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Auteurs: Authors:	Henrik Grob, Dirk Klaeschen, Michael Riedel, Sebastian Krastel, Mathieu J. Duchesne, Jefferson Bustamante Restrepo, Gabriel Fabien-Ouellet, Young Keun Jin, & Jong Kuk Hong
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Supporting Information for

Investigation of submarine permafrost conditions in the Canadian Beaufort Sea using diving wave tomography

H. Grob[1,]; D. Klaeschen[2]; M. Riedel[2]; S. Krastel[1]; M. J. Duchesne[3]; J. Bustamante[4]; G. Fabien-Ouellet[4]; Y. K. Jin[5]; J. K. Hong[5]*

[1] Kiel University, Germany
[2] GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany
[3] Geological Survey of Canada, Canada
[4] Polytechnique Montreal, Canada
[5] Korea Polar Research Institute, Rep. of Korea

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Figures S1 to S5

Introduction

The supplementary material consists of five figures. The first figure (Fig. S1) provides additional information on the performance and convergence of the diving wave tomography. Fig. S2 shows multiple shot records of Line ARA05C-05 illustrating the variety of refracted events observed in the data. Fig. S3 shows the seismic processing sequences used for Figs. 3 and 8. Fig. S4 shows the entire seismic section of the result of the prestack depth migration. Fig. S5 illustrates the differences when using isotropic or anisotropic velocities for the prestack depth migration as a side-by-side comparison.

Text S1.

The OMEGA software provides different parameters to monitor the performance and convergence of the diving wave tomography. The initial and estimated errors help to monitor convergence, as they continuously decrease with proceeding iterations. While the errors decrease, the returning rays remain relatively constant, showing preserved quality. The percentage change converges to a relatively constant level at <4%, indicating a sufficient number of iterations for convergence.

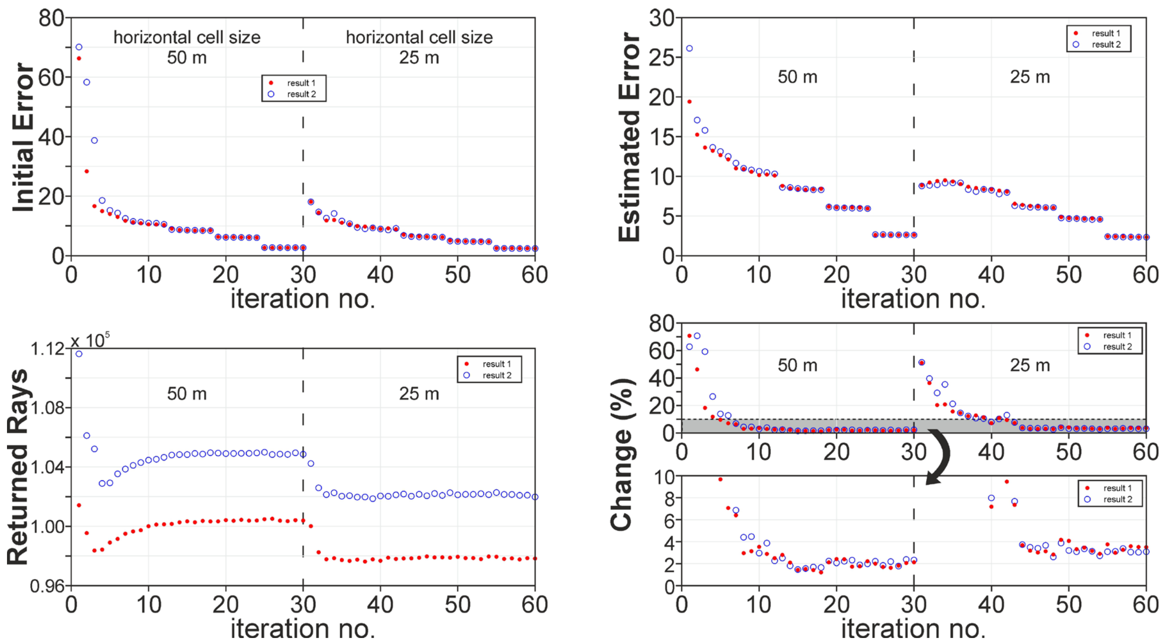

Figure S1. *OMEGA's tomography parameters for results using a start model with a lower velocity gradient (result 1) and the result using a higher velocity gradient (result 2).*

Text S2.

To provide a better visualization of the variance of the velocity model, we display multiple shot records and corresponding velocity functions (v(TWT)). Fig. S2 shows the variety of refracted events along seismic line ARA05C-05 and the corresponding variability of the velocity model.

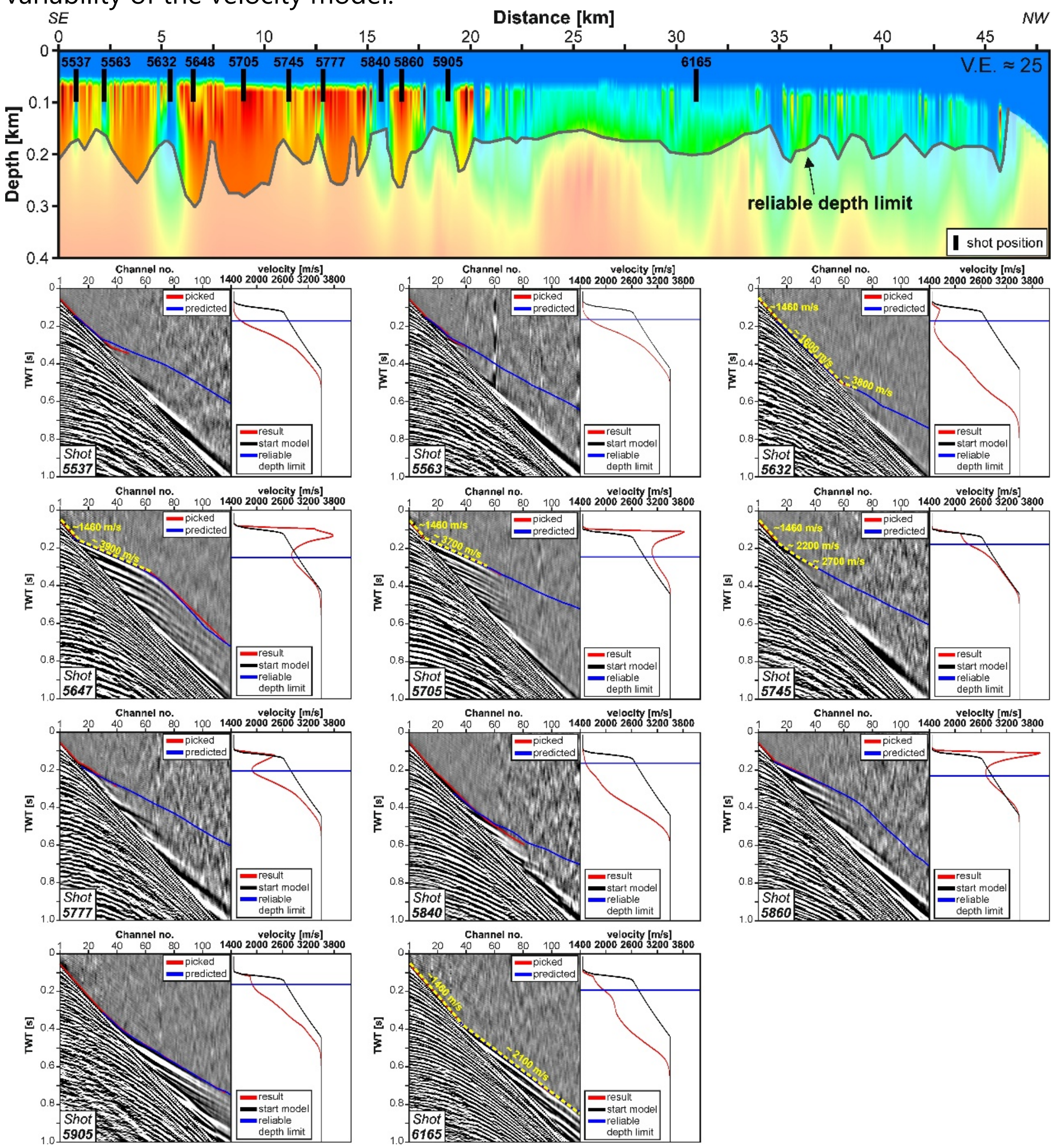

Figure S2. *Final velocity model with marked locations of shot gathers that are shown below. Shot gathers and corresponding velocity functions are plotted against TWT. Note that the velocity functions are the result of ray tracing including multiple shot records and do not represent 1 to 1 the velocities observed as shown in the shot gathers.*

Text S3.

Two seismic processing sequences applied to the seismic data. Fig. S3a shows the conventional processing sequence including multiple attenuation, noise removal and time migration to obtain a seismic stack section in time domain. With the help of the diving wave tomography, we obtain a reliable velocity field of the upper few hundred metres that help to improve the seismic processing and enables depth imaging in submarine permafrost environments. Fig. S3b shows the resulting processing sequence used to perform a prestack depth migration (Fig. 8).

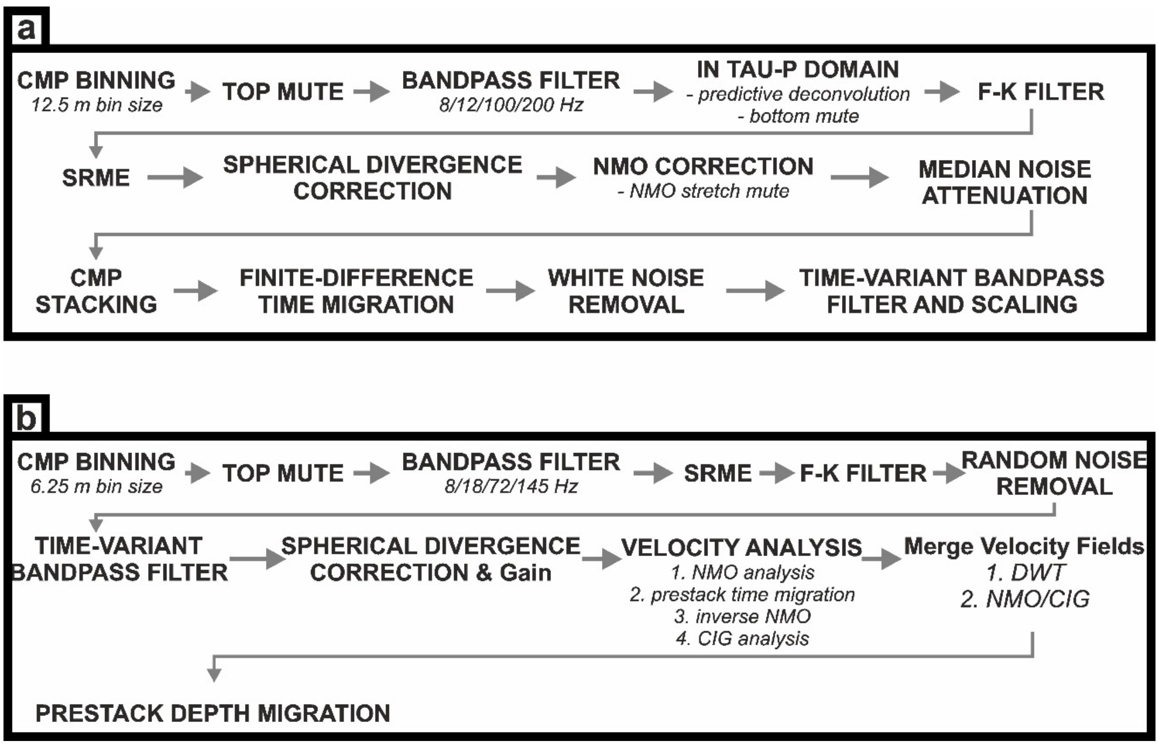

Figure S3. *Seismic processing sequence (a) for Fig. 3 and (b) for Fig. 8. The processing was operated in VISTA® desktop seismic processing (a) and in OMEGA geophysical data processing platform by Schlumberger. CMP: Common-midpoint; SRME: surface-related multiple-elimination; NMO: Normal-moveout; DWT: diving wave tomography; CIG: common image gather.*

Text S4.

The application of the prestack depth migration using the entire velocity field combined of the diving wave tomography and the NMO analysis allows to image the upper 7 km of the Canadian Beaufort Shelf in high-resolution.

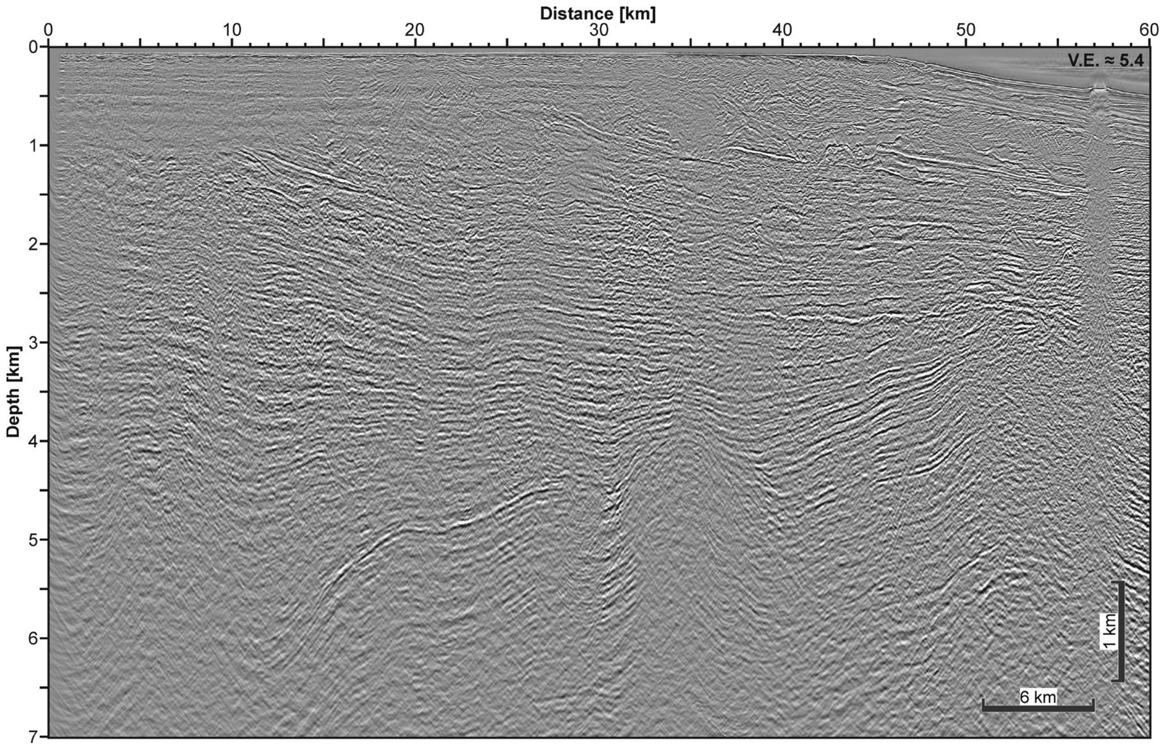

Figure S4. *Upper 7 km of the Kirchhoff prestack depth migrated seismic (PSDM) section of line ARA05C-05*

Text S5.

Side-by-side comparison of the depth section using isotropic velocities (Fig. S5a) or anisotropic velocities (b) for the Kirchhoff prestack depth migration to show significant differences.

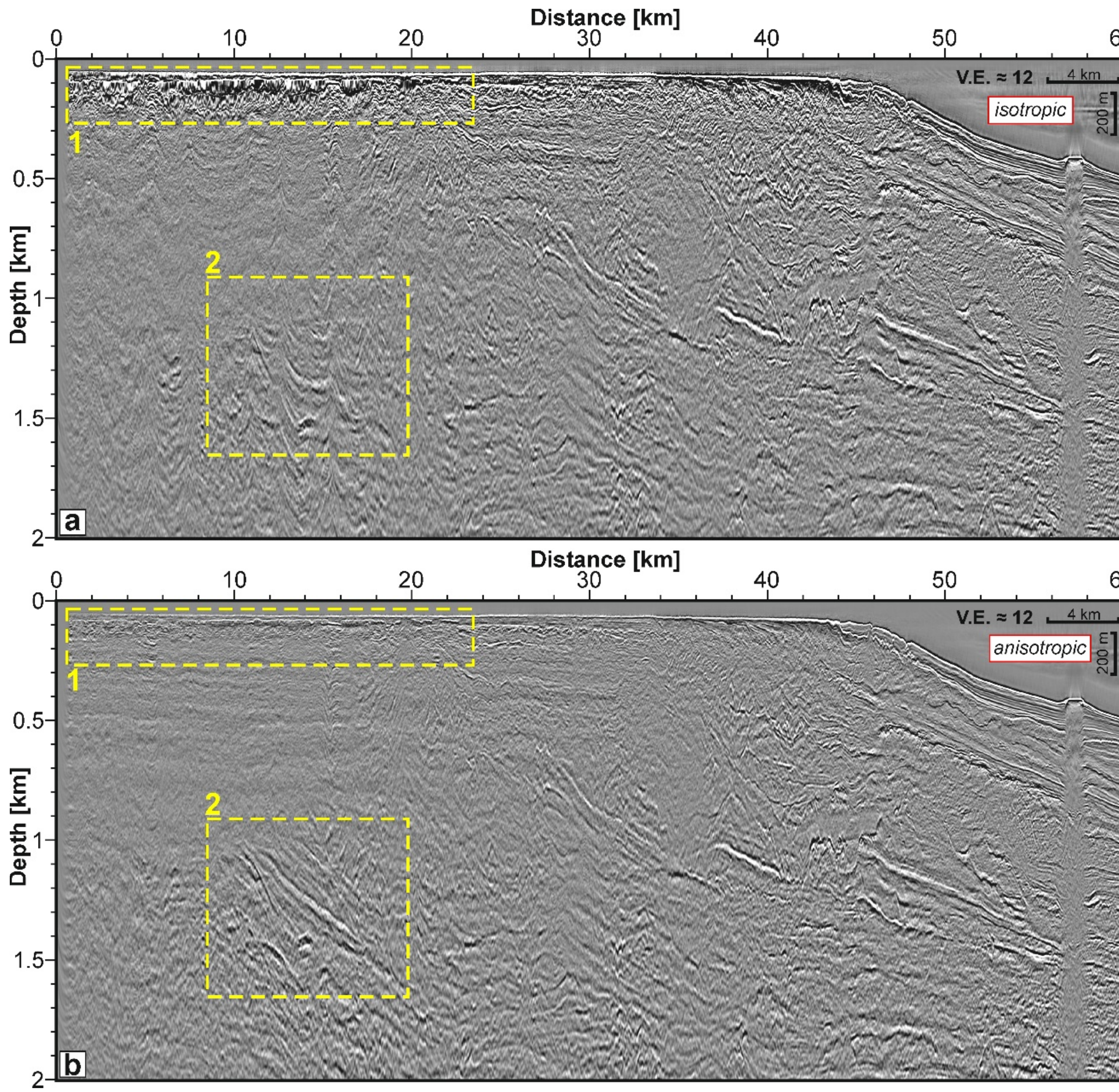

Figure S5. *Kirchhoff prestack depth migrated seismic (PSDM) section of line ARA05C-05. a) PSDM result using only isotropic velocities, b) PSDM result considering anisotropy (ε > δ = 0, Thomsen (1986)) for DWT velocities. Yellow boxes #1 and #2 point at significant differences.*