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Back-Arc Extension of the Central Bransfield Basin Induced by Ridge–Trench Collision: Implications From Ambient Noise Tomography and Stress Field Inversion

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Key Points:

- *S*-wave velocity structures beneath the Central Bransfield Basin (CBB) and adjacent areas are obtained by ambient noise tomography
- The back-arc extension is strongest in the northeastern CBB with associated mantle exhumation and gradually weakens toward the southwest
- The ridge–trench collision and subsequent detachment of the subducted Phoenix Plate initiated the back-arc extension of the CBB

Supporting Information:

Supporting Information may be found in the online version of this article.

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Abstract

The Bransfield Basin is a young (~4 Ma) back-arc basin related to the remnant subduction of the Phoenix Plate that once existed along the entire Pacific margin of the Antarctic Peninsula. Based on a recently deployed amphibious seismic network, we use ambient noise tomography to obtain the *S*-wave velocity structure in the Central Bransfield Basin (CBB). Combining with the stress field inverted from focal mechanisms, our images reveal that the CBB suffers a significant extension in the northwest-southeast direction. The extension is strongest in the northeastern CBB with associated mantle exhumation and weakens to the southwest with decoupled deformations between the upper crust and lithospheric mantle. Such an along-strike variation of extension can be explained by slab window formation and forearc rotation, which are associated with the Phoenix Plate detachment during the ridge–trench collisions at the southwest of the Hero Fracture Zone.

Plain Language Summary

Crustal extensions behind volcanic arcs are commonly attributed to subduction processes, however, subduction alone is not sufficient to trigger the back-arc extension as the latter is missing in some ongoing subduction zones. An effective way to assess the sufficient condition is to learn how the back-arc extension initiates. Here, we examine the recently formed Central Bransfield Basin (CBB), located off the Antarctic Peninsula in the back-arc setting of the Phoenix subduction zone. The stress field inverted from focal mechanisms indicates a northwest-southeast extension in the CBB. *S*-wave velocity structures imaged by ambient noise tomography show that the extension has distinctly different degrees along the axis of the CBB, which is strongest with associated mantle exhumation in the northeast and gradually weakens toward the southwest. Our observations suggest that the back-arc extension of the CBB, which started at ~4 Ma, was initiated by the ridge–trench collision at the southwest of the Hero Fracture Zone. With the subduction zone progressively eliminated during the ridge–trench collisions, the subducted Phoenix Plate has detached along the segmental Phoenix-Antarctic Ridge to form the slab window and trigger the forearc rotation, that initiated the back-arc extension of the CBB.

1. Introduction

Back-arc basins, characterized by intense extension behind island arcs or along continental margins adjacent to trenches, are commonly attributed to subduction processes involving multiple thermal and mechanical factors (Molnar & Atwater, 1978; Sdrolias & Müller, 2006; Stern, 2002). However, it remains a matter of debate if subduction alone is sufficient for initiating the back-arc extension (Mantovani et al., 2001; McCabe, 1984; Uyeda & Kanamori, 1979; Wallace et al., 2005), because back-arc basins are missing in some subduction zones, or extension has ceased while subduction is still active.

The Bransfield Basin separates the inactive island arc (i.e., South Shetland Block, SSB) from the northern tip of the Antarctic Peninsula (AP), beneath which the Phoenix Plate is subducting (Figure 1). The Phoenix Plate was formed by seafloor spreading since the Mesozoic at the Pacific-Phoenix and Farallon-Phoenix Ridges, and later on (~60 Ma) at the Antarctic-Phoenix Ridge (Eagles et al., 2004; Eagles & Scott, 2014). The subduction of the Phoenix Plate had led the Antarctic-Phoenix Ridge to successively converge with the AP from southwest to northeast since ~50 Ma (Eagles & Jokat, 2014; Larter & Barker, 1991). The present

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trench, that once extended along the entire Pacific margin of the AP throughout the Mesozoic (Birkenmajer, 1994; Leat & Riley, 2021), is the remnant subduction site that was progressively eliminated from southwest to northeast during a series of ridge–trench collisions (Eagles & Jokat, 2014; Larter & Barker, 1991; Livermore et al., 2000). The Bransfield Basin has suffered extension since ∼4 Ma (Larter & Barker, 1991; Smellie, 2021), synchronously with the latest ridge–trench collision at the southwest of the Hero Fracture Zone (Larter & Barker, 1991; Lodolo & Pérez, 2015). As a young back-arc basin formed in a long-term subduction setting, the Bransfield Basin is an ideal site to learn how the back-arc extension initiates and what is the driving mechanism behind its evolution.

The opening of the Bransfield Basin has been accompanied by extensive volcanism aligned in the northeast-southwest direction and perpendicular to the extension direction (Figure 1b). Particularly in the Central Bransfield Basin (CBB), bounded by morphological steps at the large Quaternary volcanic islands, that is, Deception Island (DI) and Bridgeman Island (BI; Smellie, 2002, 2021), a series of submarine volcanic edifices stick out of the basin floor (Gràcia et al., 1996) with hydrothermal activity (Klinkhammer et al., 2001; Petersen et al., 2004; Rodrigo et al., 2018) and moderate-to-intense seismicity (Almendros et al., 1997, 2018; Dziak et al., 2010; Jiménez Morales et al., 2017; Robertson Maurice et al., 2003). The bathymetry in the CBB is markedly asymmetric with a narrow and steep margin adjacent to the SSB, in contrast, its southeastern margin adjacent to the AP consists of a flat shelf dissected by north- to northwest-trending troughs (Figure 1b; García et al., 2009). Controlled by the geomorphic features and glacial processes, the depocenter with ∼2-km-thick sedimentary extends from the southeast of volcanic edifices to the troughs in the AP shelf (Barker & Austin, 1998; Christeson et al., 2003; García et al., 2008; Prieto et al., 1998). Given that shallow igneous materials were geophysically observed in the rift centers (Almendros et al., 2020; Catalán et al., 2013; Christeson et al., 2003; Galindo-Zaldívar et al., 2004; Janik et al., 2014) and erupted lavas resemble mid-ocean ridge basalt (MORB; Fretzdorff et al., 2004; Haase & Beier, 2021), the CBB might be in an incipient stage of seafloor spreading (Catalán et al., 2013; Gràcia et al., 1996). Previous wide-angle seismic observations depict variations in the crustal thickness in the CBB reaching a minimum of 8–10 km in the northeast and generally thickening to ∼15 km in the southwest (Barker et al., 2003; Christeson et al., 2003). Considering current shear motion in the Eastern Bransfield Basin (EBB; González-Casado et al., 2000; Gràcia et al., 1996) and GPS measurements around the Bransfield area (Berrocoso et al., 2016; Taylor et al., 2008), rifting in the CBB has been proposed to propagate from northeast to southwest (Barker & Austin, 1998; Lodolo & Pérez, 2015; Vuan et al., 2005).

To investigate the submarine volcanoes and rift dynamics along the Bransfield Basin, comprehensive geophysical experiments have been conducted in the CBB between 2017 and 2020 within the BRAnsfield VOlcanoes SEISmology (BRAVOSEIS) project (Almendros et al., 2020). The deployment of a dense, amphibious broadband seismic network (Figure 1b) offers an excellent opportunity to image high-resolution crustal structures in the CBB and adjacent areas. Here, based on these new seismic observations, we perform ambient noise tomography to image *S*-wave velocity (Vs) structures in this area. The ambient noise interferometry can obtain interstation surface wave signals with dominant energy at relatively shorter periods (Bensen et al., 2007; Shapiro et al., 2005) and provide a holistic perspective of the crust beneath the CBB, which will help to yield new insights on the initiation mechanism of back-arc extension when integrating with the stress field and regional tectonics.

2. Data and Methods

The data used in this study are mainly from the amphibious broadband seismic network deployed within the BRAVOSEIS project (Figures 1b and Figure S1 in Supporting Information S1), which includes fourteen onshore stations (network 5M; Heit et al., 2020) and eight ocean-bottom seismometer (OBS) stations (network ZX; Schmidt-Aursch et al., 2021). They were deployed across the CBB, the SSB, and the AP shelf between 2018 and 2020 with an average interstation distance of ∼30 km. We also collect data from two synchronously running permanent seismic stations operated by the Istituto Nazionale Di Oceanografia E Di Geofisica Sperimentale (1992) (network AI). Additionally, six seismic stations (network XB) that operated between 1997 and 1999 (Wiens, 1997) are also analyzed. Continuous waveforms of the vertical component from 30 broadband seismic stations are collected to calculate cross-correlations for all available station pairs similar to previous studies (Bensen et al., 2007; Ritzwoller & Feng, 2019; Figure S2 and Data Set S1 in

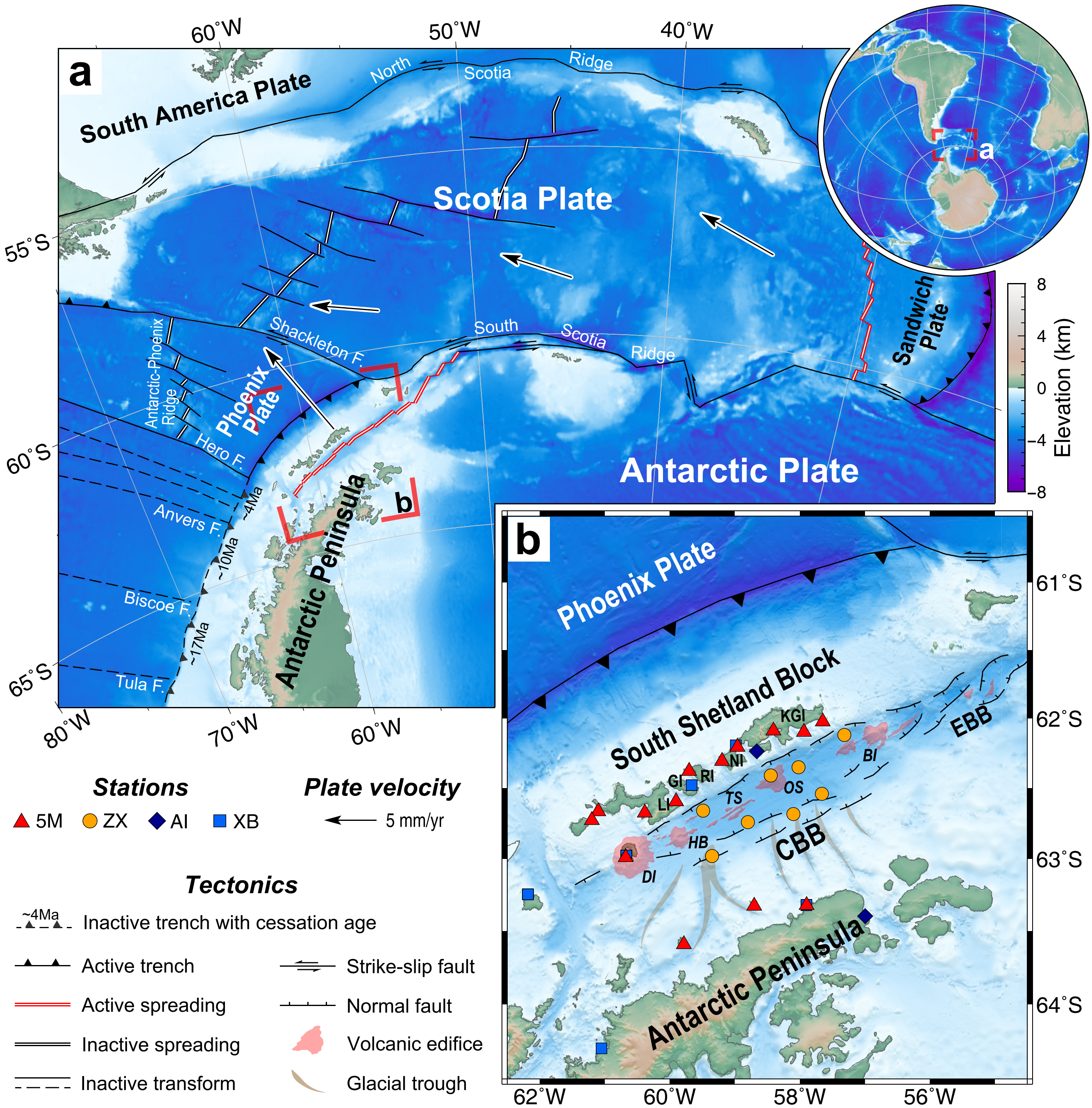

Figure 1. (a) Tectonic setting in and around the northern tip of the Antarctic Peninsula, which location is marked in the globe inset. The absolute plate motions fixed to the Antarctic Plate from the NNR-MORVEL56 (Argus et al., 2011) are plotted as black arrows. Red box represents the region of the Bransfield Basin and the South Shetland Block (SSB) in (b). (b) Topographic and tectonic map of the Bransfield Basin and the SSB. The Central (CBB) and Eastern (EBB) Bransfield Basin are characterized by linearly distributed volcanic edifices shown as translucent red areas, including Deception Island (DI), Humpback Seamount (HB), Three Sisters Ridge (TS), Orca Seamount (OS), and Bridgeman Island (BI) in the CBB. The SSB consists of several islands, including Livingston Island (LI), Greenwich Island (GI), Robert Island (RI), Nelson Island (NI), and King George Island (KGI). Stations (networks 5M, ZX, AI, and XB) used in this study are marked as symbols indicated in the legend.

Supporting Information S1). We manually extract Rayleigh wave group and phase velocity dispersions from cross-correlations using the Computer Programs in Seismology (CPS) package (Herrmann, 2013; Figure S3 in Supporting Information S1). Finally, we obtain nearly 250 group and phase velocity dispersion curves in the periods of 1–24 s (Figure S4 in Supporting Information S1), which cover well the study region (Figure

S5 in Supporting Information S1). Supporting Information S1 includes more details of these processes (Text S1 and Figures S2–S5 in Supporting Information S1). In this study, we apply the direct inversion method of surface wave dispersion proposed by Fang et al. (2015) to construct a three-dimensional (3-D) Vs model (Data Set S2 in Supporting Information S1) without the intermediate step of inverting phase or group velocity maps. Supporting information S1 provides more details of the direct inversion method and reliability tests (Text S2 and S3 and Figures S6–S9 in Supporting Information S1). We also use the MSATSI package (Martínez-Garzón et al., 2014) to invert the present-day stress field of the northeastern CBB from focal mechanisms (see details in Text S4 in Supporting Information S1), that help to further understand the geodynamic evolution of the crust and uppermost mantle structure imaged in the 3-D Vs model.

3. Results

Based on the data coverage and the resolution tests (Figures S5, S6, S8, and S9 in Supporting Information S1), we mainly focus on the 3-D Vs model between 0 and 35 km depth in the CBB and adjacent areas (Figures 2 and 3). At depths shallower than 5 km, the CBB shows two prominent low-Vs anomalies (<2.8 km/s) at the east of the Orca Seamount (OS) and between the Humpback Seamount (HB) and the Three Sisters Ridge (TS; Figures 2a, 2b and 3). These low-Vs anomalies show clear zonation along glacial troughs extending from the AP shelf (Figures 2a and 2b; García et al., 2009), with a large sedimentary thickness depicted by seismic reflection (García et al., 2008). The lowest Vs (<2.0 km/s at 1-km depth) appearing east of the OS is coincident with the depocenter covered by the thickest sedimentary layer (~2.6 km thick) in the CBB (Barker & Austin, 1998; Christeson et al., 2003; Prieto et al., 1998). The Vs model also contains relatively low-Vs anomalies (~3.4 km/s) at 10–15-km depth beneath the DI and 15–25-km depth beneath the Livingston Island (LI; Figures 2c, 2d and 3). Previous local seismic tomography (Zandomeneghi et al., 2009) and magnetotelluric study (Pedrera et al., 2012) image shallow magmatic or hydrothermal activity as low-Vs and high-conductivity anomalies beneath the DI and the LI. The relatively low-Vs anomalies imaged in this study possibly depict the deeper plumbing system there (Geyer et al., 2019), although their scale cannot be ensured due to the resolution of Vs model (Figure S8 in Supporting Information S1).

The most prominent feature in the 3-D Vs model is the contrasting crustal structures beneath the CBB and the SSB (Figures 2 and 3). The varying sedimentary thicknesses lead to low Vs (<2.8 km/s at 5-km depth) beneath the CBB but high Vs (>3.2 km/s at 5-km depth) beneath the SSB in the shallow as aforementioned, but the patterns are entirely different at depths deeper than ~15 km, which show significantly high Vs (>4.1 km/s) referring to the mantle beneath the CBB but low Vs (3.7–3.9 km/s) still referring to the crust beneath the SSB. These contrasting features reflect different crustal thickness beneath the CBB and the SSB. As shown in the cross sections (Figure 3), Moho depths indicated by previous H–κ stacking results (Biryol et al., 2018; Parera-Portell et al., 2021) are mostly close to the depth of the 4.0-km/s contours of the Vs model, that is, both are ~30-km depth beneath the SSB and the AP. We therefore use the depth of the 4.0-km/s contours as approximate Moho depths (Figure S10 in Supporting Information S1), which shows that the crust in the CBB is thinnest (~10 km) near the OS and thickens to ~20-km beneath the DI along the rift center. The crustal thickness is asymmetric across the CBB, like the bathymetry, that is an abrupt change in a narrow margin to the SSB but a gentle thickening in a relatively wide margin to the AP (Figure 3). The trend of the approximate Moho depths is mostly consistent with receiver function H–κ stacking results beneath the SSB and the AP (Biryol et al., 2018; Parera-Portell et al., 2021), and with the crustal thicknesses in the CBB revealed by wide-angle seismic surveys (Barker et al., 2003; Christeson et al., 2003). Seismic observations show that the P-wave velocity (Vp) will jump from 6.0–6.3 km/s in the upper crust to 6.6–6.8 km/s in the lower crust at the Conrad discontinuity (Christensen & Mooney, 1995; Wever, 1989). Thus, we refer to the 3.7-km/s contours of the Vs model (Vp ≈ 6.4 km/s, assuming a Vp/Vs ratio of 1.73) as the approximate interface between the upper and the lower crust here. The 3.7-km/s contours are almost constantly at 10-km depth with slight fluctuations in the study area (Figure 3), which indicates that the strong crustal thickness variation mainly reflects the significant thinning of the ductile lower crust beneath the CBB. The thickness of the lower crust is ~10 km beneath the DI, half as much as that beneath the SSB (~20 km) and is too thin to be identified beneath the OS (Figure 3). Although the surface wave method cannot accurately determine the discontinuity depth, synthetic tests indicate that our result can well image the trends of these discontinuities (Figure S11 in Supporting Information S1).

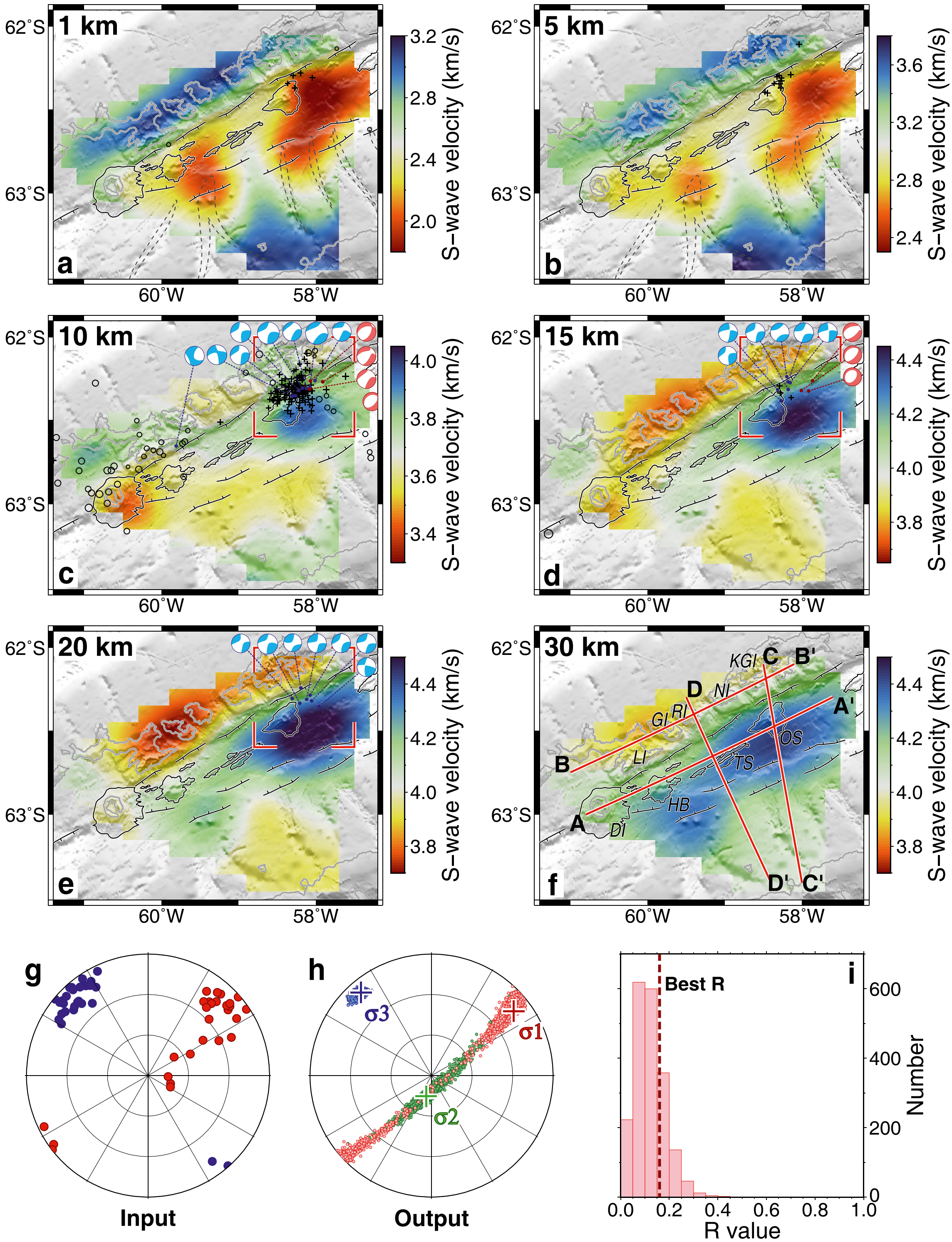
1 km
5 km
10 km
15 km
20 km
30 km
S-wave velocity (km/s)
62°S
63°S
60°W
58°W
a
b
c
d
e
f
A
A'
B
B'
C
C'
D
D'
KGI
NI
GI
RI
LI
OS
TS
HB
DI
g
h
i
Input
Output
σ1
σ2
σ3
Best R
Number
R value

Figure 2.

4. Discussion

4.1. Variations of Extensional Stage in the Central Bransfield Basin

The crustal structures observed in the 3-D Vs model exhibit features that are key to understanding the deformation and evolution of the Bransfield Basin. Foremost, the thinnest crust (~10 km) and the thickest sedimentary layer (~2 km) in the northeastern CBB indicate an intense crustal thinning that mainly affected the lower crust (Figures 2 and 3). Interestingly, there was a sharp increase of seismic activity in August 2020 in the northeast vicinity of the OS, where an abrupt change exists between the thickest crust beneath the SSB and thinnest crust beneath the basin (Figures 2 and 3). According to the earthquake location information from the USGS and the focal mechanisms from the gCMT, these earthquakes extend from the crystalline basement beneath the sedimentary basin to the Moho, and some of them are possibly located in the uppermost mantle (Figure 3). The present-day stress field of the northeastern CBB has a northwestward, horizontal minimum stress ($\sigma 3$) and a small stress ratio (R; Figure 2), which indicate that the stress field in this area is mainly organized by the northwest-southeast extension. The deep-seated seismic activities with extensional mechanism hint at coupled deformations throughout the crust and mantle lithosphere after the extreme necking of the ductile lower crust (Figure 4a). This is suggesting a hyperextension phase with possible mantle exhumation at the final transition stage from the continental rift to the seafloor spreading (Pérez-Gussinyé, 2013; Peron-Pinvidic et al., 2013). Furthermore, the predominant MORB-like lavas in the OS, sourced from the high-degree partial melting of the enriched mantle at relatively shallow depths (Fretzdorff et al., 2004; Haase & Beier, 2021; Keller et al., 2002), also support the strong lithospheric extension and possible mantle exhumation there.

In the southwestern CBB, the basin floor becomes progressively shallower through a series of morphological steps (Barker & Austin, 1998; Gràcia et al., 1996), and the crust gradually thickens to ~20-km thickness beneath the DI mainly due to the lower crustal thickening (Figure 3). In this area, seismic activity mainly limits to some shallow seismic swarms induced by the magmatic and hydrothermal activity (Almendros et al., 2018; Jiménez Morales et al., 2017). The significantly reduced seismicity in the deep crust (Figures 2 and 3) implies decoupled deformations between the upper crust and the lithospheric mantle, accommodated by the less-necked lower crust (Figure 4a). The generally increasing $(Ce/Yb)_N$ and Nb/Yb in the incompatible element ratios of the lavas toward the DI also reflect decreasing partial melting degrees of mantle sources (Haase & Beier, 2021). Therefore, the southwestern CBB is currently experiencing a thinning phase, it should be at a less-extending stage compared to the hyperextension phase that is occurring in the northeast (Pérez-Gussinyé, 2013; Peron-Pinvidic et al., 2013).

4.2. Initiation Mechanism of the Central Bransfield Basin Extension

Our images reveal that the CBB displays significant extension with possible mantle exhumation associated in the northeast (Figures 2, 3 and 4a). As the Bransfield Basin is situated in a back-arc setting, the rollback of the subducted Phoenix Plate has been proposed as the favored model for the initiation of the extension in the Bransfield Basin (Figure 4b; e.g., Dziak et al., 2010; Galindo-Zaldívar et al., 2004; Larter & Barker, 1991). The subducted Phoenix Plate, suggested to be located beneath the Bransfield Basin, is also supported by the high concentrations of fluid-mobile elements in the lavas (Fretzdorff et al., 2004; Haase & Beier, 2021) and can be seen in the seismic tomographic images as the southeastward dipping high-velocity anomaly extending from the trench to ~300-km depth (Lloyd et al., 2020; Park et al., 2012; Figure 4c and Figure S12 in Supporting Information S1). Plate reconstruction revealed that the western segments of the Antarctic-Phoenix Ridge have collided with the trench step by step and have subducted below it (Eagles & Jokat, 2014; Larter &

Figure 2. (a–f) Horizontal slices of the Vs model at depths of 1, 5, 10, 15, 20, and 30 km, respectively. Earthquakes within ±2.5-km swath along each slice are plotted as circles for the Reviewed ISC Bulletin (1964–2018; https://doi.org/10.31905/D808B830) and crosses for the recent USGS Catalog (2019–2020; http://earthquake.usgs.gov). Beach balls denote focal mechanisms (1976–2020) within the same swath downloaded from the gCMT (http://globalcmt.org). The compressional quadrants of focal mechanisms are colored as blue for strike-slip faulting and red for normal faulting. Red boxes indicate the region, where focal mechanisms are used for the stress field inversion. Red lines delineate the locations of the cross sections displayed in Figure 3. Volcanic edifices in the CBB are delineated with black lines, and coastlines are shown as gray lines. Dashed lines represent glacial troughs extending from the Antarctic Peninsula shelf. Abbreviations are the same as in Figure 1b. (g) Compression (red) and tension (blue) axes of focal mechanisms used as the input of the stress field inversion are shown in the stereo net. (h) Result of the stress field inversion. Crosses represent inverted principal stress axes. Colored points represent the 95% confidence level of the results estimated in bootstrap inversions. (i) Distributions of stress ratio ($R = (\sigma 1 - \sigma 2)/(\sigma 1 - \sigma 3)$).

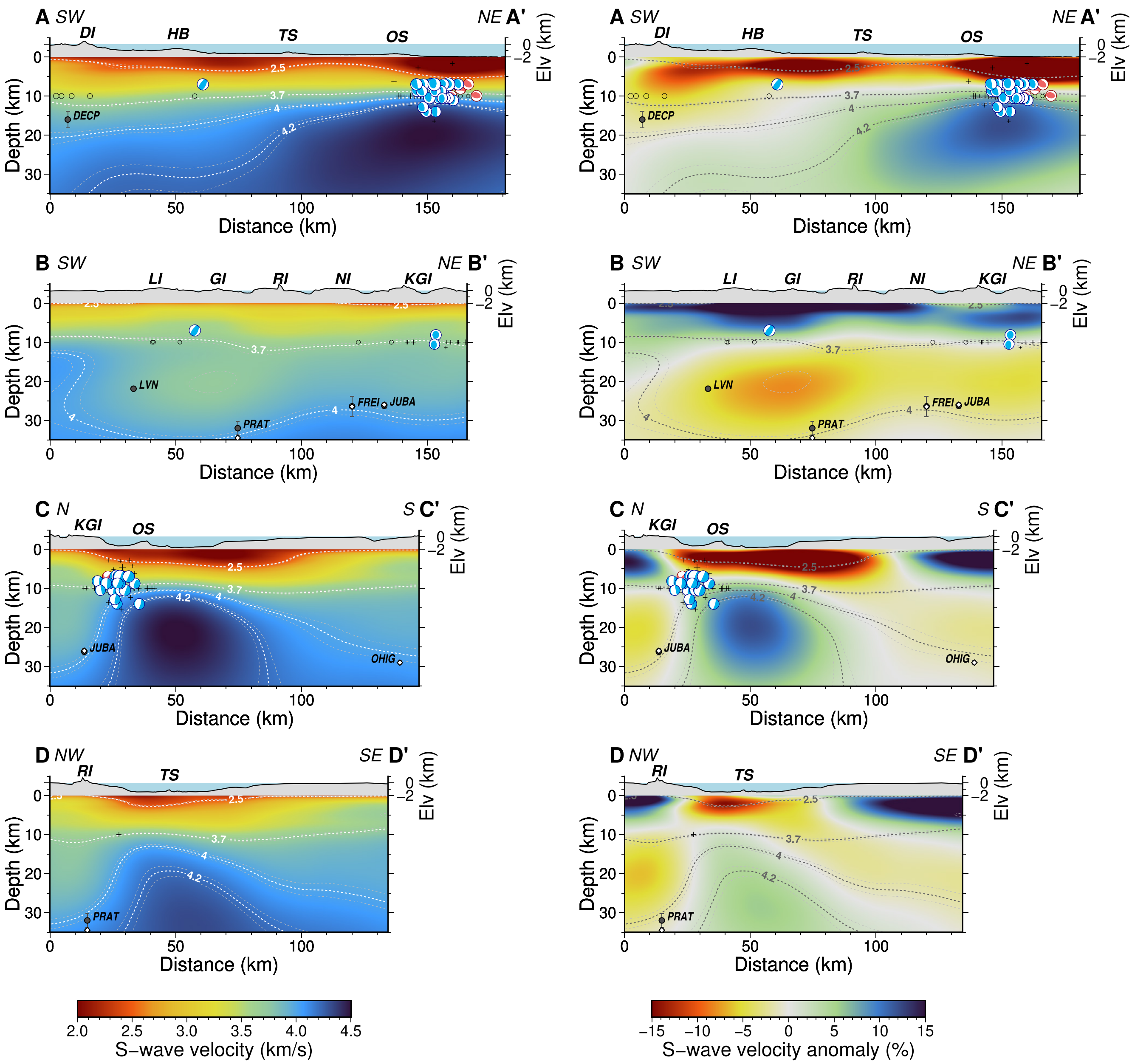

Figure 3. Vertical cross sections of the Vs model and corresponding Vs perturbation along lines AA, BB, CC, and DD indicated in Figure 2f. Vs perturbations are relative to the average value at each depth of the Vs model. Topography is plotted above each cross section with labels representing the locations of volcanic edifices and islands, abbreviations are the same as in Figure 1b. Earthquakes along each cross section with ±10-km swath are denoted as circles and crosses for different catalogs same as Figure 2. Similarly, focal mechanisms from the gCMT in the same swath are also projected onto each section and displayed using the half-sphere behind the plane. The points with error bars represent the Moho depth from previous H–$\varkappa$ stacking results (white ones from Biryol et al. [2018] and black ones from Parera-Portell et al. [2021]). White and black dashed lines show the contour lines of certain Vs with the ±0.025-km/s range bounded by the dashed lines.

Barker, 1991). With the subduction zone progressively eliminated during the ridge–trench collisions along the AP, the western part of the Phoenix Plate has been detached and a slab window has opened while the subduction continues in the eastern part (Figure 4b; Barker & Austin, 1998; Burkett & Billen, 2010). Such a slab window is well depicted by the adjoint tomography (Lloyd et al., 2020; Wiens et al., 2021) as a low-velocity gap between the slab-related high-velocity anomalies emerging at >150-km depth and the ceased trench at the southwest of the Hero Fracture Zone (Figure 4c and Figure S12 in Supporting Information S1). Consequently, it became progressively easier for mantle material to flow around the slab and slab rollback

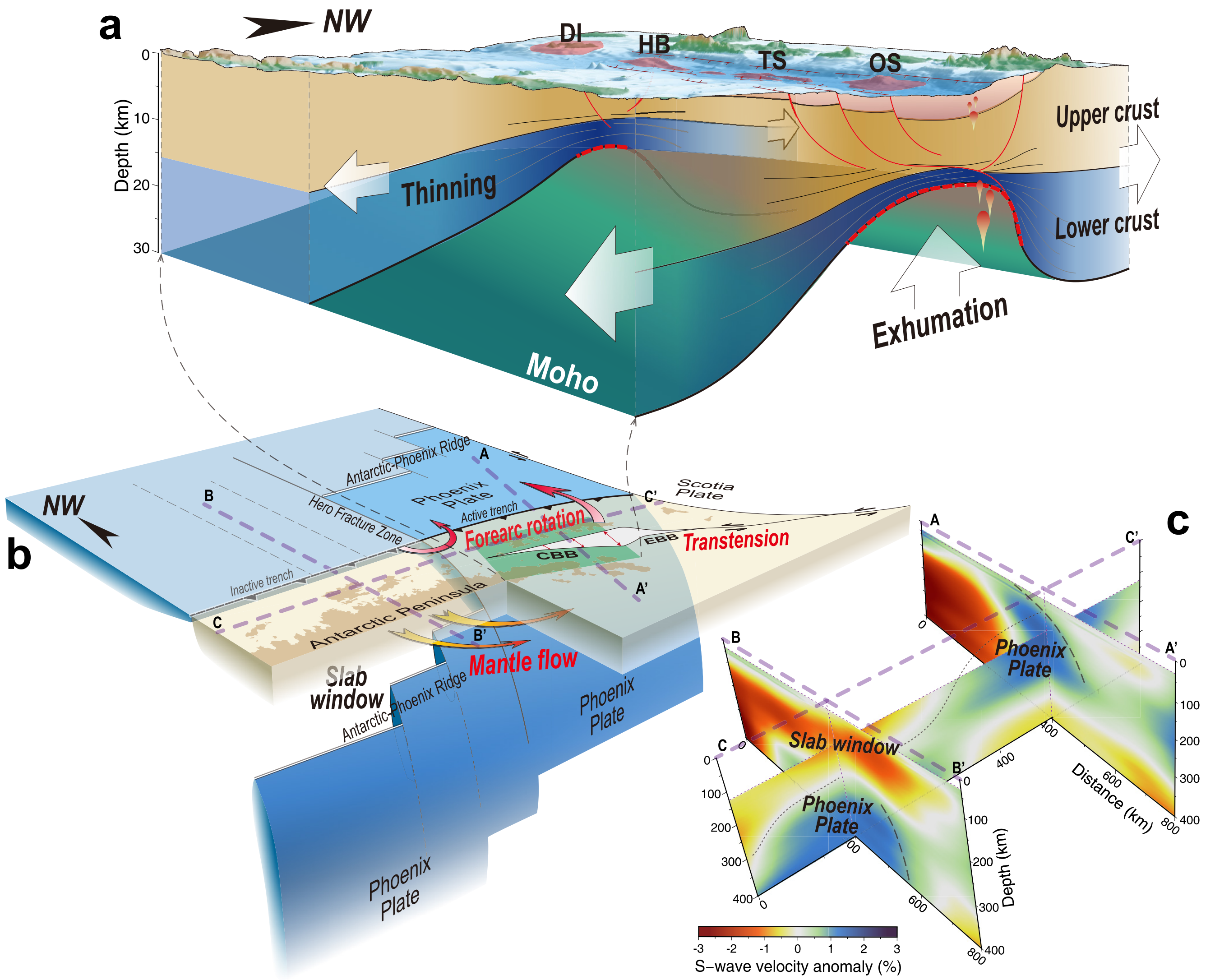

Figure 4. (a) Cartoon of the discrepant extensions in the CBB. The crust in the CBB is remarkably thin induced by northwest-southeast extension and mainly depicts ductile lower crustal necking. The lower crust is so thinned that faults can deeply penetrate through the crust in the northeast. Whereas the less-thinned lower crust in the southwest decouples upper crust and lithospheric mantle deformations. (b) Cartoon of the ridge–trench collision accounting for the initiation of back-arc extension in the CBB. Slab rollback is promoted by the mantle flow through the slab window formed by the detachment of the subducted Phoenix Plate. The collision of the remaining buoyant plate and the Antarctic Peninsula caused the forearc rotation, causing along-strike variation of the extension in the CBB. The transtension related to the shear motion between the Scotia Plate and the Antarctic Plate might further contribute to this extensional regime. (c) 3-D view of three cross sections extracted from the upper mantle Vs model imaged by the previous adjoint tomography (details are shown in Figure S12 in Supporting Information S1, original model is from Lloyd et al., 2020). These cross sections are plotted as Vs perturbation along purple lines AA, BB, and CC indicated in (b), and well depict the subducted Phoenix Plate and the slab window interpreted in (b).

started to initiate back-arc extension (Figure 4b). This ridge–trench collision model with the subsequent detachment of the subducted Phoenix Plate can explain why the back-arc extension has only developed in the Bransfield Basin, but not along the entire margin of the AP which was also affected by the subduction of the Phoenix Plate (Eagles & Jokat, 2014; Larter & Barker, 1991).

The Vs model also suggests that the crust extension gradually weakens from northeast to southwest in the CBB. The crust is thicker (~20-km thickness) in the southwestern CBB with decoupled deformations between the upper crust and the lithospheric mantle (Figures 3 and 4a). Such an along-strike variation of the back-arc extension can be excepted by the partial collision in the subduction system, which can generate forearc rotation around a nearby pole and lead to the strongest back-arc extension at the far end (Moresi et al., 2014; Wallace et al., 2005, 2009). After the Phoenix Plate detached along the Antarctic-Phoenix Ridge

(Larter & Barker, 1991), the remaining buoyant plate separated from the Phoenix Plate by the ridge had collided with the margin of the AP (Eagles & Jokat, 2014; Figure 4b). Therefore, we propose that the latest collision of the remaining buoyant plate and the AP at the southwest of the Hero Fracture Zone caused the forearc rotation of the SSB, which should have resulted in the strongest extension in the northeastern part of the CBB but weakest in the southwest (Figures 4a and 4b). Moreover, left-lateral shear motion between the Scotia Plate and the Antarctic Plate might cause transtension in the EBB (González-Casado et al., 2000; Gràcia et al., 1996) and contribute to the further development of the extensional regime in the CBB (Barker & Austin, 1998; González-Casado et al., 2000; Lodolo & Pérez, 2015).

5. Conclusions

We construct a 3-D Vs model of the CBB and adjacent areas by ambient noise tomography and invert the present-day stress field from focal mechanisms. Our new model reveals coupled deformations throughout the lithosphere in the northeastern CBB and decoupled deformations between the upper crust and lithospheric mantle in the southwest, indicating that along its strike, the CBB is suffering different extensional phases of continental rift-seafloor spreading transition. We suggest that the along-strike variation of extension was a consequence of the slab window formation and the forearc rotation, which are associated with the Phoenix Plate detachment during the ridge–trench collision at the southwest of the Hero Fracture Zone. The role of the Phoenix Plate in this process implies that the ridge–trench collision and subsequent slab detachment are the main initiation mechanism of back-arc extension in the CBB.

Data Availability Statement

Continuous data of the onshore stations of the BRAVOSEIS project are archived at the GEOFON Data Centre (5M, Heit et al., 2020). The OBS data are archived at the PANGAEA repository (ZX, Schmidt-Aursch et al., 2021). The data from permanent stations and other temporary stations can be accessed through the IRIS DMC. AI at: https://doi.org/10.7914/SN/AI and XB at: https://doi.org/10.7914/SN/XB_1997. The cross-correlations and the final 3-D Vs model are provided in Data Sets S1 and S2 which are archived at: https://doi.org/10.6084/m9.figshare.16702411.

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