual RMS velocity range -0.25 to 0.25 corresponds to a change in RMS velocity of 25% in the background RMS velocity.

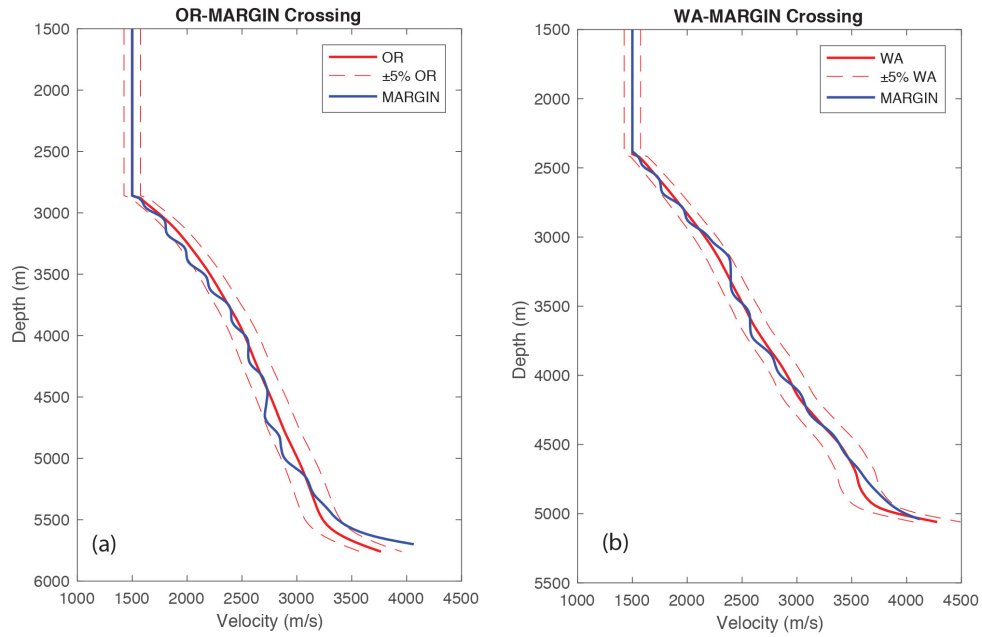


Figure S6 Comparison of velocity profiles at line crossings. (a) OR and MARGIN transect crossing. (b) WA and MARGIN transect crossing.

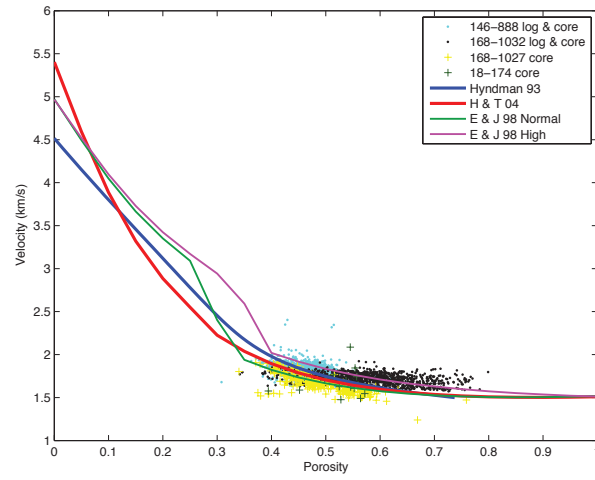


Figure S7 Vp-porosity measurements from DSDP/ODP drilling Legs 18, 146, 168 compared with empirically derived Vp-porosity relationships⁸⁻¹⁰. Shale ratio of 45% is used for Erickson & Jarrard⁹ relationships.

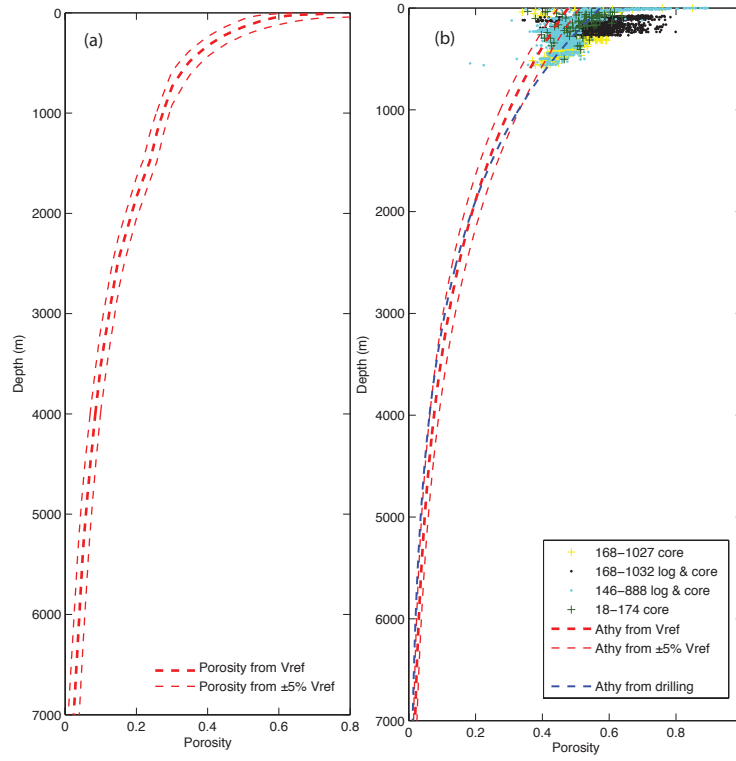


Figure S8 Porosity-depth profiles. (a) Porosity converted from reference velocity and $\pm 5\%$ of reference velocity using H&T04¹⁰ relationship; (b) Athy's relationships by fitting the converted porosity-depth profiles in (a) and compared with the porosity measurement from core and logging data.

Table S1 Décollement depth compilation

Latitude	Survey	Data Acquisition Year	Line Name	Incoming sediment thickness at deformation front (TWTT, sec)	Sediment thickness beneath the décollement near the deformation front (TWTT, sec)	Incoming sediment thickness at deformation front (km)	Sediment thickness beneath the décollement near the deformation front (km)
47°24'N	Ridge2Trench	2012	WA Transect	2.2 ⁽¹⁾	0.06-0.08 ⁽¹⁾	3.1 ⁽²⁾	0.2 ⁽²⁾
47°17'N	ORWELL	1996	103			3.3 ⁽³⁾	0.6 ⁽³⁾ , 0.2 ⁽²⁾
47°01'N	ORWELL	1996	104			3.2 ⁽⁴⁾	0.5 ⁽⁴⁾
46°48'N	ORWELL	1996	105			2.9 ⁽⁴⁾	0.2 ⁽⁴⁾
46°39'N	ORWELL	1996	107			2.6 ⁽⁴⁾	0.2 ⁽⁴⁾
45°54'N	ORWELL	1996	109			4.2 ⁽⁴⁾	0 ⁽⁴⁾
45°14'N	ODP Leg 146 site survey	1989	OR-33	2.6 ⁽⁵⁾	0.3 ⁽⁵⁾		0.4 ⁽⁵⁾
44°59'N	ODP Leg 146 site survey	1989	OR-23	2.5 ^(5,6)	0.3 ^(5,6)	4.0 ^(5,6)	0.4 ^(5,6)
44°51'N	ODP Leg 146 site survey	1989	OR-18	2.6 ⁽⁵⁾	1.0 ⁽⁵⁾		(c) 1.5 ⁽²⁾
44°39'N	ODP Leg 146 site survey	1989	OR-05	2.5 ⁽⁶⁾	0.8 ⁽⁶⁾		1.4 ⁽⁶⁾
44°37'N	Ridge2Trench	2012	OR Transect	2.4 ⁽¹⁾	1.1 ⁽²⁾	3.4 ⁽²⁾	1.7 ⁽²⁾
44°33'N	ODP Leg 146 site survey	1989	OR-01	2.5 ⁽²⁾	1.1 ⁽²⁾		(c) 1.7 ⁽²⁾

Décollement depth is measured within 1 km seaward and landward of the deformation front. (c) Converted from TWTT above basement to thickness using average interval velocities between the décollement and the basement from nearby Ridge-to-Trench line.

Reference: ⁽¹⁾Han et al., 2016; ⁽²⁾this study; ⁽³⁾Adam et al., 2004; ⁽⁴⁾Booth-Rea et al., 2008; ⁽⁵⁾MacKay, 1995; ⁽⁶⁾MacKay et al., 1992.

Table S2 Drilling data compilation

Leg	Site	Data type	Location	Distance from the deformation front (along our transect orientation)	Maximum penetration depth
18	174	Core	44.8897°N, 126.3567°W	85 km	879 m
146	888	Core & log	48.1664°N, 126.6634°W	10 km	600 m
168	1027	Core	47.7565°N, 127.731°W	120 km	632 m
168	1032	Core & log	47.7796°N, 128.122°W	150 km	338 m

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