Geochemistry, Geophysics, Geosystems Supporting Information for

Extension dynamics of the northern Fonualei Rift and Spreading Centre and the southern Mangatolu Triple Junction in the Lau Basin at 16 °S

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Introduction

Multiple Checkerboard test runs were calculated in order to assess the tomography's resolution limits both in terms of amplitude and spatial reconstruction. Both crustal phases (Pg1, Pg2) and the mantle refractions were considered in the checkerboard test and were also used as masks to the velocity models. However, because the mantle refractions propagated predominantly through the very shallow mantle, little of the mantle can be resolved. For the checkerboard tests, artificial checkerboard anomalies of +/-5% velocity

perturbation were superimposed onto the average velocity model. Different checker sizes were used in order differentiate between the smallest resolvable anomaly in the upper and lower crust. Tests were calculated for checkerboard cells of the size 7 x 2 km, 9x2 km, 11x2 km. Subsequently, synthetic travel time data were calculated based on this checkerboard models using the forward modelling subroutine of the tomo2D code (Korenaga et al., 2000). In order to make the synthetic data more representative of real data, randomly generated noise was added to the synthetic travel time data (0.01 s, 0.05 s and 0.08 s and were applied to all phases alike). After the random noise was added to the synthetic travel times, the initial average model was inverted to study how well the checkerboard anomalies could be reconstructed by the synthetic travel times. Any inversion parameters, such as the correlation length and smoothing factors were kept as in the Monte Carlo inversion for the average velocity model.
Different derivatives of the final velocity model, such as the relative v_p distribution, were calculated from the final inversion result and discussed during this study in order to highlight velocity or velocity depth gradient anomalies. While the velocity depth gradient model is calculated by depth ward derivation of the final velocity model, the relative v_p distribution plot is calculated by determining a 1D horizontal average v_p model and subtracting it from the final velocity model.

Text S1.

For each checkerboard test, the true checkerboard model and the inversion result of the synthetic data is shown. In order to make the imposed checkerboard anomalies more apparent, the average velocity model was subtracted from both the true checkerboard model and the inversion result.

All performed checkerboard tests show a resolution that decreases with depth and toward the ends of the profiles, which can thus be correlated with decreasing ray coverage. In the first set of checkerboard tests (Fig. S1A) that was executed with a checker geometry of 7 x 2 km and the three different maximum noise levels. The inversion of the synthetic data could reproduce the checkerboard pattern adequately down to a depth of about 4 km below the seafloor no matter the noise level (Fig. S1A). Little resolution is lost when higher noise levels are added to the synthetic data, aside from a slight smearing of the positive checker anomalies.
All checkerboard anomalies that are located above the Moho, which is approximately the height of the last row of complete checkers, can be resolved when the size of the checkers is increased to 9x2 km (Fig. S1B). Similar to the previous checkerboard test, increasing the maximum noise levels merely results in an increased smearing of the positive anomalies. Further, since the entire depth of the crust can be studied with this second set of Checkerboard tests (Fig. S1B), it becomes evident that the influence of the increasing noise levels, and thus the smearing of positive anomalies, is strongest in the upper crust. This sensitivity of the upper crust to increased noise levels is likely the result of 1) the low pick uncertainty and 2) shorter travel times of the upper crustal refraction, compared to the other considered phases. The tops of some of the 9x2 km checkers that are located within the mantle can be resolved (Fig. S1B), though their shape often appears horizontally smeared. Since enlarging their horizontal extent (Fig. S1C) did not improve their resolution

significantly, the ray geometry of the tomography appears to have very low sensitivities in the mantle.

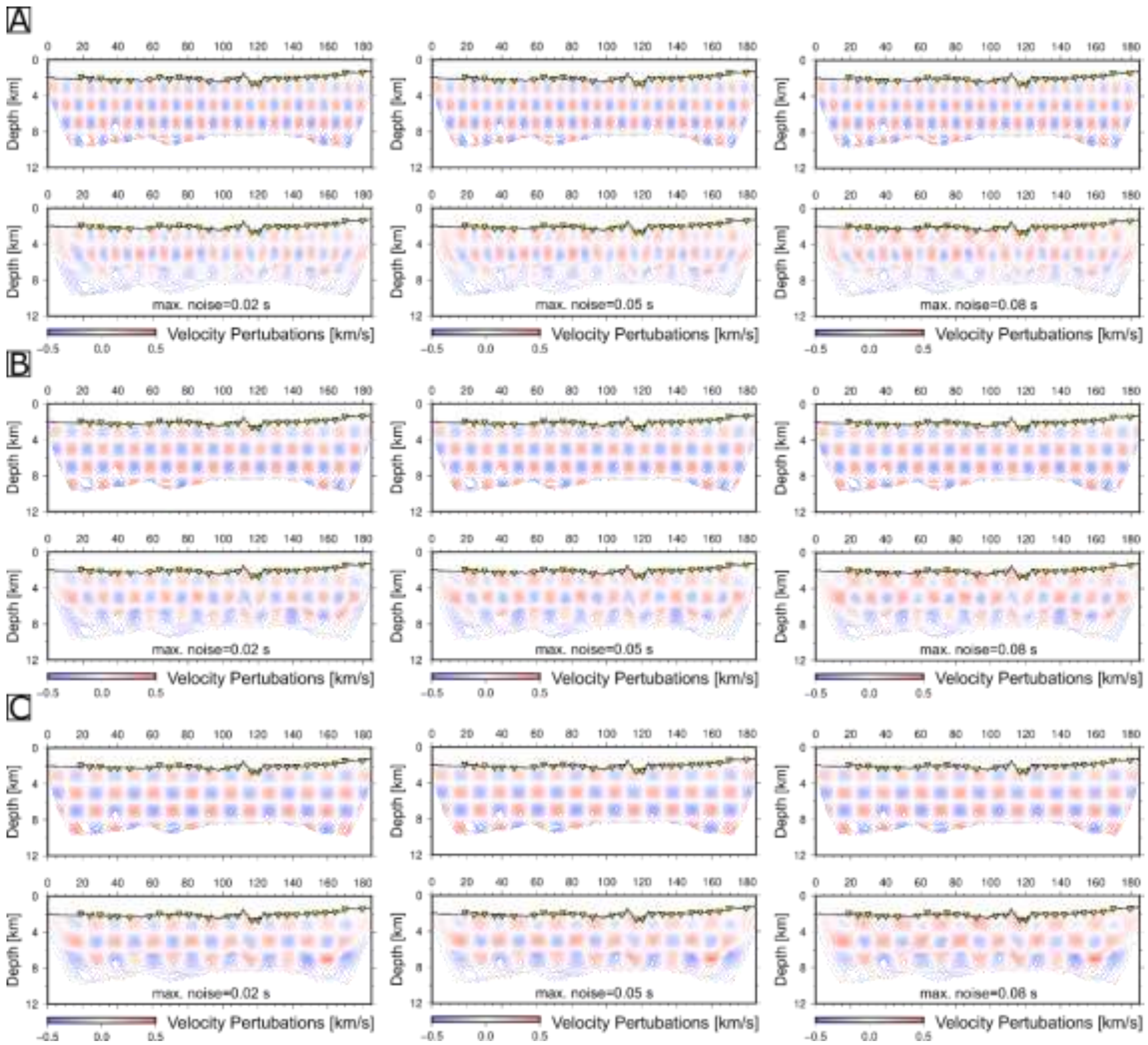

Figure S1. Overview of the performed sets of checkerboard tests all masked with the ray paths of the crustal refractions (Pg1, Pg2) and the mantle refractions (Pn). For each checkerboard test, the true checkerboard model is plotted above the checkerboard model that was reconstructed during inversion. The amount of noise that was added to the synthetic travel time data increases from left to right from 0.01 s to 0.05 s and 0.08 s. Subplot A shows the set of tests performed with a 7x2 km checkerboard pattern, Subplot B shows the tests that were performed with a 9x2 km checker pattern and Subplot C shows the checkerboard test performed with a 11x2 km checkerboard pattern.

Text S2.

A 1D average model was determined from the final inversion result in order to calculate a relative v_p distribution plot. The edit_smesh subroutine of the tomo2D code (Korenaga et al., 2000) was used to set all velocities to the horizontal average. In this calculation, the horizontal average refers to the relative depth below the seabed. The thus created model is shown in Figure S2.

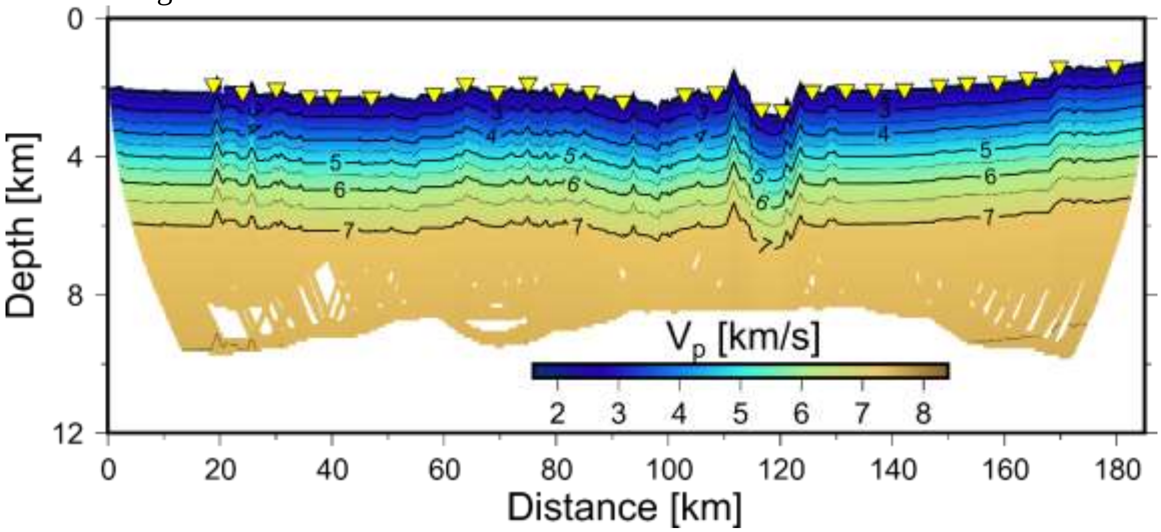

Figure S2. 1D horizontal average velocity model used for the calculation of the relative v_p distribution.

References

Korenaga, Holbrook, W. S., Kent, G. M., Kelemen, P. B., Detrick, R. S., Larsen, H.-C., et al. (2000). Crustal structure of the southeast Greenland margin from joint refraction and reflection seismic tomography. *Journal of Geophysical Research: Solid Earth*, *105*(B9), 21591–21614. https://doi.org/10.1029/2000JB900188